19.0 INTELLIGENT TRANSPORTATION SYSTEMS AND TOLL COLLECTION INFRASTRUCTURE

The Contractor shall provide the Intelligent Transportation System (ITS) and Electronic Toll Collection (ETC) infrastructure elements for the Project. The purpose of these elements is to inform the roadway users, collect various data to assist agencies in the maintenance and operation of the facility, and collect the tolling revenue to support the Project's funding sources.

The ITS system includes various devices, such as Variable Message Signs (VMS), Closed Circuit Television (CCTV) Cameras, Ramp Meter Stations (RMS), Microwave Vehicle Radar Detectors (MVRD), Automatic Traffic Recorders (ATR), Road Weather Information Systems (RWIS), and Variable Toll Message Signs (VTMS). In addition, the ITS system includes the various components that make up the communication system, such as conduit, fiber optic cable, and Ethernet switches.

The ETC system includes additional items such as Automatic Vehicle Identification (AVI) Readers, Automatic License Plate Recognition (ALPR) Cameras, Loop Detectors, and ETC Lane Controller Cabinets. The ETC system will rely on the fiber optic infrastructure to link the ETC field devices to the ETC back-office.

The Contractor shall be responsible for the design, furnishing, and installation of all ITS devices, the communications network, the supporting infrastructure that is necessary to maintain the existing ITS infrastructure, and the supporting infrastructure that is necessary to install and operate the ETC system components. The actual ETC system components shall be designed and installed by the ETC System Integrator, which will be E-470 Public Highway Authority (E-470). All ITS and ETC elements of the Project shall comply with the requirements of this Section. Additionally, testing and integration shall be performed per the Testing and Integration Plan included in the Reference Documents.

All design and construction shall comply with the relevant requirements and standards listed in Book 3. In addition, the references listed in the Reference Documents are provided as supplementary information.

19.0.1 List of Abbreviations

AC	Alternating Current
ACL	Access Control List
ALPR	Automatic License Plate Recognition
ARE	Additional Requested Element
ATR	Automatic Traffic Recorder
AVI	Automatic Vehicle Identification
CDOT	Colorado Department of Transportation
CCTV	Closed Circuit Television
CTMC	Colorado Transportation Management Center
CTMS	Colorado Transportation Management Software
CWDM	Coarse Wavelength Division Multiplexing
DSRC	Dedicated Short Range Communications
DTD	Division of Transportation Development
ETC	Electronic Toll Collection
HPTE	High-Performance Transportation Enterprise
IGMP	Internet Group Management Protocol
IP	Internet Protocol
ITS	Intelligent Transportation System
LED	Light Emitting Diode

MVRD	Microwave Vehicle Radar Detector
NEC	National Electric Code
NTCIP	National Transportation Communications for ITS Protocol
OCR	Optical Character Recognition
OSHA	Occupational Health and Safety Administration
PA	Public Address
PoE	Power over Ethernet
POE	Port of Entry
QoS	Quality of Service
RFC	Released for Construction
RFP	Request for Proposals
RMS	Ramp Meter Station
ROW	Right-of-Way
RWIS	Road Weather Information System
SFP	Small Form-factor Pluggable
SMFO	Single-Mode Fiber Optic
SNMP	Simple Network Management Protocol
TTI	Travel Time Indicator
UPS	Uninterrupted Power Supply
VLAN	Virtual Local Area Network VMS Variable Message Sign
VTMS	Variable Toll Message Sign

19.0.2 List of References

The Contractor shall comply with the requirements of the following manuals and standards (latest versions at Proposal Due Date) for the design and construction of the Work for the Project.

Author	Title
CDOT	*Standard Specifications for Road and Bridge Construction*
CDOT	*M&S Standards*
CDOT	CDOT *Sign Design Manual*
RTD	Design Guidelines and Criteria
AASHTO	*A Policy on Geometric Design of Highways and Streets*
AASHTO	*Roadside Design Guide*
ASTM	American Society for Testing and Materials
EIA	Electronic Industries Alliance
FHWA	*Manual on Uniform Traffic Control Devices*
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ITU	International Telecommunications Union
NFPA	*National Electric Code*
RUS	Rural Utilities Service
Telcordia	Telcordia Technologies
TIA	Telecommunications Industry Association

19.1 Design Requirements

The Contractor shall design the ITS and ETC infrastructure components in accordance with the requirements in this Section 19. No part or attachment of any equipment shall be substituted or applied contrary to the manufacturer's recommendations and standard practices, without CDOT Approval. Infrastructure locations shall meet the requirements of CDOT and the ETC System Integrator.

The Contractor shall submit ITS/ETC Design Documents to both CDOT and the ETC System Integrator for Acceptance by CDOT. The ITS/ETC Design Documents shall show all known utility information.

The Contractor shall submit a Temporary Communications and Device Plan to CDOT for Approval as part of the Pre-RFC Review Documents. This plan shall describe how the Contractor plans to maintain and keep operational all existing ITS devices during construction.

Refer to the Project Special Provisions at the end of this Section for design requirements in addition to those described in this Section.

19.1.1 Electrical Power

The Contractor shall provide alternating current (AC) power service to every ITS and ETC device and cabinet that does not have existing metered service. This includes all existing devices or cabinets that are relocated by the Contractor. The Contractor shall design a complete and operational power service system in accordance with the power service provider's requirements and shall obtain (from the power service provider) approval of the power service design. All power connections to devices shall include a quick-disconnect. Separate disconnects shall be installed for ITS and ETC devices.

The Contractor shall be responsible for the coordination of power source work to be performed by the local electrical utility provider. The Contractor shall coordinate with the local electrical utility provider to establish the metered power sources for ITS and ETC devices. The Contractor shall perform all work necessary to maintain existing or establish new metered power sources for ITS and ETC devices. All costs and necessary materials, including meter, labor, and coordination required to maintain existing or establish new metered power sources, shall be included in the Work.

19.1.2 Location and Protection of ITS and ETC Elements

The Contractor shall locate all ITS and ETC infrastructure elements within the public Right-of- Way (ROW) such that routine maintenance, including the use of a bucket truck, will not require a lane closure, affect traffic operations, or require complex traffic control, unless Approved otherwise in writing by CDOT. Whenever possible, ITS and ETC elements shall not be located in the highway median, except the center support of freeway VTMS related to the express lane, and AVI and ALPR support structures.

All existing utilities shall be identified, and all ITS and ETC infrastructure elements shall be designed to avoid or minimize conflicts with these facilities. The Contractor shall be responsible for all repairs to facilities damaged during construction. The Contractor shall be responsible for maintaining and keeping operational all existing ITS devices during construction.

All existing lateral cables to remain that are currently spliced into the backbone shall be identified by the Contractor in the Design Documents and protected in place.

The Contractor shall ensure that all equipment, including but not limited to, devices, interconnect wiring, communications devices, communications lines, power supplies, antennas, operator controls, and power

service are protected to eliminate damage by external and internal sources (including power surges), lightning, induced voltages, and static discharge. A grounding system and protection devices that are suitable for the specific installation and equipment shall be included in the design.

ITS/ETC design plans shall show existing and proposed underground and overhead utilities and drainage facilities to aid in determining conflicts during design reviews.

19.1.3 Communication System

The communications system is used to transmit data and video to and from all existing and proposed ITS devices. In addition, the system is responsible for transmitting all ETC tolling data to and from the back-office for processing, issuing of tolls, and updating of information in the lanes.

19.1.3.1 Design Requirements

The Contractor shall retain the existing fiber optic communication system. In locations where the existing backbone may need to be relocated, it shall not be located in the travelled way, shoulder, or bikeway, with the exception of crossings. No additional highway crossings of the fiber backbone shall be permitted. The Contractor shall coordinate all ITS device relocations with CDOT. The Contractor shall be responsible for all costs associated with any impacts or relocation of the CDOT fiber optic lines. The Contractor shall provide Internet Protocol (IP) Ethernet communication to all ITS devices within the Project limits, except ramp meters. The Contractor shall provide optical transceivers for ramp meter communications. The MVRD units at RMS locations shall be connected to the CDOT ITS network utilizing IP Ethernet communication and the ramp meter network utilizing optical transceivers. The Ethernet Switches for the MVRD units at RMS shall be installed in the ground-mounted RMS cabinets.

All fiber allocations, splicing diagrams, and network diagrams shall be prepared by the Contractor and submitted to CDOT for Approval. Splicing of fiber optic cable shall be performed in manholes only.

All splices for ITS device laterals to the fiber optic backbone shall utilize Coarse Wavelength Division Multiplexing (CWDM) splicing, except ramp meter laterals. Ramp meter lateral splices to the backbone shall utilize standard optics. Standard optics shall be defined as that operating within the O-band transmission window (notably 1310 nm).

Lateral splices to the fiber optic backbone shall be spaced no closer than 0.5 mile apart, unless otherwise Approved by CDOT. End-to-end fiber optic backbone splices shall be spaced no closer than 20,000 feet apart at locations Approved by CDOT.

One CDOT fiber buffer tube (fiber strands required per the design) will be allocated to E-470 along the CDOT Interstate 25 (I-25) backbone from the SH 66 Node to the Port of Entry (POE) Node. The Contractor shall be responsible for all splicing work necessary to provide this communications path. The Contractor shall submit Network Diagrams to CDOT for Approval as part of the Pre-RFC Review Documents. These Network Diagrams shall be reviewed by both CDOT and the ETC System Integrator.

19.1.3.2 Material Requirements

The Contractor shall furnish all components required to achieve a fully-functioning communications system, excluding tolling equipment to be installed in ETC lane controller cabinets. The communications system shall be designed based on the following material requirements, at a minimum:

- Provide 12-strand SMFO cable laterals from the CDOT backbone to all DTD, ITS, and ETC field devices.

- Provide fiber quick disconnects at all unprotected ITS device and equipment locations where new laterals are installed. The fiber quick disconnects shall allow the fiber laterals to be disconnected to prevent damage to the fiber backbone in case any of the devices or equipment along the corridor are damaged. The fiber quick disconnect shall be installed in areas where they will not be submerged in water and per the manufacturer's recommendations. Bend insensitive (ITU-T G.657 A) tactical fiber optic cable with a polyurethane jacket shall be used for all patch cables and shall be fully compatible with all fiber optic laterals.

- Provide hardened Ethernet switches with 8 10/100 Ethernet ports in addition to two Small Form-Factor Pluggable (SFP) based 1 Gigabit Ethernet ports. Each switch shall provide Virtual LAN (VLAN) Quality of Service (QoS), Internet Group Management Protocol v3 (IGMP) snooping/filtering, and security access control lists (ACLs) and SNMPv1, SNMPv2, and SNMPv3 management protocols. The switches shall also provide sufficiently sized optics for each device. Optical attenuators shall also be provided. Per the Project Special Provisions at the end of this Section, Ciena 3930 or 3931 shall be provided at ITS device locations throughout the Project corridor and a Ciena 5160 shall be provided at the POE Node Building.

- Provide fiber optic termination panels at ITS field devices and the POE Node Building per Project Special Provisions at the end of this Section.

19.1.4 Variable Message Signs

The VMS are large dynamic displays that are used for a wide range of purposes, including providing driver information regarding weather advisories, travel times, AMBER Alerts, and construction and incident notifications. The VMS along I-25 will not be used for tolling purposes.

There are four existing shoulder mounted VMS within the Project limits at the following approximate locations:

- Northbound and southbound, south of U.S. Highway (US) 34 (mile point 256.20, Project Station 3390+65)

- Northbound south of Kechter overpass (mile point 263.29, Project Station 3767+98)

- Southbound north of Kechter overpass (mile point 264.32, Project Station 3823+48)

19.1.4.1 Design Requirements

All existing VMS impacted by the Project shall be relocated to another suitable shoulder mounted location as approved by CDOT. An 8-foot wide paved maintenance access area outside of the shoulder shall be provided in locations where ROW permits, as determined by CDOT. If an existing VMS Cabinet is relocated, the Contractor shall provide design and inspection documents certifying that the existing cabinet and its structural elements (including the support angle connection members which will attach to the new sign structure) are adequate for reuse and can accommodate the required loading and attachment to the new sign structure, as detailed in CDOT standard S-614-60. The design and inspection records shall be signed and sealed by the Contractor's Engineer, and submitted to CDOT for Acceptance. All new mounting hardware shall be provided for reuse of existing VMS cabinets. If any structural modifications to the cabinet are proposed (including the angle connection members), shop drawings and calculations shall be submitted to CDOT for Acceptance. The shop drawings and calculations shall be signed and sealed by the Contractor's Engineer.

The Contractor shall prepare a structural design including cross sections for each VMS structure. The Contractor may not reuse existing VMS sign structures for permanent VMS installations.

VMS shall have a minimum of 17.5 feet of vertical clearance above the highest point of the roadway and meet the current MUTCD standards.

All existing VMS removed by the Contractor that are not reset shall be returned to CDOT.

Additional VMS shall be installed at the following approximate locations:

- Northbound mile point 257.8 (Project Station 3480+00)
- Southbound mile point 261.8 (Project Station 3689+00)

Revisions to these locations may be made with CDOT Approval.

19.1.4.2 Material Requirements

The Contractor shall furnish new VMS signs and all associated equipment necessary to achieve a fully-functioning system at the locations indicated above. The new VMS signs shall be designed based on the following material requirements, at a minimum:

- The sign shall utilize Light Emitting Diode (LED) displays.
- The sign shall be equipped with the ability to display three lines of text with a character height of 18 inches.
- The sign shall utilize a full-matrix display.
- The sign must have a walk-in cabinet.
- The sign shall have a minimum design life of 20 years.
- The VMS controller and sign must be NTCIP compliant, provide an Ethernet interface, and must be compatible with the Colorado Transportation Management Software (CTMS).

19.1.5 Closed Circuit Television

The CCTV cameras are used for monitoring travel conditions in the corridor, such as weather conditions, accidents, traffic congestion, and other events. The video images are also shared with the public via the internet (www.CoTrip.org) and television news agencies.

19.1.5.1 Design Requirements

The Contractor shall provide a CCTV system that provides full surveillance coverage along the extent of the project limits with no obstructions. The coverage shall include the entire I-25 roadway surface within the limits of the project, including all mainline lanes, ramp lanes, and interchanges at a minimum of 32x optical zoom and 12x digital zoom. Cameras shall be spaced no more than one mile apart. The Contractor shall prepare a coverage plan to be submitted to CDOT for Approval during preliminary design to demonstrate proper CCTV coverage.

Additional CCTV cameras shall be installed at the following approximate locations:

- Mile point 258.3 (Project Station 3506+00)
- Mile point 260.3 (Project Station 3611+00)
- Mile point 261.3 (Project Station 3664+00)
- Mile point 266.3 (Project Station 3928+00)
- Mile point 268.4 (Project Station 4039+00)

CCTV camera poles shall be placed as far away from the roadway as possible within the right-of-way, while still providing full surveillance coverage. If any CCTV camera poles are placed within the clear zone, they shall be protected in accordance with the *Roadside Design Guide* (AASHTO). The Contractor shall provide cross section drawings and pole installation and foundation details for each of the proposed CCTV locations.

19.1.5.2 Material Requirements

The Contractor shall furnish new CCTV cameras and all associated equipment necessary to achieve a fully-functioning system. All CCTV cameras within the Project limits shall meet the following minimum requirements:

- High Definition and Ethernet-based,
- All-in-one color surveillance dome camera unit (IP66 and NEMA 4x ratings),
- Pan, 220 degree tilt, zoom operation,
- Minimum 32x optical zoom and 12x digital zoom,
- Minimum illumination no less than 0.3 lux, and
- H.264 video stream.

The CCTV camera shall also include a weatherproof dome housing, steel pole, lowering device, mount adapter, camera transformer, attachment hardware and all other hardware, cables, and test equipment necessary for a complete installation. CCTV camera poles shall be a minimum of 50 feet in height. The poles shall also include a lowering device that allows CCTV cameras to be lowered to the ground for maintenance purposes without interfering with any other pole-mounted devices or cabinets.

Existing CCTV cameras located outside of the Project limits may be utilized at their existing locations to provide full surveillance coverage. However, resets of existing cameras are not allowed unless they meet the minimum requirements outlined above. All existing CCTV cameras not utilized by the Contractor shall be salvaged and returned to CDOT ITS.

19.1.6 Ramp Meter Stations

- The RMS help control the number of vehicles entering I-25 when the highway experiences congestion. There are currently no RMS operating within the Project limits; however, by spring of 2017, RMS will be in operation at the following locations:
- Southbound on-ramp at State Highway (SH) 392
- Northbound on-ramp at SH 392
- Southbound on-ramp at Harmony Road

19.1.6.1 Design Requirements

If the Contractor impacts any of the existing RMS along the corridor, the Contractor shall design and reconstruct a fully functioning RMS in accordance with the latest CDOT guidelines on ramp metering stations.

In addition, the Contractor shall design and construct new RMS at the following locations:

- Southbound on-ramp at Prospect Road
- Northbound on-ramp at Prospect Road
- Northbound on-ramp at Harmony Road
- Southbound on-ramp at Crossroads Boulevard
- Northbound on-ramp at Crossroads Boulevard
- Southbound on-ramp at eastbound US 34 to northbound I-25
- Northbound on-ramp at westbound US 34 to southbound I-25
- Southbound on-ramp at SH 402
- Northbound on-ramp at SH 402

19.1.6.2 Material Requirements

The Contractor shall furnish all the elements of the RMS necessary to achieve a fully-functioning system. All RMS shall utilize the following components:

- MVRD to collect mainline data for each lane and associated loop emulation cards
- Detector loops for on-ramp detection and associated loop amplifier cards
- Where impacted, install new or reset existing 334 controller cabinets and controllers on new fiberglass porch-style foundations

- Pull boxes, conduit, communications, controllers, signal equipment, advance flashers, wiring, and all other items necessary to provide a complete and functioning RMS

Existing RMS cabinets, controllers, and communications equipment may be salvaged and reused.

19.1.7 Microwave Vehicle Radar Detectors (MVRD)

MVRD, also referred to as side-fire radar, are used to collect point data of volume, occupancy, speed, and classification in each lane of travel. The data is used primarily for measuring and analyzing traffic conditions, both in real-time and for studies.

19.1.7.1 Design Requirements

The Contractor shall prepare a design to locate MVRD units to provide full vehicle detection coverage within the Project limits. MVRD units shall be installed no further than one-half mile apart. The Contractor shall prepare a coverage plan to be submitted to CDOT for Approval during preliminary design to demonstrate the necessary MVRD coverage. MVRD units shall be co-located on other ITS Poles or overhead sign structures where possible. New MVRD units shall be installed at the following approximate locations:

- Existing ITS pole and sign structure locations

New MVRD unit locations are in addition to the MVRD units required at RMS. Revisions to these locations may be made with CDOT Approval.

19.1.7.2 Material Requirements

The Contractor shall furnish all new MVRD units and all associated equipment necessary to achieve a fully-functioning system. All MVRD units within the Project limits shall be a Wavetronix SmartSensor HD. All MVRD units within the Project limits shall detect all individual lanes of travel, including the general purpose and express lane(s) in both directions. Data collection shall include volume, occupancy, speed, and classification.

If co-location on an ITS pole or sign structure is not feasible for new MVRD units, a new ITS Pole of an appropriate height to allow for detection of all individual lanes of travel shall be used.

19.1.8 Travel Time Indicators

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19.1.9 DTD Automatic Traffic Recorders

The CDOT Division of Transportation Development (DTD) Automatic Traffic Recorder (ATR) stations continuously collect vehicle volume and functional classification data using in-pavement loops and piezoelectric sensors. Currently, there is one DTD ATR station at the following location within the Project limits:

- Mile point 256.09, Project Station 2819+00 (northbound and southbound, south of US 34)

19.1.9.1 Design Requirements

The Contractor shall design a replacement DTD ATR station for the location that is impacted by the Project. The DTD ATR must collect data for all lanes of travel, including the general purpose lanes and express lanes in both directions.

The existing DTD ATR cabinet shall remain in place and the existing in-pavement loops and piezoelectric sensors shall be replaced at the same mile point as the existing equipment.

Communications to the DTD ATR station shall be provided via a 12-strand SMFO lateral provided from the CDOT fiber optic backbone to the DTD ATR cabinet.

19.1.9.2 Material Requirements

The Contractor shall furnish all equipment necessary to achieve a fully-functioning DTD ATR system. The DTD ATR stations consist of loop detector wires and piezoelectric axle sensors.

19.1.10 Doppler Radar

Not required on this project.

19.1.11 Road Weather Information System

Road Weather Information Systems (RWIS) are used for traveler information systems and highway maintenance operations by providing on-site weather information. There is currently one RWIS operating within the Project limits at the following location:

- Northbound I-25, south of Crossroads Boulevard interchange

In addition, the Contractor shall design and construct a new non-intrusive RWIS at the following location:

- Mile point 265.85, Project Station 3330+00 (Cache La Poudre River bridge)

19.1.11.1 Design Requirements

The Contractor shall upgrade existing RWIS within the Project limits to meet the minimum requirements described herein. The new RWIS shall be designed to provide pavement condition data of the northbound and southbound I-25 bridges over Cache La Poudre River.

19.1.11.2 Material Requirements

The Contractor shall furnish all new RWIS equipment and any and all associated equipment necessary to achieve a fully-functioning system. All RWIS within the Project limits shall have a weather monitoring system including the following minimum requirements:

- Remote Processing Unit
- Precipitation Type Sensor
- Air Temperature/Relative Humidity Sensor

- Ultrasonic Wind Sensor
- Wireless Road Surface Sensor
- Non-Intrusive Pavement Condition Sensor
- CCTV camera
- Concrete Pad
- Cabinet

19.1.12 Variable Toll Message Signs

A Variable Toll Message Sign (VTMS) is a combination of a static sign with one or two electronic VMS inserts that are utilized to display the specific tolls for each segment of the project corridor. All mainline VTMS shall be located upstream of the express lane ingress/egress points. This will allow the roadway users sufficient time to read the toll rate and then make their decision whether to enter or exit the express lane(s).

19.1.12.1 Design Requirements

The Contractor shall design a complete VTMS system so that the following requirements are met:

- VTMS shall be provided prior to each express lane ingress/egress point on the mainline, and the VTMS shall be mounted overhead and visible to both express lane and general purpose lane users, including roadway users that have just entered the facility via on-ramps.
- Each VTMS in the northbound direction, between SH402 and SH392 shall have two VMS inserts capable of displaying the toll rates to the next two major destinations. Each VTMS in the same direction between SH392 and SH14 shall have one VMS insert.
- Each VTMS in the southbound direction, between SH14 and SH392 shall have two VMS inserts capable of displaying the toll rates to the next two major destinations. Each VTMS in the same direction between SH392 and SH402 shall have one VMS insert.
- All VTMS shall be mounted overhead.
- VTMS structures and structure foundations shall be designed to accommodate future larger signs that will be part of the Ultimate Configuration in the portion of the Project constructed to the FEIS alignment.

19.1.12.2 Material Requirements

The Contractor shall furnish all new VTMS signs and any and all associated equipment necessary to achieve a fully-functioning system. The VTMS signs shall be designed based on the following material requirements, at a minimum:

- The sign shall utilize LED displays,

- The signs shall be equipped with the ability to display a minimum of 7 characters, including the toll rate (the $ sign, the numerical value of toll rate, and decimal) or the word "CLOSED"; all with a character height of at least 18 inches,
- The VTMS shall have a minimum design life of 20 years,
- The VTMS cabinet shall be installed on a concrete foundation to the right of the travelled way and shoulder so that maintenance can be performed without the need for lane closures,
- The VTMS controller and sign must be NTCIP-compliant, provide an Ethernet interface, and must be compatible with the CDOT software, and
- UPS shall be provided for each VTMS to ensure that each sign is operational for 8 hours in the event of a power failure.

The Contractor shall purchase and install the UPS in the VTMS controller cabinet.

19.1.13 Toll Point

The Toll Points collect information from vehicles so that the users are appropriately charged for use of the express lanes. A toll point is defined as a single toll collection point for one direction of travel.

19.1.13.1 Design Requirements

Each toll point includes AVI readers/antennas, ALPR cameras, an ETC lane controller, and a UPS, as well as all associated pull boxes, conduit, cabinets, communications equipment, and power for one direction of travel. The Contractor shall be responsible for the design and installation of the ETC cabinet and associated foundation; the conduit to connect the ETC lane controller to the AVI antenna, in-pavement loops, and ALPR cameras; and providing communications and power to the cabinet. The ETC System Integrator will be responsible for the integration of Toll Points.

The Contractor shall install toll points within 1,000 feet of the following locations:

- Northbound and southbound I-25 at mile point 257.7 (Project Station 3474+00)
- Northbound and southbound I-25 at mile point 261.1 (Project Station 3654+00)
- Northbound and southbound I-25 at mile point 267.4 (Project Station 3985+00)

Revisions to these locations may be made if approved by CDOT and the ETC System Integrator. The Contractor shall consider environmental factors and utilities in determining exact toll point locations. The Contractor shall submit a single-lane toll point detail for Approval by CDOT as part of the Pre-RFC Review Documents. These details will be reviewed by both CDOT and the ETC System Integrator. Any toll point layout or configuration deviating from the existing configuration in use may be considered at CDOT's discretion, and should be designed in coordination with the manufacturer of the ETC equipment (3M). The Contractor shall include time in their schedule for the ETC System Integrator to perform testing to verify that any such proposed deviated toll point layout or configuration is able to perform in a manner equal to that of the existing configuration in use.

UPS shall be provided for each toll point to ensure that each ETC lane controller is operational for 8 hours in the event of a power failure. The Contractor shall purchase and install the UPS in a separate controller cabinet, as described in Project Special Provisions at the end of this Section.

All pavement joints within the vicinity of a toll point shall be coordinated with E-470.

19.1.14 Automatic Vehicle Identification Reader

An AVI reader and antennas shall be installed at each tolling point and used to read the tag information stored inside each transponder.

19.1.14.1 Design Requirements

The AVI reader shall be installed by the ETC System Integrator in the ETC lane controller cabinet, and the antennas that will read the tag information shall be mounted directly above the express lane. The Contractor shall be responsible for providing a structure at each tolling point (either dedicated or shared with another installation) to allow the ETC System Integrator to mount the AVI antennas in the correct positions. The Contractor shall be responsible for providing a design including cross sections for each of these structures at the toll points as part of the Pre-RFC Review Documents.

The AVI reader that is anticipated to be utilized by the ETC System Integrator is the Sirit Model 6204. Each tolling point will require a structure upon which two antennas (approximately 4 feet wide each), per direction, per express lane, can be mounted 18.5 feet above each express lane. The AVI antenna shall be mounted on a 2-inch diameter pole spanning the express lane, allowing a minimum of 6-inches of clearance between the pole and the bottom of the structure for angling and installation of the supporting hardware. The Contractor shall coordinate with the ETC System Integrator to ensure that the proper civil infrastructure and structural attachments are provided at each AVI antenna installation location. All other antennas or readers shall be mounted a minimum of 1,000 feet away from each AVI reader.

In addition to the structure and mounting brackets, the Contractor shall also provide two 2-inch conduits between the ETC lane controller cabinet and the base of the overhead structure supporting the AVI antenna. All cabling shall be installed internal to the structure, and the contractor shall provide 1.5-inch liquid-tight flexible metal conduit from the penetration in the overhead sign structure to the bottom of the bracket where the AVI antenna is mounted. Communications to the AVI antenna shall be provided by coaxial cable installed by the ETC System Integrator. The Contractor shall ensure that the ETC cabinet and the structures used to support the AVI antenna equipment are located such that the maximum coaxial cable length does not exceed 175 feet.

19.1.14.2 Material Requirements

The Contractor shall be responsible for providing a bracket upon which the ETC System Integrator can mount the AVI antenna. The exact type of bracket will depend on the type of structure that the AVI antenna shall be mounted on. The Contractor shall coordinate with the ETC System Integrator and CDOT to determine the type, number, sizing, and placement of brackets that shall be necessary.

19.1.15 Automatic License Plate Recognition Cameras

The ALPR cameras shall be used to obtain an image of the vehicle's license plate if a transponder is not detected. In-pavement loops shall be used to signal to the ALPR camera that a vehicle is present. Once the image is taken, the Optical Character Recognition (OCR) system inside the camera unit (or the ETC lane controller) will process the image to identify the vehicle's license plate. This information will then be

sent to the ETC lane controller. Tolling points require both front-shot and rear-shot cameras, necessitating separate mounting locations.

19.1.15.1 Design Requirements

For the single-lane toll point locations, the ALPR cameras shall be mounted by the ETC System Integrator on break-away sign supports on the concrete median barrier. The Contractor shall provide these sign supports at the locations determined by the ETC System Integrator. It is anticipated that two ALPR supports will be needed at each tolling point. The Contractor shall also provide two 1-inch conduits between the median pull box and the base of the ALPR camera supports, temporarily capped at the top of the concrete barrier.

Communications cabling to the ALPR cameras shall be provided and installed by the ETC System Integrator.

In-pavement loops shall be saw cut into each express lane by the ETC System Integrator. The Contractor shall provide the necessary conduit for the loop installation. The location and quantity of the conduit to be installed by the Contractor shall be coordinated with the ETC System Integrator. The pavement surface temperature must be dry and at least 50 degrees (and not falling) in order for the ETC System Integrator to properly install the in-pavement loop sealant. As a result, the Contractor shall coordinate with the ETC System Integrator to ensure the Baseline Schedule reflects this temperature restriction.

19.1.15.2 Material Requirements

The Contractor shall design the support system for the ALPR cameras at single-lane toll points to meet the following material requirements:

- The break-away sign supports used to mount the ALPR cameras shall be CDOT Standard S-614-21 slipbase barrier stub mounted on the concrete median barrier.

- Each support shall include mounting brackets and hardware to allow for the installation of the ALPR cameras and a cap for the top of the post.

19.1.16 ETC Lane Controller

The ETC lane controller shall be located in a cabinet on the outside shoulder and shall be connected to the rest of the electronic tolling equipment via conduit system. The ETC lane controller will be used for all data processing and transmittal of transponder tag and license plate information via the fiber optic communications network to the ETC back-office for processing through the POE Node building, which is located on the west side of I-25 at Mile Post 266.10.

19.1.16.1 Design Requirements

Although the ETC System Integrator shall be responsible for the installation and configuration of the ETC lane controller, the Contractor shall be responsible for the design of the ETC lane controller cabinet and associated foundation; the conduit to connect the ETC lane controller to the AVI antenna, and ALPR cameras; and the conduit to provide communications and power to the cabinet. When an eastbound and westbound toll point are collocated along the corridor, only one ETC lane controller cabinet will be required for both toll points. The locations of the cabinets, foundations, and conduits shall be coordinated with and approved by the ETC System Integrator; however, the maximum conduit length between the

ETC lane controller and the ETC devices (AVI antennas and ALPR cameras) shall be such that the maximum device cable length does not exceed 175 feet.

19.1.16.2 Material Requirements

The Contractor shall have the following responsibilities at each tolling point where an ETC lane controller is required:

- Furnish and install a NEMA Type 3R rated Type M Stretch cabinet with a minimum size of 68 inches high x 31 inches wide x 19 inches deep. Cabinets shall have a backplane with dimensions of 25 inches (width) by 54 inches (height), mounted on fixed bolts.
- Provide a 12-strand SMFO fiber optic communications lateral between the cabinet and the CDOT fiber optic backbone. The fiber optic lateral shall terminate at a patch panel that shall be installed inside the communications cabinet and be labeled before ETC installation.
- Provide power to the cabinet to power the ETC lane controller and all associated equipment.
- Contractor shall deliver tolling cabinet backplane, DIN rail, and circuit breakers to ETC System Integrator.

19.1.17 Pull Boxes and Manholes

19.1.17.1 Design Requirements

The Contractor's design shall utilize fiberglass reinforced, polymer concrete pull boxes and pre-cast concrete manholes as described in Project Special Provisions at the end of this Section. All fiber optic splicing of ITS devices shall be performed in manholes; no fiber optic splicing shall be performed in pull boxes. Pull box and manhole spacing shall be as follows:

- CDOT manholes shall be spaced a maximum of 1.5 miles apart and clustered in a group in common areas to accommodate future utility locates. A manhole shall be located at each splice point.
- A pull box or manhole shall be installed every 1200 feet and at every ITS device location as described in this Section.
- Between manholes, pull boxes shall be spaced no more than 1200 feet.

The Contractor may reuse existing CDOT ITS pull boxes and manholes if they meet all the requirements for the Project. The Contractor may add equipment such as racking or ladders in order to upgrade existing CDOT ITS pull boxes and manholes to meet the requirements for the Project.

19.1.17.2 Material Requirements

All pull boxes and manholes shall be consistent with the requirements outlined in Project Special Provisions at the end of this Section. Communications pull boxes shall be 24 inches x 36 inches x 24 inches or larger, as required. Electrical pull boxes shall be 11 inches x 18 inches x 12 inches.

19.1.18 ITS Device Cabinets

The Contractor's design shall utilize 332D cabinets at all VTMS and VMS locations. The Contractor's design shall utilize pole-mounted Type 2 cabinets at all CCTV lowering device locations and sign structure locations where a new cabinet is required without a VTMS or VMS. At all other ITS device locations requiring a new cabinet, Type 2 ground-mounted cabinets shall be used. At RMS locations, the existing ground-mounted cabinets that are affected by the Project shall be reset.

19.1.19 Cabling and Conductors

The Contractor shall design conductors and cables utilizing a minimum of #12 AWG for all electrical conductors. All video-device control cables and connectors shall be designed in accordance with the manufacturer's recommendation and the CCTV manufacturer's signal attenuation requirements.

19.1.20 Conduit

19.1.20.1 Design Requirements

The Contractor shall design new and separate conduit systems (including all hardware, fasteners, and accessories) for communication and power control systems, where necessary. Existing conduit may be reused where it is not impacted by the Project. Conduits shall not exceed the NEC fill ratio requirements.

The following conduit colors shall be used so that the contents can be easily identified:

19.1.20.1.1 Backbone Conduit

Longitudinal conduits for the communications network shall be installed within the ROW and as close to the ROW Line as practical. The mainline communications run shall contain three 2-inch conduits (one red, one green, one blue colored conduit) for the CDOT backbone.

19.1.20.1.2 Lateral Conduit

When a lateral is installed within the backbone duct bank, an additional conduit shall be installed for the lateral.

- Terra Cotta: one 2-inch lateral conduits
- Black with Red Stripes: one 2-inch CDOT power conduit

Any additional power conduits required by the Contractor shall be a different color than backbone or lateral conduits.

19.1.20.2 Material Requirements

All conduits shall meet CDOT specifications. The conduit shall be factory lubricated, low friction, high-density conduit constructed of virgin Schedule 80 high-density polyethylene resin. Conduit shall be capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation, without affecting its properties or performance.

Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel or cylindrical wire brush and blown out with compressed air. The Contractor shall provide an Existing

Conduit Conditions Report showing the results of their cleaning and investigation work for all existing conduit to be utilized on the project. The report shall also provide a proposed method for repairing any damaged conduit segments, which must be reviewed and accepted by CDOT prior to commencing repair work. All segments of the existing conduit shall be repaired by the Contractor.

19.1.21 Dedicated Short Range Communications Radios

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19.1.22 Port of Entry Clearance System

19.1.22.1 Design Requirements

The Contractor shall prepare a design to replace POE Weigh In Motion (WIM) and electronic clearance system in the northbound and southbound direction of I-25 at the POE Weigh Station. The Contractor's design shall include new WIM load cell scales, pavement sensors, loops, antenna, wiring, mast arms, controller, and required conduits.

The Contractor shall be responsible for furnishing and installing all devices and the supporting infrastructure that is necessary to install and operate the POE WIM and electronic clearance system components, and for connecting them to the existing POE local communications network. The Contractor shall submit product sheets for all devices and materials to CDOT for Acceptance prior to installation.

The Contractor shall be responsible for all coordination with the existing POE, and designing and phasing temporary and permanent traffic configurations so that all POE systems are operational at all times during construction, with the following exceptions:

- The POE Open/Closed signs shall not be inoperable for longer than 1 hour at any time.
- The POE electronic clearance system (PrePass) shall not be inoperable for longer than 8 hours at any time.
- The POE WIM Stations shall not be inoperable for longer than 7 consecutive days at any time.

Any closure of any system for a period of time greater than 1 hour shall require 2-weeks advance notice to the POE. Closures of any system for less than 1 hour shall require 1 day advance notice to the POE. No closures of any systems shall be allowed in both NB and SB directions simultaneously.

19.1.22.2 Material Requirements

The Contractor shall furnish new WIM equipment including:

- Weigh In Motion Station (Type III)
- Electronic clearance system.

19.2 Construction Requirements

The Contractor shall be responsible for furnishing and installing all ITS devices, the communications network, and the supporting infrastructure that is necessary to install and operate the ETC system

components. The Contractor shall submit product sheets for all ITS devices and materials prior to installation for Acceptance by CDOT.

The Contractor shall notify CDOT upon installation or reinstallation of each ITS device and complete and submit a CDOT data sheet. The Contractor shall be responsible for the integration of all ITS devices back to the CTMC. CDOT ITS shall be responsible for modifying the CTMS and Camera Cameleon software to incorporate the new devices.

Due to the risk of obsolescence, equipment should not be purchased or ordered more than six months prior to the installation date for any piece of equipment without prior written Acceptance by CDOT.

Refer to Project Special Provisions at the end of this Section for construction requirements in addition to those described in the following Sections. Refer to the Testing and Integration Plan included in the Reference Documents for testing requirements.

19.2.1 Electrical Power

The Contractor shall coordinate with the power service provider for installation or relocation of power service. The Contractor shall also be responsible for all costs of installing or relocating power sources, including involvement with the power service provider at locations for new services throughout the Project. The Contractor shall be responsible for all ongoing monthly electricity costs of all new services installed under this Project until Final Acceptance. CDOT will be responsible for ongoing electricity costs of existing ITS equipment. The Contractor shall ensure the transition and reassignment of electrical service with the appropriate CDOT office so that there is no disruption in service.

19.2.2 Location and Protection of ITS and ETC Elements

The Contractor shall be responsible for locating all underground existing facilities to avoid or minimize conflicts with these facilities. If any facilities are damaged during construction, the Contractor shall be responsible for all repairs.

The Contractor shall install a grounding system and protection devices that are suitable for each specific ITS and ETC element.

19.2.3 Communications System

The Contractor shall furnish and install the fiber optic communications system and connect all ITS and ETC field elements to the system. Prior to performing any work that may impact existing ITS communications systems, the Contractor shall coordinate with CDOT ITS.

The Contractor shall submit all network equipment cut sheets to CDOT for Acceptance. This submittal shall include, but not be limited to, the following project network equipment items:

- Ethernet Switches: Ciena 3930, Ciena 3931 (including mounting brackets and hardware), and Ciena 5160
- 1310nm Wavelength Small Form-Factor Pluggable Optic Modules
- Fiber Optic Attenuators
- All Network Licensing and Warranty Documentation

- Fiber Optic Splice Closures
- All materials associated with the above items for the installation of the Ethernet optical network

The Contractor shall have Ciena-certified personnel configure all of the Ethernet switches installed by the Project. The Contractor shall submit a configuration plan to CDOT for Approval.

The network equipment as part of this project requires both the Contractor's Ciena-certified configuration specialist and Ciena technical network representatives to jointly configure each individual Ethernet switch, in addition to the configuration of the project network into the Colorado Transportation Management Center (CTMC) statewide intelligent transportation optical network. The Contractor shall provide, as part of the configuration plan, all required information to the CTMC for the Ethernet switches. This includes, but is not limited to, the highway mile point of the Ethernet switch, the Project stationing of the Ethernet switch, and the devices to which the Ethernet switch is connected.

19.2.4 Variable Message Signs

The Contractor shall be fully responsible for protecting the existing I-25 VMS during construction, including but not limited to transportation and installation of the sign as required for resets. The Contractor shall carry out all reinstallation and field-testing of each relocated unit. Any existing VMS that are not reused shall be salvaged and returned to CDOT ITS.

The Contractor shall be fully responsible for furnishing and installing all new VMS signs to the installation site and all damages that occur in the installation and delivery process. The VMS shall be installed in accordance with manufacturer's recommendations. A qualified factory representative shall be available on site to ensure proper installation and testing.

Each VMS system shall be connected to the communication system using fiber optic laterals extended into the VMS controller cabinet. The Contractor shall notify CDOT ITS using the "ITS Offline Device Notification Form".

19.2.5 Closed Circuit Television

The Contractor shall furnish all new CCTV cameras and carry out all installation or resetting, field-testing, burn-in of the system, and connection of each device to the communication system using fiber optic laterals. Existing CCTV cameras may be reused as long as they meet the appropriate material requirements outlined herein. Any existing CCTV cameras that are not reused shall be salvaged and returned to CDOT ITS.

At a minimum, the Contractor shall maintain existing CCTV coverage during construction.

19.2.6 Ramp Meter Stations

The Contractor shall furnish all RMS-related equipment and carry out all installation, field-testing, and burn-in of the system. Existing RMS equipment may be reused as long as it meets the appropriate material requirements outlined herein. Any existing RMS equipment that is not reused shall be salvaged and returned to CDOT ITS.

In-pavement detector loops installed in new asphalt pavement shall be installed prior to the final lift of asphalt.

Each RMS system shall be connected to the communications system using fiber optic laterals.

19.2.7 Microwave Vehicle Radar Detectors

The Contractor shall furnish all new MVRD and carry out all installation or resetting, field-testing, and burn-in of the system per the manufacturer's recommendations and CDOT standards. Each device shall be connected to the communication system using fiber optic laterals. Existing MVRD units may be reused as long as they meet the appropriate material requirements outlined herein. Any existing MVRD units that are not reused shall be salvaged and returned to CDOT ITS.

19.2.8 Travel Time Indicators

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19.2.9 DTD Automatic Traffic Recorders

The Contractor shall furnish all DTD ATR-related equipment and carry out all installation, field-testing, and burn-in of all DTD ATR counting stations that are affected by the Project. All work shall be inspected by the Traffic Data Collection Unit (TDC) during installation. The Contractor shall test and operate the piezos and loops under actual traffic conditions.

In-pavement detector loops installed in new asphalt pavement shall be installed prior to the final lift of asphalt.

In order to maintain DTD ATR functionality during construction, the Contractor shall set up a temporary DTD ATR site utilizing a Wavetronix SmartSensor HD126 side-fire radar unit. A CDMA wireless modem shall be used for communications from the DTD central system to the field ATR. DTD will provide Phoenix Traffic Counter(s) for use at these temporary locations.

19.2.10 Doppler Radar

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19.2.11 Road Weather Information System

The Contractor shall furnish all RWIS-related equipment and carry out all installation, field-testing, and burn-in of all RWIS that are affected by the Project. Each device shall be connected to the communication system using fiber optic laterals. Existing RWIS equipment and cabinet may be reused as long as it meets the appropriate material requirements outlined herein. Any existing RWIS equipment that is not reused shall be salvaged and returned to CDOT ITS.

19.2.12 Variable Toll Message Signs

The Contractor shall be fully responsible for furnishing and transportation of all VTMS to the installation site and all damages that occur in the installation and delivery process. The VTMS shall be installed in accordance with manufacturer's recommendations. A qualified factory representative shall be available on site to ensure proper installation and testing.

19.2.13 Pull Boxes and Manholes

The Contractor shall furnish and install all pull boxes and manholes based on the Project Special Provisions at the end of this Section. Each location shall be easily accessible for maintenance purposes. Pull boxes and manholes shall not be placed in a known flood-prone area or drainage ditch. A fiber optic cable label shall be attached to each fiber optic cable located within a pull box or manhole. All fiber optic cable splices inside manholes shall be housed in a splice closure.

The Contractor shall clean out all existing CDOT ITS pull boxes that are reused as part of the Project by draining any water and removing any built up sediment down to the pea gravel. The Contractor shall clean out all existing CDOT ITS manholes that are reused as part of the Project by excavating one foot below the sump and refilling to sump depth with pea gravel

19.2.14 Salvaging of Materials

The Contractor shall salvage all existing ITS elements that are affected by the Project but are not reused. Salvaged equipment shall be returned to CDOT. Existing fiber cable, pull boxes, and manholes that are not reused shall be disposed of by the Contractor.

19.2.15 Cabling and Conductors

All cables shall be installed per the manufacturer requirements for each device or the requirements found in the Project Special Provisions at the end of this Section. The maximum conduit fill ratio for both new and existing conduits shall be in accordance with the NEC, latest version.

19.2.16 Conduit

For bores that contain more than one conduit, the conduit shall be bundled together and contained in a single bore.

Refer to the Project Special Provisions at the end of this Section for detailed construction requirements for all conduit installations.

19.2.17 Dedicated Short Range Communications Radios

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19.2.18 Weigh In Motion Equipment

The Contractor shall furnish all WIM Equipment and carry out all installation, field-testing, and calibration per the manufacturer's recommendations and CDOT standards. Each device shall be connected to the existing POE communication.

19.2.19 Testing and Integration

Testing and Integration shall be performed for all fiber optic cable, as well as new devices, reset devices, and existing devices connected to the fiber optic backbone according to all requirements outlined in the Testing and Integration Plan included in the Reference Documents. Testing shall demonstrate that all devices operate per the manufacturer's specifications, as well as any additional requirements outlined in this document and the Project Special Provisions at the end of this Section.

19.2.20 Maintenance Period

The Contractor shall maintain the CDOT equipment and communications infrastructure the Contractor installs for a period of one year after Final Project Acceptance.

For the duration of the 1-year maintenance period, the Contractor shall appoint a contact qualified in installing, maintaining, troubleshooting, and repairing the ITS equipment and communications infrastructure. That person's credentials shall be submitted to CDOT for Approval.

The Contractor shall repair any malfunctioning or damaged devices and equipment within 24 hours of being notified of the problem by CDOT, with the exception of backbone communication and VTMS failures, which shall be repaired and restored within four hours of being notified of the problem by CDOT. The Contractor shall furnish all devices, equipment, and materials necessary to complete the repairs. If the devices and equipment are not repaired within the specified timeframe, CDOT will mobilize maintenance forces to fix the problem(s). The costs associated with such mobilization, labor, and equipment will be calculated and deducted from project retainage owed to the Contractor.

19.2.21 Training and Documentation

The Contractor shall provide CDOT personnel with instruction in the operation and maintenance of the hardware and software associated with the ITS equipment and infrastructure. The Contractor shall also provide training materials and documentation for all ITS equipment.

19.3 ETC System Coordination

E-470 will be responsible for installing and integrating all ETC equipment at each toll point. E- 470 will also be responsible for lane testing of the ETC equipment. The Contractor shall be responsible for providing traffic control when requested by the ETC System Integrator, including lane closures for ETC equipment installation.

19.3.1 Prerequisites for E-470 Integration

Prior to E-470's work to install and integrate all ETC equipment at each tolling location, the following conditions must be met:

- Cabinet backplane has been provided to the ETC System Integrator at least one month prior to tolling location installation.
- Barrier or guardrail has been installed (as needed).
- Tolling and UPS cabinets and pull boxes have been installed.
- Loop wire conduits have been installed.
- Final pavement has been placed where loops will be installed.
- Camera supports have been installed.
- Overhead structure and mounting brackets have been installed.

- Pull tape has been installed in all conduit runs from the ETC cabinet to the device locations.
- Permanent power and communications connections have been completed.
- The Contractor has performed all fiber and power testing to the toll locations, utilizing the testing procedures described herein to confirm functionality of the toll cabinets and lateral fiber.
- All debris has been removed from the site and the lanes have been swept to prepare for loop installation.
- Traffic management plans have been reviewed with the ETC System Integrator personnel.
- The express lanes shall be closed to allow for the ETC System Integrator to perform installation, mapping, and testing.
- Photos shall be sent to the ETC System Integrator for their review of readiness.
- A walkthrough shall be scheduled with the ETC System Integrator to verify the location is ready for installation and integration of ETC equipment.

Prior to E-470's work for lane testing of the ETC equipment, the following conditions must be met:

- E-470's work to install and integrate all ETC equipment, described above, must be complete.
- Traffic must travel through the final alignment of the toll point being tested. This can be accomplished through use of temporary traffic control.
- 12,000 vehicles must travel through the toll point over a minimum of a 24-hour period to account for a mix of traffic during both day and night.

Prior to E-470's final acceptance testing of the ETC equipment, traffic must be traveling through the final alignment for all toll points and final striping must be in place. See the E-470 Project Plan Requirements for Lane Installations included in the Reference Documents for more information.

19.3.2 Scheduling Requirements

E-470 requires at least two weeks of unrestricted access during favorable weather conditions at each tolling location to install and integrate the ETC equipment. Work at multiple toll points must be performed sequentially, not concurrently. The Contractor shall incorporate time for this requirement to be met at all toll points into the Baseline Schedule; if E-470 completes their work within two weeks at each toll point, no time extensions or schedule allowances will be granted to the Contractor. Once E-470 has installed the ETC equipment at a toll point, a preliminary inspection shall be performed by CDOT.

E-470 requires at least one week to conduct the lane test at each toll point and work at multiple toll points must be performed sequentially, not concurrently. The Contractor shall incorporate time for this requirement to be met at all toll points into the Baseline Schedule; if E-470 completes their lane tests within one week at each toll point, no time extensions or schedule allowances will be granted to the Contractor.

In addition, the ETC System Integrator requires testing and evaluation under normal traffic patterns to perform final acceptance testing for assurance that the ETC back-office system is functioning correctly.

Final acceptance testing shall run for a period not to exceed 70 business days from the date that the last tolling point lane acceptance testing is completed (i.e. 12,000 vehicle test) and be under normal traffic pattern data for all of the installed tolling points concurrently. Traffic must be provided in the express lane during this final acceptance testing period. However, lane closures could be possible for any additional work required as a result of the acceptance testing. Additionally, the Contractor shall provide advance notice to E-470 of any lane closures or other impacts to traffic through the toll points during the final acceptance testing period. The Contractor shall incorporate this final acceptance testing period into the Baseline Schedule; if E-470 completes their work within the 70-business day timeframe, no time extensions or schedule allowances will be granted to the Contractor.

See the E-470 Flow Chart included in the Reference Documents for more information on the ETC System Integrator's general process.

19.4 Deliverables

The Contractor shall submit the following to CDOT for Approval or Acceptance:

Table 19-1 Deliverables

Deliverable	Review, Acceptance, or Approval	Schedule
List of milestone dates for Tolling/ITS, including when Deliverables will be submitted	Acceptance	To be included with the Baseline Schedule
CCTV Coverage Plan	Approval	Concurrent with The Preliminary Design Plans (30%) Submittal
Preliminary ITS/ETC Design Plans	Acceptance	Concurrent with The Preliminary Design Plans (30%) Submittal
Temporary Communications and Device Plan	Approval	4 weeks prior to any temporary installations
Existing Conduit Conditions Report	Acceptance	4 weeks prior to conduit repair work
Network and Wiring Diagrams	Approval	Concurrent with The Pre-RFC Review Documents and Final RFC Documents Submittals
ITS and Toll Point Details	Approval	Concurrent with The Pre-RFC Review Documents and Final RFC Documents Submittals
Structural Design for VMS Structures and Toll Point Structures	Approval	Concurrent with The Pre-RFC Review Documents and Final RFC Documents Submittals
Cross Sections for CCTV Locations	Approval	Concurrent with The Pre-RFC Review Documents and Final RFC Documents Submittals
ITS/ETC Design Plans	Review/ Acceptance	As Part of The Preliminary Design Plans (30%) Submittal, Pre-RFC Review Documents, and Final RFC Documents Submittals
Fiber Allocations and Splicing Diagrams	Approval	4 weeks prior to splicing
Method Statement and Cutover Plan	Approval	4 weeks prior to splicing
Supporting reports and design calculations including electrical calculations	Review/ Approval	Concurrent with The Pre-RFC Review Documents and Final RFC Documents Submittals
Detailed ITS construction schedule	Approval	4 weeks prior to any ITS construction, including underground conduit and pull box infrastructure
Trenching and Boring Plan	Approval	1 week prior to any trenching or boring
Network Equipment Cut Sheets	Acceptance	Prior to ordering
ITS infrastructure product sheets and certifications	Acceptance	Prior to ordering and installation

Deliverable	Review, Acceptance, or Approval	Schedule
Ciena Configuration Plan	Approval	4 weeks prior to Ciena configuration
Acceptance Test Procedures for VTMS and VMS	Acceptance	5 weeks prior to testing and integration
Testing Plan for the Network Design	Approval	5 weeks prior to testing and integration
Testing results	Acceptance	Within 5 business days after test period of each component
CDOT device data sheets	Acceptance	4 weeks prior to device integration
Maintenance Period Contact's Credentials	Approval	4 weeks prior to start of Maintenance Period
ITS equipment training, manuals, and associated documentation	Acceptance	Prior to Final Acceptance
As-built CAD documentation	Acceptance	Prior to Final Acceptance
Inspection and design records certifying reuse of existing VMS Cabinets	Review/Acceptance	As Part of The Preliminary Design Plans (30%), Pre-RFC Review Documents, and Final RFC Documents Submittals

The Contractor shall address all major aspects of this Work, including for individual construction areas/phases and stages, in the Traffic Management Plan (TMP), Traffic Control Plans (TCP), and Methods of Handling Traffic (MHTs) according to Section 16 – Maintenance of Traffic.

Review by CDOT of the deliverables does not extend to accuracy of dimensions, means, methods, techniques, sequences, schemes, procedures of construction, or to safety precautions. Review does not relieve the Contractor of the responsibility for the correctness of their work.

19.5 Project Special Provisions

The following Project Special Provisions shall be applicable to the Project.

This Section sets forth modifications to the CDOT *Standard Specifications* for design-build projects. The first section contains revisions to Division 100 of the *Standard Specifications*. The second section contains revisions to Divisions 200 through 700 of the CDOT *Standard Specifications*, as well as Standard Special Provisions applicable to the Project.

These Contract Provisions are a revised version of the CDOT *Standard Specifications* and contain requirements generally applicable to the Work to be performed by the Contractor. In certain cases, provisions in Section 100 of the CDOT *Standard Specifications* have been superseded by other provisions of the Contract Documents. For ease of reference, this document uses the same Section numbers as the Standard Specifications for Road and Bridge Construction, and identifies provisions of the Contract Documents that have replaced or modified the standard clauses.

All references to "Engineer" that are incorporated into this Section refer to the Contractor's Engineer, unless the context requires otherwise. Non-capitalized terms, such as "work" that are defined in Book 1, Exhibit A, shall have the meanings defined therein unless the context requires otherwise. References to "approve, approval or approved" shall mean "Approve, Approval or Approved" as defined in Book 1,

Exhibit A, when the approval is by CDOT or a division of CDOT. If the interpretation(s) pursuant to this paragraph are not clear, CDOT shall decide, in its sole discretion, how these terms shall be interpreted.

When these specifications describe actions, materials, means or methods that are required and that are qualified by phrases such as: “as directed by the Engineer”, “when directed by the Engineer”, “as determined by the Engineer”, “with or without permission of the Engineer”, “in the opinion of the Engineer”, “unless authorized by the Engineer”, “satisfactory to the Engineer”, “as approved by the Engineer”, or “unless another type is specified or is permitted with approval of the Engineer”, such phrases shall be disregarded. If it is not clear whether a phrase should be disregarded, CDOT will make that decision in its sole discretion.

When these specifications refer to “ Department”, ”Resident Engineer”, “Agricultural Engineer”, “Bridge, Construction or Maintenance Engineer”, “TMC system inspector”, “Concrete Engineer”, “Project Engineer”, “Materials Engineer”, “Commissioner”, “Structural Metals Engineer”, “Department’s Lighting Engineer”, “Geotechnical Engineer” or any other specific CDOT special engineer, such reference shall mean the CDOT Project Director.

When these specifications use the term engineer relating to the approval of any activities involving the use of explosives, such term shall mean the CDOT Project Director.

When an approval or authorization of the Engineer or CDOT is required in these specifications for the use of alternative or substituted processes or components, the Engineer shall mean CDOT. If it is not clear whether a phrase involves the use of alternative or substituted processes, CDOT will make that determination in its sole discretion.

If these specifications refer to an approval of any correction or repair that deviates from the Contract requirements, the approval must be by CDOT. If it is not clear whether a specification involves a correction or repair that deviates from the Contract requirements, CDOT will make that determination in its sole discretion.

When these specifications provide that reports, records or other documents shall be submitted to CDOT or to the Engineer, such reports shall be made available to CDOT and do not have to be submitted unless either they are otherwise listed in the deliverables in the Contract Documents, or are required shop drawings, warranties, parts lists, instruction sheets or manufacturer’s drawings or specifications. Such documents shall be submitted to CDOT as required by the specifications.

When these specifications require actions, materials, means or methods that are “either as indicated in the Plans or as designated by the Engineer,” the Contractor shall disregard the phrase “or as designated by the Engineer.”

When these specifications refer to the “Engineer” ordering work beyond the scope of work in the Contract, “Engineer” shall mean CDOT. Whenever in these specifications the Engineer may order work that results in additional costs to CDOT, the “Engineer” shall mean CDOT.

Any acceptances on behalf of CDOT or the State shall be performed by CDOT.

Any references to other standards, codes, or criteria, or to the latest version of other standards, codes, or criteria in Book 2 of the Contract Documents shall mean the latest version at the Proposal Due Date.

Project Special Provisions for ITS and ETC Elements

The CDOT 2011 *Standard Specifications for Road and Bridge Construction* controls construction of this Project. The following special provisions supplement or modify the *Standard Specifications* and take precedence over the *Standard Specifications* and plans.

Revision of Section 202 – Removal of Closed Circuit Television Pole
Revision of Section 202 – Removal of ITS Devices
Revision of Section 202 – Removal of Pull Box
Revision of Section 202 – Removal of Manhole
Revision of Section 210 – Reset CCTV Cameras
Revision of Section 210 – Reset Microwave Vehicle Radar Detector (MVRD)
Revision of Section 210 – Reset Variable Message Sign
Revision of Section 604 – Manhole (Traffic Management System)
Revision of Section 612 – Location Markers
Revision of Section 613 – Electrical Conduit (Liquidtight Flexible Metal)
Revision of Section 613 – ITS Electrical Conduit
Revision of Section 613 – ITS Pull Boxes
Revision of Section 614 – Automatic Traffic Recording Station
Revision of Section 614 – Buffer Tube Fan-out Kit
Revision of Section 614 – Breakaway Tapered ITS Steel Pole
Revision of Section 614 – Closed Circuit Television Camera
Revision of Section 614 – Closed Circuit Television Pole with Lowering Device
Revision of Section 614 – Coarse Wavelength Division Multiplexing Module
Revision of Section 614 – Coarse Wavelength Division Multiplexing SFP
Revision of Section 614 – Communications Cabinet
Revision of Section 614 – Communications Cabinet (Type 2)
Revision of Section 614 – Controller Cabinet Foundation
Revision of Section 614 – Disincentive for ITS Offline Devices
Revision of Section 614 – Ethernet Router (5160)
Revision of Section 614 – Ethernet Switch (3930)
Revision of Section 614 – Ethernet Switch (3931)
Revision of Section 614 – Fiber Optic Cable (Single Mode)
Revision of Section 614 – Fiber Optic Pre-Connectorized Cable
Revision of Section 614 – Fiber Optic Splice Closure
Revision of Section 614 – Fiber Optic Termination Panel
Revision of Section 614 – Global Positioning System (GPS)
Revision of Section 614 – Grounding and Bonding
Revision of Section 614 – ITS System As Built Documentation
Revision of Section 614 – Microwave Vehicle Radar Detection (334)
Revision of Section 614 – Microwave Vehicle Radar Detection (Non-334)
Revision of Section 614 – Optical Attenuator
Revision of Section 614 – Optical Transceiver
Revision of Section 614 – Serial to IP Converter
Revision of Section 614 – Single Wavelength Coarse Wavelength Division Multiplexing (CWDM) Optical Filter
Revision of Section 614 – Small Form-Factor Pluggable – SFP
Revision of Section 614 – Test Fiber Optic Cable
Revision of Section 614 – Uninterrupted Power Supply
Revision of Section 614 – Variable Message Sign (LED) (Overhead)
Revision of Section 614 – Variable Toll Message Sign (VTMS)
Revision of Section 614 – Weather Monitoring System

REVISION OF SECTION 202
REMOVAL OF CLOSED CIRCUIT TELEVISION POLE

Section 202 of the Standard Specifications is hereby revised to include the following:

DESCRIPTION

This work consists of removing and disposing of existing Closed Circuit Television (CCTV) poles and related materials.

CONSTRUCTION REQUIREMENTS

CCTV camera poles designated to be removed shall be removed along with any associated hardware, conduit, cabling, and other equipment.

The foundation shall be removed to a depth of 1 foot below natural ground surface, or as necessary to accommodate the proposed construction. Waste material shall be removed and the remaining foundation shall be backfilled with native material.

REVISION OF SECTION 202
REMOVAL OF ITS DEVICES

Section 202 of the Standard Specifications is hereby revised to include the following:

DESCRIPTION

This work consists of removing ITS devices, cabinets, communications equipment, and related materials, and salvaging them to CDOT ITS staff at the CTMC (425 C Corporate Circle, Golden, CO 80401).

CONSTRUCTION REQUIREMENTS

ITS devices designated to be removed shall be removed along with communications equipment, cabinets, mounting hardware and brackets, conduit, cabling and electrical equipment.

All ITS devices shall be carefully removed and delivered to CDOT ITS staff at the CTMC in Golden, CO.

For ITS devices designated for removal that are being replaced with new ITS devices, the Contractor shall have the new ITS device in place before the existing ITS device is taken out of service. Downtime for transition from old ITS device to new ITS device shall be limited to the period of time set forth in Revision of Section 614 – Disincentive for ITS Offline Devices.

REVISION OF SECTION 202
REMOVAL OF PULL BOX

Section 202 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

This work consists of the removal and disposal of pull boxes.

CONSTRUCTION REQUIREMENTS

The Contractor shall remove and dispose of all pull boxes which are identified as such on the project.

Removal of Pull Box shall include removal of pull box, concrete collars, any backfill necessary to match grade, and other incidental materials. At locations where the pull boxes are being replaced or the existing cabling and materials within the pull box are not being abandoned, Contractor shall take appropriate precautions and exercise care to avoid damaging any existing cabling and equipment within the pull box.

REVISION OF SECTION 202
REMOVAL OF MANHOLE

Section 202 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

This work consists of the removal and disposal of manholes.

CONSTRUCTION REQUIREMENTS

The contractor shall remove and dispose of all manholes which are identified as such on the project.

Removal of Manhole shall include removal of manhole, cover, frame, adapter, concrete collars, any backfill necessary to match grade, and other incidental materials comprising such item.

REVISION OF SECTION 210
RESET CCTV CAMERAS

Section 210 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

This work consists of resetting Closed Circuit Television (CCTV) cameras and related materials. All CCTV cameras to be reset shall be carefully removed, stored, and reinstalled in a manner that avoids loss or damage. All infrastructure shall be in place for the reset CCTV location before the existing CCTV is taken out of service.

MATERIALS

The Contractor shall reset the existing CCTV camera and related materials. Any new electrical and communications conduit, cabling and equipment necessary to restore the CCTV service at the new location shall be provided as part of this work.

CONSTRUCTION REQUIREMENTS

CCTV cameras designated to be reset shall be relocated along with communications and electrical equipment. Any new electrical and communications equipment necessary to restore the CCTV service at the new location shall be installed. Equipment and materials shall be cleaned prior to being reset. Contractor shall verify CCTV functionality prior to reset.

Downtime shall be limited to the time periods set forth in the Cutover specification. The Contractor shall coordinate this work with Jill Scott at CDOT ITS at (303) 512-5805.

The CCTV camera shall be installed in accordance with these specifications and in accordance with manufacturer's recommendations.

See project specific Testing & Integration Plan for additional requirements for reset CCTV cameras.

REVISION OF SECTION 210
RESET MICROWAVE VEHICLE RADAR DETECTOR

Section 202 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

This work consists of resetting Microwave Vehicle Radar Detector (MVRD) systems.

MATERIALS

The Contractor shall reset the existing MVRD and related materials. Any new electrical and communications conduit, cabling and equipment necessary to restore the MVRD service at the new location shall be provided as part of this work.

CONSTRUCTION REQUIREMENTS

The MVRD system shall be removed, relocated and integrated per the manufacturer's standards and recommendations. The MVRD system must be fully installed and integrated over the fiber optic network, and testing must be accepted by CDOT ITS.

Downtime shall be limited to the time periods set forth in the Disincentive for ITS Offline Devices specification. The Contractor shall coordinate this work with Jill Scott at CDOT ITS at (303) 512- 5805.

The MVRD system shall be installed in accordance with these specifications and in accordance with manufacturer's recommendations.

See project specific Testing & Integration Plan for additional requirements for reset MVRDs.

REVISION OF SECTION 210
RESET VARIABLE MESSAGE SIGN

Section 210 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of resetting a full, overhead Variable Message Sign (VMS). Major work elements include removing and resetting the existing VMS and controller cabinet to a new location.

MATERIALS

The Contractor shall reset the existing VMS and related materials. Any new electrical and communications conduit, cabling and equipment necessary to restore the VMS service at the new location shall be provided as part of this work.

CONSTRUCTION REQUIREMENTS

The VMS shall be relocated and mounted per the manufacturer's standards and recommendations. The VMS must be fully wired, operational, connected to the fiber network, able to communicate with the Colorado Transportation Management Software (CTMS), and must be accepted by CDOT ITS. The Contractor shall test the VMS to ensure all equipment is fully operational both before and after each reset.

If the existing VMS installation has a ground mounted cabinet, a polymer concrete cabinet foundation shall be furnished and installed to house the existing cabinet at its new location per the CDOT standard plans.

The Contractor shall maintain operability of the VMS sign during construction. Construction for the temporary installation shall include a new caisson, power, communications, and all other work necessary to fully relocate the VMS and keep in service throughout construction until the permanent VMS is ready.

See project specific Testing & Integration Plan for additional requirements for reset VMS.

REVISION OF SECTION 604
MANHOLE (TRAFFIC MANAGEMENT SYSTEM)

Section 604 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Manhole (Traffic Management System) shall include the installation of manholes for the Traffic Management System at locations approved by the Engineer.

MATERIALS

Manhole (Traffic Management System) shall be pre-cast concrete, circular or square, with a base and cast iron frame ring and cover. Each manhole, frame, and cover shall conform to American Association of State Highway and Transportation Officials (AASHTO) HS20-44. Manholes shall be capable of accepting concrete grade rings to add height to raise the ring and cover to a future finished grade.

Pre-cast units shall be provided with factory-installed knockouts that will permit the installation of a minimum of six two-inch conduits. The factory-installed knockouts shall be at a depth of three feet below the top of the manhole. The manhole shall have a detachable cover that has a skid- resistant surface and have the words “CDOT COMM” physically impressed on its top. The cover shall be attached to the manhole body by screw-in bolts.

Each Manhole shall include all hangers and hooks that accommodate all proposed fiber and communication cabling. Fiber management hangers and hooks for fiber coils and splice canisters shall be of sufficient quantity to hang each backbone and lateral cable installed in the manhole separately on its own set of hangers.

CONSTRUCTION REQUIREMENTS

The Contractor shall neatly excavate the site of manhole installation. A minimum of 12 inches of ¾ inch granite-gravel shall be placed below the manhole.

In pavement and sidewalks, the top of the manhole shall be flush with the existing grade. Outside of pavement and sidewalks, the top of the manhole shall be two inches above existing grade.

Backfill around the manhole excavation shall conform to Section 206, Structure Backfill (Class 2).

Fiber optic cable coils shall be tied to each cable rack with plastic cable ties. The Contractor shall coil the fiber cable per the manufacture’s recommendations. If hangers are not factory installed in the manhole, the bolts shall be installed in the manhole walls by means of either an epoxy compound or expansion type fitting. Conduit that enters the manhole base shall have sweeps attached so conduit entrance is elevated a minimum of six inches above the bottom of the manhole.

Backfill for Manhole (Traffic Management System) shall conform to Section 206, Structure Backfill (Class 2).

REVISION OF SECTION 612
LOCATION MARKERS

Section 612 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Contractor shall furnish and install location markers for identifying fiber optic conduit and other utility conduit at locations shown on the plans.

MATERIALS

Location Marker (Fiber Optic) (Dome) shall be made of non-conductive high-density polymer, and shall be integrally white in color with an orange cap. All colors shall be stabilized against ultraviolet light such that they will not fade under continuous exposure to direct sunlight and conform to the American Public Works Association (APWA) Uniform Color Code for delineating underground utility lines. The marker shall retain dimensional stability in temperatures ranging from -40º F to 175º F. In some instances when markers are installed on National Forest Service Lands the location marker shall be brown (Federal Standard Color 20059 or approved by Project Engineer) in color.

The Location Marker (Fiber Optic) (Dome) shall include a label with CDOT contact information and the designation of "FIBER OPTIC CABLE". The label shall have black lettering on an orange background. The label shall include the highway milepost of the Pull Box or Manhole (TMS). The mile post shall be to the nearest hundredth mile. This label shall be placed below the "FIBER OPTIC CABLE" warning label. When markers are installed on National Forest Service Lands the dome marker label shall have black lettering on a brown (Federal Standard Color 20059 or approved by Project Engineer) background. The Contractor shall provide the label submittal to the Project Engineer.

Location Marker (Utility) (Flat Slat) shall be made of fiberglass reinforced composite, and shall be orange or red in color. The marker shall retain dimensional stability in temperatures ranging from

-40º F to 175º F. In some instances when markers are installed on National Forest Service Lands the location marker shall be brown (Federal Standard Color 20059 or approved by Project Engineer) in color.

The Location Marker (Utility) (Flat Slat) shall include a label with CDOT contact information and the designation of "ELECTRICAL CABLE" or "TELEPHONE CABLE". The label shall have black lettering on a red background for electrical and black lettering on an orange background for telephone. In some instances when markers are installed on Forest Service Lands the flat marker label shall have black lettering on a brown (Federal Standard Color 20059 or approved by Project Engineer) background. The Contractor shall provide the label submittal to the Project Engineer for approval.

Concrete footing for dome marker shall be 18 inches x 18 inches x 12 inches. Concrete footing shall be Concrete Class B and shall be in accordance with Section 601.

CONSTRUCTION REQUIREMENTS

Location Marker (Fiber Optic) (Dome) shall be installed at all Pull Box and Manhole (Traffic Management System) locations that contain fiber optic cable. Intermediate markers shall be installed at 1000-foot spacing along each conduit run.

Location Marker (Utility) (Flat Slat) shall be installed at utility pull box and manhole locations and utility point of service to identify both electric and telephone communication lines. Contractor shall designate the utility line with a marker installed mid-point between the utility point of service and the device.

REVISION OF SECTION 613
ELECTRICAL CONDUIT (LIQUIDTIGHT FLEXIBLE METAL)

Section 613 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work includes furnishing and installing new liquidtight flexible metal conduit (LFMC) and fittings for use with fiber optic cable, electrical conductors, and communications cabling. All underground-to-aboveground and aboveground conduit installations shall utilize LFMC.

MATERIALS

All materials furnished, assembled, fabricated, and installed under this item shall be new, Underwriters Laboratories (UL) listed, corrosion resistant, and National Electric Code (NEC) compliant.

LFMC shall meet UL safety standard UL 360 – *Liquid-Tight Flexible Metal Conduit.*

The LFMC shall be rated for use in wet locations.

For below ground to above ground transitions, LFMC to Polyvinylchloride (PVC) coupling and LFMC to High Density Polyethylene (HDPE) coupling shall be listed for use.

CONSTRUCTION REQUIREMENTS

Prior to installation, the contractor shall submit technical data sheets for all conduit types, couplings, fittings, elbows, L-bends, mounting hardware, conduit plugs, and sealing plugs to the Engineer for written approval.

LFMC shall be installed in all below ground to above ground conduit transitions. Below ground, the contractor shall couple the LFMC conduit to the below ground conduit using approved coupling technology that is listed for use with LFMC.

Above ground LFMC shall be installed between pole-mounted communications cabinets and device poles. LFMC shall be installed between Variable Message Sign (VMS) housing and the VMS support structure. For above ground LFMC entries into cabinets, poles, and VMS housings, the contractor shall use fittings listed for use with LFMC. At entries into cabinets, poles, and VMS housings, the Contractor shall ensure that the entry hole is free from sharp edges and burrs.

The Contractor shall use factory drilled entries for connection of LFMC to cabinets, poles, and VMS housings. If the LFMC is to be used on an existing structure or cabinet on which no factory drilled entry exists, the Contractor shall receive approval from the Project Engineer prior to field drilling cabinets, poles, and VMS housings.

At field drilled steel poles, the Contractor shall repair all damaged galvanizing by hot dip or metallizing process as described in American Society for Testing and Materials (ASTM) A780 or shall paint with one full brush coat of a zinc-rich paint meeting Military Specification Department of Defense (DOD) DOD-P-21035A. Spray can applications of zinc will not be allowed.

LFMC installation shall conform to the requirements of NEC Article 350 LFMC. LFMC shall be secured and supported per NEC Article 350.30.

REVISION OF SECTION 613
ITS ELECTRICAL CONDUIT

Section 613 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work includes furnishing and installing new High-Density Polyethylene (HDPE) and Polyvinyl Chloride (PVC) electrical conduit and fittings for use with fiber optic cable, electrical conductors, and communications cabling.

MATERIALS

All materials furnished, assembled, fabricated, or installed under this item shall be new, Underwriters Laboratories (UL) listed, corrosion resistant, and National Electric Code (NEC) compliant. Materials shall be submitted to the Project Engineer for approval.

Electrical conduit shall be Schedule 80. Electrical conduit and fittings shall be UL listed.

HDPE conduit and fittings shall be certified by the manufacturer as meeting American National Standards Institute (ANSI) ANSI/UL 651A. PVC conduit and fittings shall be certified by the manufacturer as meeting ANSI/UL 651. The manufacturers shall be International Organization for Standards (ISO) ISO 9001 compliant.

All HDPE conduit shall be factory lubricated, low-friction, high-density conduit constructed of virgin high-density polyethylene resin. HDPE conduit shall be capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently used for installation, without affecting its properties or performance.

Each conduit shall be equipped with a pull tape. The pull tape shall have a minimum tensile strength of 1800 pounds and be of a design and manufacture that prevents cutting or burning into the conduit during cable installation. The pull tape shall include a continuous 22 gauge tracer wire. Splices in the pull tape and tracer wire may occur inside manholes and pull boxes and shall not be permitted inside conduit.

A minimum 12 gauge tracer wire shall be included in conduits containing fiber optic cable.

CONSTRUCTION REQUIREMENTS

All conduit and fittings installation shall conform to the NEC.

Electrical conduit that is installed using a trenchless technology such as boring shall be HDPE. Electrical conduit that is installed using direct burial methods such as plowing, open trenching, or other excavation methods shall be PVC or HDPE.

Prior to construction, the Contractor shall submit a trenching and boring plan to the Engineer for approval. The plan shall show the limits of the planned work areas and the areas of anticipated disturbance. All disturbances outside the planned work areas created by Contractor's operations shall be restored to their original condition at the Contractor's expense.

During construction operations, the contractor shall maintain boring logs that include the depth at specific distances along the bore. Boring logs shall be submitted on a weekly basis.

Excavations and conduit installation shall be performed in a continuous operation. All trenches shall be backfilled by the end of each shift. Material from trenching operations shall be placed in a location that will not cause damage or obstruction to vehicular or pedestrian traffic or interfere with surface drainage.

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REVISION OF SECTION 613
ITS ELECTRICAL CONDUIT

The Contractor shall be responsible for damage due to over-excavating a trench and heaving damage to the existing asphalt and concrete mat caused by equipment directly and by dislodging rocks or boulders. All damage from over-excavation and heaving shall be repaired at the Contractor's expense. The Contractor shall bear the cost of backfilling all over-excavated areas with the appropriate backfill material approved by the Engineer.

The Contractor shall restore all surface materials to their original condition or better, including but not limited to pavement, sidewalks, sprinkler systems, landscaping, shrubs, sod, and native vegetation that is disturbed by the conduit installation operation. All repairs shall be included in the cost of the conduit.

The Contractor shall use UL listed splice couplings that comply with the NEC. The coupling technology used to connect conduit ends shall require no special tools and form a watertight, airtight seal. The breaking force between segments shall exceed 250 pounds. Conduit splices shall be kept to a minimum and all such locations shall be approved and inspected by the Engineer and the authority having jurisdiction. Additional pull boxes shall not be substituted for conduit splices.

Conduit plugs that are watertight, removable, mechanical, and equipped with a tie rope for connection to a pull rope and pull tape shall be supplied and installed in all open conduit ends immediately following conduit installation. Conduit shall be plugged at all termination points including, but not limited to pull boxes, manholes, controller cabinets, structures, poles, and node buildings. Conduits containing cable shall be plugged with durable and reusable split type plugs, fabricated without metallic parts. The plugs shall allow easy removal and reinstallation around in- place cables. Split type plugs shall provide a watertight and airtight seal of at least 22 pounds per square inch. They shall be installable by hand without using tools and without damaging the cable. All plugs shall be correctly sized to fit the conduit being plugged.

All conduits shall use sweeps to elevate the buried conduits to the final grade within a pull box or manhole. The sweeps shall be terminated within the pull boxes and manholes to allow for easy installation and removal of conduit plugs. The sweeps shall be set above the ground surface of the inside of the pull box at a height that does not interfere with coiling of the fiber optic cable.

All conduits terminating in a pole or sign structure shall extend to a point 6 inches below the handhole in the pole or structure.

All conduit runs containing fiber optic cable shall have a limited number of bends. The sum of the individual bends on a single conduit run between any two pull points shall not exceed 270 degrees. No individual bend shall exceed 90 degrees. All conduit bends shall have a minimum acceptable radius of 48 inches for 90 degree bends and for conduit containing fiber optic cable, and 24 inches for all other bends. HDPE conduit minimum bending radius shall conform to Table 354.24 in the NEC.

New conduits may be installed into existing pull boxes, manholes, and cabinet bases, and the Contractor shall carefully excavate around the existing facility and install the new conduit as shown on the plans. The Contractor shall not damage the existing facility or its contents. If the existing conduit, pull box, lid and concrete collars are damaged during conduit installation, the Contractor shall restore the damaged item or section to current CDOT requirements at no additional cost to the project.

Conduit shall always enter a pull box, manhole, cabinet base or any other type structure from the direction of the run only.

All conduit ends shall be free from sharp edges and burrs.

REVISION OF SECTION 614
ITS PULL BOXES

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Contractor shall furnish and install fiberglass reinforced, polymer concrete pull boxes and concrete aprons.

MATERIALS

Pull boxes shall be verified by a 3rd Party Nationally Recognized Independent Testing Laboratory as meeting all test provisions of American National Standards Institute/Society of Cable Telecommunications Engineers (ANSI/SCTE) 77, 2013 Specification for Underground Enclosure Integrity, Tier 22 rating. Pull boxes shall be Underwriters Laboratories (UL) listed. Certification documents shall be submitted with material submittals.

Each pull box shall have an Electrical Marker System (EMS) locator disk manufactured into the lid for communication line locating. The locator disk shall be compatible with a CDOT cable locator and utilize the APWA Uniform Color Code standard for visual reference, if disk is observable on the exterior of the lid. The locator disk shall utilize the proper locate frequency for the pull box type.

Pull boxes 24 inches by 36 inches and larger shall have removable split lids with a removable metal center support beam. Lid segment weight shall not exceed 100 pounds.

Pull box removable lids shall be provided with a skid-resistant surface and have the words “CDOT FIBER” or “CDOT POWER”, as well as “EMS MARKER EMBEDDED IN COVER” and the tier level rating cast into the surface. Painting of words shall not be accepted. The cover shall be attached to the pull box body by means of 3/8 inch x 7 inch lag thread hex head stainless steel bolts.

One piece lids shall have a minimum of two lift slots per lid, while split lids shall have a minimum of one lift slot per lid. Lift slots shall be rated for 3000 pounds.

Test point locations shall be integrated into the pull box lids to provide for attachment of test leads of various connector types for underground conduit tracing. The minimum number of test point locations shall equal the number of conduit banks entering the pull box, up to a maximum of five test points. Pull boxes with split lids shall have the test points on one split lid section only. Pull box lids shall be furnished with 3/8 inch x 1/16 inch deep recesses at locations adjoining each test point for the application of direction arrow symbols indicating the direction of underground conduit exiting the pull box. Recesses shall be thoroughly cleaned with alcohol prior to applying arrow symbols.

Wire mesh shall be installed in a manner to completely surround the box. The wire mesh shall meet the material standard ANSI/American Society of Testing and Materials (ANSI/ASTM) A555-79 and made of T-304 stainless steel, 0.025 inch wire diameter minimum and shall have a spacing of 10 mesh per inch.

Pull boxes installed in dirt or landscaped areas shall have a Class B concrete apron or a pre-cast polymer concrete apron. Class B concrete shall be in accordance with Section 601.

The pre-cast polymer concrete apron shall be non-metallic, non-conductive, and UV resistant, and shall include two lifting slots for placement in the field. The pre-cast polymer concrete apron shall be a minimum of 4 inches deep and shall extend a minimum of 11 inches from each side of the pull box. The gap between the pre-cast polymer concrete apron and outer wall of the pull box shall be a maximum of ½ inch.

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REVISION OF SECTION 614
ITS PULL BOXES

Pull Box (Surface Mounted) shall be aluminum type with a hinged front door and have at least a National Electrical Manufacturers Association (NEMA) 3R rating. The hinged door shall be provided with both a weather tight seal and an aluminum hasp. Surface mounted pull boxes shall be approved by the Engineer.

CONSTRUCTION REQUIREMENTS

A minimum of 12 inches of ¾ inch granite-gravel shall be installed as a base for the pull box. The granite-gravel shall be free of dirt and debris and spread evenly to facilitate a level base for the pull box. The Contractor shall ensure that sufficient compaction is met prior to the installation of granite-gravel to alleviate future settling.

Wire mesh shall be installed to completely surround the box. The wire mesh shall be installed prior to the installation of the pull box above the bed of ¾ inch granite-gravel and extending one foot past the outer edges of the concrete apron. The wire mesh shall be gently cut to allow only the entrance of the conduit through at the bottom of the box. All openings cut in the wire mesh that are larger than the diameter of the conduit shall be covered with additional wire mesh in a manner to completely surround the pull box with wire mesh.

Tracer wire shall be attached to the trace test points on the underside of the pull box lid. Each trace wire shall be attached to an individual trace point, no two wires shall be attached to the same point. The Contractor shall coil an additional 6 feet of tracer wire inside the pull box to ensure that the tracer wire will not disconnect from test points when the lids are removed.

At pull boxes installed in dirt and landscaped areas, the Contractor shall install a concrete apron or a pre-cast polymer concrete apron around the edges of the pull box. Three sides of the concrete apron shall measure 12 inches wide by 6 inches deep and one side shall measure 18 inches wide by 6 inches deep. The apron side measuring 18 inches wide by 6 inches deep shall be located on the edge of the pull box furthest from the roadway, and shall contain a 4 inch diameter round knockout for fiber optic marker installation. Pull boxes shall not be installed above the grade of the apron. The concrete apron shall have a 1 percent slope away from the top of pull box to allow for drainage.

Surface mounted pull boxes shall be mounted on or embedded into hard surfaces such as bridge decks, concrete barriers, retaining walls, or buildings, as approved by the Engineer. Surface mounted pull boxes shall be attached using 3/8-inch epoxy anchors or other methods approved by the Engineer. Surface mounted pull boxes shall not be used for ground installations. Pull rope and tracer wire shall be installed in surface mounted pull boxes.

REVISION OF SECTION 614
AUTOMATIC TRAFFIC RECORDING STATION

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of replacing any and all existing Division of Transportation Development (DTD) Automatic Traffic Recording (ATR) Station equipment that is impacted during construction. This also includes providing a cabinet to house all components for the ATR station.

The Contractor shall furnish and install any in-pavement loops, piezoelectric axle sensors (piezo), conduit and pull boxes for the existing permanent DTD ATR Stations that are impacted during the construction.

The Contractor shall coordinate all work with Mike DelCupp, Traffic Data Collection Manager, at 303-757-9816.

MATERIALS

Permanent ATR Station - the permanent ATR Station materials shall include a cabinet, cabinet foundation, loop detector wire, and piezos. The cabinet, cabinet foundation, loop detector wires, and piezos shall meet the following specifications:

- NEMA Type M cabinet with one outlet, fan, thermostat, 20 amp breaker, and a shelf.
- Each communications cabinet shall include a polymer concrete or poured concrete pad that extends at least 2'-6" beyond the cabinet base on each cabinet door side and at least 6" beyond the cabinet base on the other two sides. The cabinet base shall be sealed around the conduits.
- Loop detector wire shall consist of specified loop wire encased in ¼ inch OD, 3/16 inch ID vinyl or polyethylene tubing. (14-1/C Loop detector cable 19 STR. PVC/Nylon/PVC Tube 600v IMSA 51-5)
- Loops shall be sealed with a two-part self-curing, self-bonding weatherproof epoxy approved for sealing loops. Loops shall be 6 feet by 6 feet.
- The piezo shall be class II and 6 feet in length. The piezo shall have sufficient lead in cable, so the lead in cable can be pulled into the cabinet without splicing.
- Grout or epoxy for the installation of the loops and piezos shall conform to manufacturer's recommendations.
- *Pole Mounted Cabinet*: The pole-mounted cabinet shall be NEMA 4R rated and shall be sized adequately to house all of the ATR Station components, such as the counter, CDMA modem, Wavetronix equipment, power supplies, cabling, and wiring. The cabinet shall be a minimum of 20 inches x 20 inches with a 120 volt outlet.
- *Equipment Supplied by CDOT DTD*: CDOT DTD will provide the following equipment that will be needed for each fully functional temporary ATR site: 1 – 4 lane Phoenix Traffic Counter, 2 cables to interface the counter to the Click 100 and 1 cable to connect the counter to the modem. The Contractor shall contact Mike DelCupp at 303-757-9816 for the equipment supplied by DTD.

CONSTRUCTION REQUIREMENTS

1. *General.* A minimum of five days prior to installation for the permanent ATR, the contractor shall submit a schedule of installation activities including alternative scheduling to the CDOT Project Manager and the Traffic Data Collection Manager (Mike DelCupp 303-757-9816; mike.delcupp@state.co.us). The installation instructions from the manufacturer shall also be submitted for approval. Installation shall not begin until approval has been received from CDOT.

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REVISION OF SECTION 614
AUTOMATIC TRAFFIC RECORDING STATION

For the permanent ATR, the Contractor shall install the loops and piezos as close to the existing detection equipment locations as possible. Exact locations, dimensions, and configurations may vary based on site conditions, and shall be as approved by CDOT.

All work will be inspected by the Traffic Data Collection Unit (TDC) during installation.

The permanent ATR shall be installed in accordance with these specifications, the project details, and in accordance with manufacturer's recommendations.

2. *Installation of Loops.* Loops shall be centered in the travel lane with two sides parallel to lane striping. The saw cut for the loops shall be made 3/8 inch wide and 3-½ inches deep. The saw slot shall be as straight as possible and shall not vary more than ½ inch when checked with a straightedge. No more than one set of loop lead wires shall be placed in one saw slot. Saw cuts shall be hydro-blasted with a mixture of water and air and then blown free of water and debris with compressed air, using a large capacity air compressor of at least 150 CFM. The cuts shall be dry prior to placement of loop wire.

The Contractor shall locate all buried utilities, which may interfere with the planned location of the ATR site. The Contractor shall contact the Utility Notification Center of Colorado (UNCC) at 811 or 1-800-922-1987 for location of member utilities at least three working days prior to any excavation, not including the day of actual notice.

The Contractor shall also locate non-member utilities, such as storm sewer and ditch. Any utility conflicts encountered with the proposed installation shall be brought to the attention of the Engineer

After the saw slot is cleaned of debris and dried, the wire shall be placed for the loop by pushing it into the slot with a blunt non-metallic object. A screwdriver or other sharp tool will not be permitted. Care shall be used to avoid abrading or damaging the insulation.

All loop corners shall be rounded using a 1-½ inch hole drilled to a minimum depth of 3-½ inches. Loop leads shall be drilled when leaving the roadway surface at a 45 degree angle 8 inches from pavement edge out through the side or bottom of roadway, the drilled hole shall be no larger than ¾ of an inch. All holes shall be spaced a minimum of three inches from one another. No more than one set of loop lead wires shall be placed in one drill hole.

One continuous length of loop wire shall be used for each loop from pull box or cabinet around the loop with 4 turns and back to the pull box or cabinet with no splices. The wires shall be seated in the bottom of the saw slot. A ½-inch backer-rod shall be installed to insure wires do not float to the surface during grouting. Backer-rod shall be installed in 4 to 6 inch pieces with 1 to 2 foot gaps in-between, to insure the sealant will come in contact with the loop wire. One continuous piece of backer-rod will not be allowed.

After the loops are properly seated and tested, the slots shall be filled with a two-part self- curing, self-bonding epoxy or grout, as recommended by the manufacturer. Excess epoxy shall be removed to avoid unnecessary high spots, and level with the roadway surface.

Loop leads shall be pulled into cabinet without splices to match original installation when applicable.

All detector loops shall measure six feet by six feet.

Installation at an ATR count or classification site shall consist of one loop or one loop set (two loops) within a single lane. The loop sets shall be separated by 10 feet, plus or minus 1 inch, resulting in a distance of sixteen feet from the leading edge of the first loop in the direction of travel to the leading edge of the second loop.

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REVISION OF SECTION 614
AUTOMATIC TRAFFIC RECORDING STATION

Loop and loop leads shall be installed directly into the pavement, to pavement edge, pull box or cabinet. If loops are installed during asphalt paving, the loops shall be installed before the final lift is placed.

Loop lead wires from pavement edge to pull box shall be enclosed in ¾ inch PVC conduit or ¾ inch rubber hose to protect wire from abrasion. Loop lead-in pairs from pavement edge, to pull box, shall be symmetrically twisted 5 turns per 1 foot. Pull boxes or cabinet shall contain a minimum of 3 feet of loop lead wire for splicing. All loop and loop leads shall be clearly labeled in all pull boxes and cabinets. The Contractor shall be responsible for all trenching and digging from pavement edge to pull box.

All splices shall be made with approved waterproof pressure connector. All splices shall be capable of satisfactory operation under continuous submersion in water.

3. *Piezo Installation.* The piezo shall be permanently installed by grouting into the roadway flush to 1/16 of an inch above the roadway surface by grouting into a concrete roadway or the final lift of asphalt.

Piezo sensors shall be installed in compliance with the manufacturer's recommendations.

At an ATR axle classification site, one 6 foot piezo sensor per lane shall be installed at the exact midpoint between the two loops and to the right or left side of the line, centered in the wheel path.

The saw cut shall be as straight as possible and shall not vary more than ½ inch when checked with a straightedge. The size of the saw cut shall be to the manufacturer's specifications and not vary more then 1/8 of an inch in width. The slot for the piezo lead wire shall be 3 inches deep and 3/8 of an inch wide. Only one piezo lead wire shall be placed in the saw slot.

Piezo lead shall be drilled when leaving the roadway surface at a 45 degree angle 8 inches from the pavement edge out through the side or bottom of the roadway, the drilled hole shall be no larger than ¾ of an inch. All holes shall be spaced a minimum of 3 inches from one another. No more than one piezo lead wire shall be placed in one drill hole.

Saw cuts shall be hydro-blasted with a mixture of water and air and then blown free of water and debris with compressed air, using a large capacity air compressor of at least 150 cubic feet per minute. The cuts shall be dry and cleaned with acetone prior to placement of the piezo.

The piezo shall not be installed if roadway surface temperature is not above the manufacturer's recommended minimum temperature, or cannot be maintained above this temperature for a minimum of two hours after installation. The piezo shall not be installed if roadway surface temperature is above the manufacturer's highest recommended temperature for grout installation.

The piezo lead wire shall be placed in the saw slot with a blunt non-metallic object. A ½ inch backer-rod shall be installed to insure the wire does not float to the surface during grouting. The backer-rod shall be installed in 4 to 6 inch pieces with 1 to 2 foot gaps in between, to insure the sealant will come in contact with the piezo lead wire. One continuous piece of backer-rod will not be allowed.

The sealant for the piezo lead wire shall be the same as that used for loops.

Piezo lead wire shall be pulled into the cabinet without splices, unless the length exceeds 300 feet.

Only one lead wire shall be placed in a saw slot.

Piezo lead wires from pavement edge to pull box shall be enclosed in ¾ inch PVC conduit or ¾ inch rubber hose, to protect wire from abrasion. Pull boxes or cabinet shall contain a minimum of three feet of piezo lead wire for splicing. Lead wire shall be clearly labeled as approved by the Engineer and the TDC.

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REVISION OF SECTION 614
AUTOMATIC TRAFFIC RECORDING STATION

All splices in piezo wiring shall be soldered and enclosed in a resin filled splice kit.

Pull Boxes. All pull boxes on the shoulder of the roadway surface shall be raised to finished grade or level with the surrounding ground. If the shoulder has been raised to the point that the conduit is below the bottom of the pull box, then the conduit shall be raised. All wiring splices for existing wiring shall be a minimum of 12 inches in length above the conduit.

All existing pull boxes that are found to be damaged shall be replaced.

4. *Water Valves.* A minimum of two feet of slack shall be provided on the loop and piezo wires that are contained in water valves.

   No splices shall be allowed in water valves.

5. *Pull Rope.* A 1/8 inch nylon pull rope shall be installed in all new conduits and all existing conduits where a wire or cable is added or an existing wire or cable is replaced.

6. *Conduit*. The contractor shall seal all conduits with a sealing compound where a wire or cable is added or an existing wire or cable is replaced. The sealing compound shall be UL tested and approved for use. Sealing compound shall be a permanently soft, fibrous, non- staining sealer that can be easily applied and removed by hand at all working temperatures. Sealing compound shall be designed to seal out weather, moisture, dust rodents, and atmospheric conditions both indoors and outdoors. No foam sealant will be allowed.

7. *Telephone Drop/Connection*. The contractor shall maintain the existing telephone drop/connection to the permanent ATR cabinet for connection to DTD until the fiber connection to the CDOT backbone is connected.

REVISION OF SECTION 614
BUFFER TUBE FAN-OUT KIT

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project, the Buffer Tube Fan-out Kit shall be furnished and installed on single mode fiber optic lateral cable ends in field communications cabinets.

MATERIALS

Buffer Tube Fan-Out Kits shall match the number of fiber strands in the lateral fiber optic cable. Buffer tube fan-out kits shall be compatible with the fiber optic cable being terminated and shall be color-coded to match the lateral fiber strand color. Fan out kit buffer tubes shall be 900 um. The buffer tube fan out kit fiber strand length shall be sufficient for routing and placement in the termination panel. All components of the fan-out kit shall be rated for outdoor use.

CONSTRUCTION REQUIREMENTS

The Contractor shall install fiber optic buffer tube fan-out kits on the lateral cable in each communications cabinet. The Contractor shall install fanned out cables on the ends of lateral fiber cable strands. Buffer tubes for lateral fiber strands shall be neatly coiled and secured within the field termination panels. Taping or leaving the buffer tubes unmanaged shall not be allowed.

REVISION OF SECTION 614
BREAKAWAY TAPERED ITS STEEL POLE

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project, this work shall consist of furnishing and installing the steel tapered pole, breakaway transformer base, and fiber-optic disconnect, as described herein.

MATERIALS

An aluminum transformer base shall be provided which shall conform to breakaway requirements of the American Association of State Highway and Transportation Officials (AASHTO), 2013 Sixth Edition of the Standard Specification for the Supports for Highway Signs, Luminairies and Traffic Signals; and accepted for use by the Federal Highway Administration (FHWA). An aluminum access door and grounding provision with hardware shall be provided in the transformer base. The door opening shall be approximately 11 inches tall, 8.5 inches wide at the top, and 9 inches wide at the bottom. Connecting bolts, flat washers, bearing washers and hex nuts shall be provided with the base assembly. All structural fasteners shall be galvanized high strength carbon steel. All non-structural fasteners shall be galvanized or zinc-plated carbon steel or stainless steel. A satin finish shall be provided unless otherwise requested by the Engineer.

The fiber optic connection to the communications cabinet shall include a breakaway reusable connection system, within the transformer base, which is designed to disengage upon breakaway impact to the steel support pole. This breakaway connection shall be flood resistant, dust proof, and waterproof. Connection shall be immediately reusable after breakaway impact, without field repair or re-termination of the fiber optic cable.

Steel Pole shall conform to the following requirements:

1. *Fabricator.* The fabricator shall be certified under Conventional Steel Building Structures (SBD) as set forth by the American Institute of Steel Construction (AISC) Quality Certified Fabricators Program. Proof of this certification shall be supplied with the submittal of poles to confirm that the fabricator has the personnel, organization, experience, procedures, knowledge, equipment, capability and commitment to fabricate quality steel pole structures.

2. *Welding.* All welding shall be in accordance with Sections 1 through 8 of the American Welding Society (AWS) D1.1 *Structural Welding Code Steel.* Tackers and welders shall be qualified in accordance with the code. Tube longitudinal seam welds shall be free of cracks and excessive undercut, performed with automatic processes, and be visually inspected.

   Longitudinal welds suspected to contain defects shall be magnetic particle inspected. All circumferential butt-welded pole splices shall be ultrasonically or radiographically inspected.

3. *Material Certifications.* All materials and products shall be manufactured in the United States of America, and comply with American Society for Testing and Materials (ASTM) or AASHTO specifications. Mill certifications shall be supplied as proof of compliance with the specifications.

4. *Pole Shaft.* The pole shaft should be one piece construction, and shall conform to ASTM A595 with a minimum yield strength of 55 kips per square inch or ASTM A572 with a minimum yield strength of 55 kips per square inch. The shaft shall have a constant linear taper of 0.14 inch per foot, and contain only one longitudinal seam weld. Circumferential welded tube butt splices and laminated tubes are not permitted. Longitudinal seam welds within 6 inches of complete penetration pole to base plate welds shall be complete penetration welds.

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BREAKAWAY TAPERED ITS STEEL POLE

5. *Ground Lug.* A ground lug shall be provided within the interior base of the pole for connection to a grounding system as specified in Revision of Section 614 – Grounding and Bonding. A bare copper ground wire shall be provided by the Contractor between the pole's ground lug and a ground rod adjacent to the pole's caisson to provide grounding. The ground wire shall be installed in a dedicated conduit (0.5 inch diameter, minimum) within the pole caisson provided by the Contractor. The Contractor shall bond the ground wire to the pole's ground lug and the ground rod in accordance with the Grounding and Bonding project special provision.
6. *Base Plates.* At a minimum, base plates shall conform to ASTM A36 Standard Specification for Carbon Structural Steel or A572 Grade 50. Plates shall be integrally welded to the tubes with a telescopic welded joint or a full penetration butt weld with backup bar. Plates shall be hot dip galvanized per the requirements of the contract documents and finished in accordance with these specifications.
7. *Anchor Bolts.* At a minimum, anchor bolts shall conform to the requirements of ASTM F1554 for Grade 55. The upper 12 inches of the bolts shall be hot dip galvanized per ASTM A153. Each anchor bolt shall be supplied with two hex nuts and two flat washers. The strength of the nuts shall equal or exceed the proof load of the bolts.

CONSTRUCTION REQUIREMENTS

All work shall conform to the specifications referenced herein and the current edition of NFPA 70, and shall conform to subsection 107.01.

Each Breakaway Tapered ITS Steel Pole shall be installed as designated herein. The Contractor shall furnish and install all incidentals necessary to provide a complete working system at each location.

REVISION OF SECTION 614
CLOSED CIRCUIT TELEVISION

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing a High Definition (HD) Internet Protocol (IP) Closed Circuit Television (CCTV) camera.

MATERIALS

CCTV camera shall include: The camera housing, pole mount adapter, Power over Ethernet (PoE) power supply, manufacturer supplied management software, Category 5e rated (CAT5e) cables, and all attachment hardware needed for a functionally complete installation.

1. *Camera.* The camera shall have pan, tilt, and zoom functionality enclosed in a sealed, environmentally controlled dome housing designed to operate in 100 percent humidity at an operating temperature range of -58°F to 122°F. The camera housing shall carry both IP66 and National Electrical Manufacturers Association (NEMA) 4x ratings. The camera shall utilize a 100 megabits per second 802.3 Ethernet connection for native communications and be powered from an 802.3at compliant Power over Ethernet (PoE) supply.

   The camera shall be able to display multiple individually configurable video streams up to 30 frames per second in high definition resolutions from 1920 x 1080 pixels to 320 x 180 pixels at a 16:9 aspect ratio in H.264 and Motion JPEG (MJPEG) formats using unicast or multicast delivery. The camera shall include functionality for onscreen titling, image overlay, and remote capture of at least 256 preset views. It shall include electronic image stabilization, ability to reduce effects of rain and fog in picture, and include ability to run manufacturer or third party analytics designed for roadway applications with output to initiate internal user programed events or alarms to external systems using an open application programming interface (API) structure. An internal web interface shall be included for configuration with security functionality allowing a minimum of 20 user access levels with password protection.

   The camera shall be capable of implementing stream authentication for video security and the ability to modify view and control priority among configured users. Options for video storage shall be available via onboard Secure Digital (SD) memory slot or to network share. Camera status and diagnostics shall be available via Simple Network Management Protocol (SNMP) traps. The camera shall support:

   - IPv4/v6
   - Hypertext Transfer Protocol (HTTP)
   - Hypertext Transfer Protocol Secure (HTTPS)
   - Secure Socket Layer/Transport Layer Security (SSL/TLS)
   - Quality of Service (QOS) Layer 3 Differentiated services (DiffServ)
   - File Transfer Protocol (FTP)
   - Simple Mail Transfer Protocol (SMTP)
   - SNMP v1/2/3
   - Universal Plug and Play (UPnP)
   - Domain Name System (DNS)
   - Dynamic Domain Name System (DDNS)
   - Network Time Protocol (NTP)

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CLOSED CIRCUIT TELEVISION

- Real-time Transport Protocol (RTP)
- Real Time Streaming Protocol (RTSP)
- Transmission Control Protocol (TCP)
- User Datagram Protocol (UDP)
- Internet Group Management Protocol (IGMP)
- Real-time Transport Control Protocol (RTCP)
- Address Resolution Protocol (ARP)
- Socket Secure (SOCKS)

The camera shall be Open Network Video Interface Forum (ONVIF) compliant. Technical specifications for the camera shall be as follows:

- The lens shall be f=4.44 to 142.6 mm, F1.6 to 4F14.41, autofocus; focus range of 35 mm (wide) to 800 mm (telephoto) to infinity, with 62.8 degrees to 2.23 degrees horizontal angle of view.
- Minimum illumination:
    - Color: 0.3 lux at 30 IRE F1.6
    - Black and White: 0.03 lux at 30 IRE F1.6
- Shutter speed shall be variable from 1/33,000 to 0.25 seconds at 60 hertz.
- The pan, tilt, and zoom functions shall provide 360 degrees of continuous pan rotation at
- 0.05 degrees per second to 450 degrees per second, a 220 degree tilt range allowing for 20 degree view above the horizon at 0.05 degrees per second to 450 degrees per second, and minimum 32 times optical and 12 times digital zoom.

2. *Manufacturer's Supplied Configuration and Management Software.* Configuration software shall be included which gives the user access to discover and configure the camera using standard network protocols.

   A centralized management software shall also be available to remotely discover and manage all available cameras across an Ethernet network for monitoring and configuration. The management software should be based on a server client architecture and shall include functionality to receive camera status, manage and apply blanket firmware updates to applicable devices, view/add/change user access accounts, and manage and apply device configuration templates using specific parameters saved by the user.

3. *Pole-Mount Adapter Arm and Bracket.* The adapter shall have a minimum 33 pound load rating and have provisions that allow mounting directly to the weatherproof dome housing without modification to the housing. The adapter bracket shall have slots for a minimum of two straps or banding material for mounting to the poles with diameters ranging from 3 inches to 6 inches. The bracket shall have cable strain relief in at least two locations on the reverse side, between the bracket and the pole.

4. *Cat5e Cable.* Cable shall be an eight wire twisted pair cable constructed of 24 American Wire Gauge (AWG) stranded copper wires with minimum Cat5e rating. The outer jacket shall be ultraviolet (UV) resistant polyvinylchloride (PVC) insulation designed for outdoor use. Shielded cable shall be used when prescribed by the manufacturer, run through conduit and enclosed structures, and when needed for equipment or electrostatic grounding. Shielded cable shall be terminated with either conductive or non-conductive male 8P8C connectors. Where shielded cable is used as an equipment ground, conductive connectors shall be used on both ends of the cable. Where shielded cable is used as an electrostatic drain, the grounded side of the connection shall be terminated with a conductive connector and the ungrounded side shall be terminated with a non-conductive connector. Unshielded cable shall be used for interconnections within the same cabinet, or where

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CLOSED CIRCUIT TELEVISION

grounding and electromagnetic interference is not present. Unshielded cable shall be terminated with non-conductive male 8P8C connectors on both ends. All Cat5e cables used for Ethernet data shall conform to the Telecommunications Industry Association/Electronic Industries Alliance (TIA/EIA) T-568B pin/pair assignments.

CONSTRUCTION REQUIREMENTS

The CCTV camera shall be installed in accordance with these specifications and in accordance with manufacturer's recommendations. The Contractor shall make arrangements required for a qualified manufacturer's representative to be on-site to ensure proper installation of the CCTV camera.

The weatherproof dome housing shall be attached to the pole mount adapter using the materials supplied from the manufacturer.

The camera shall be attached 1 foot below the top of the pole at an orientation to achieve the optimal view of both the main and crossroad traffic, or as directed by the Engineer. Three quarter inch type 201 stainless steel strap used in conjunction with type 201 stainless steel buckles shall be used to band the camera assembly and pole mount adapter to the pole.

The PoE midspan module shall be securely mounted in the communication cabinet as directed by the Engineer. The PoE shall be plugged into a grounded non-ground-fault circuit interrupter (GFCI) protected outlet. If available, an Uninterruptible Power Supply (UPS) protected outlet shall be used to power the power supply.

A shielded Cat5e cable with conductive RJ-45 terminations shall be run from the PoE supply to the camera providing a path to ground. A shielded Cat5e cable with a conductive RJ-45 termination on one end and non-conductive termination on the other shall be installed from the PoE supply to the field communication device with the conductive termination plugged into the PoE supply.

A maximum 1 inch hole shall be drilled in the mounting pole to allow passage of the Cat5e cable. The hole shall be free of burs and sharp edges prior to the installation of the cable. The cable shall be attached to the reverse side of the mounting bracket to ensure proper strain relief. The Ethernet cable shall run down the interior of the structure and exit through non-metallic flexible conduit to the communication cabinet. The non-metallic flexible conduit shall be weather sealed on each end to eliminate exterior liquid entry. The Contractor shall provide a weather seal for the adapter bracket at the 1 inch hole at the top of the pole per the manufacturer's recommendations.

The Contractor shall ensure that the installation meets all minimum requirements set forth by the manufacturer in a manner to ensure all work will be covered by the manufacturer's warranty.

The Contractor shall configure the camera with an IP address as provided by the Engineer. The cameras shall be tested for full functionality and verification of access on the connected network. See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
CLOSED CIRCUIT TELEVISION POLE WITH LOWERING DEVICE

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project, this work shall consist of furnishing and installing the Closed-Circuit Television (CCTV) Internet Protocol (IP) based camera pole(s) and lowering system(s) as described herein.

MATERIALS

Subsection 614.02 shall include the following:

The camera lowering system shall be designed to support and lower an Ethernet (IP-based) CCTV camera, lens, housing, Pan-Tilt-Zoom (PTZ) mechanism, cabling, connectors and other supporting field components without damage or causing degradation of camera operations. The camera lowering system device and the pole are interdependent; and shall be considered as single systems. The lowering system shall consist of a steel pole, suspension contact unit, divided support arm, and a pole adapter for attachment to a pole top tenon, pole top junction box, conduit mount adapter and camera connection box. The divided support arm and receiver brackets shall be designed to self-align the contact unit with the pole center line during installation and ensure the contact unit cannot twist under high wind conditions. Round support arms will not be accepted. The camera lowering system shall withstand wind forces of 110 mph with a 30 percent gust factor using a 1.65 safety factor. The lowering system manufacturer shall furnish independent laboratory testing documents certifying adherence to the stated wind force criteria utilizing, as a minimum Effective Projected Area (EPA), the actual EPA or an EPA greater than that of the camera system to be attached. The camera lowering system to be furnished shall be the product of manufacturers with a minimum of five years of experience in the successful manufacturing of camera lowering systems. The lowering system provider shall be able to identify a minimum of three previous projects where the proposed system has been installed successfully for over a one-year period of time each.

The lowering system manufacturer shall furnish an authorized factory representative to support the Contractor with the assembly and testing of the first lowering system onto the pole assembly. The manufacturer shall furnish documentation to CDOT certifying that the Contractor has been instructed on the installation, operation and safety features of the lowering system for this specific project. The Contractor shall be responsible for providing applicable “on site" operational instructions for CDOT maintenance personnel.

1. *Suspension Contact Unit.* The suspension contact unit shall have a load capacity 600 pounds with a 4 to 1 safety factor. There shall be a locking mechanism between the fixed and moveable components of the lowering system. The movable assembly shall have a minimum of two latches. This latching mechanism shall securely hold the device and its mounted equipment. The latching mechanism shall operate by alternately raising and lowering the assembly using the winch and lowering cable. When latched, all weight shall be removed from the lowering cable. The fixed unit shall have a heavy duty cast tracking guide and means to allow latching in the same position each time.

   The contact unit housing shall be weatherproof with a gasket provided to seal the interior from dust and moisture. The entire unit shall have a minimum temperature rating of -40ºF to +190ºF.

   The prefabricated components of the lift unit support system shall be designed to preclude the lifting cable from contacting the data, power or video cabling. The lowering system manufacturer shall provide a conduit mount adapter for housing the lowering cable. This adapter shall have an interface to allow the connection of a contractor provided 1.25 inch PVC conduit and be located just below the

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CLOSED CIRCUIT TELEVISION POLE WITH LOWERING DEVICE

cable stop block at the back of the lowering system. The Contractor shall supply internal conduit in the pole as directed by the lowering system manufacturer. The only cable permitted to move within the pole or lowering system during lowering or lifting shall be the stainless steel lowering cable. All other cables must remain stable and secure during lowering and lifting operations. Lowering systems for two camera installations shall be configured to not interfere with each other at any time during lowering operations.

The lowering system must be specifically equipped with electrical contacts connectors designed for extreme environmental outdoor use with a CCTV IP camera connected via an outdoor-rated CAT5e Shielded Twisted Pair (STP) cable utilizing Power over Ethernet (PoE).

The female and male socket contact halves of the connector block shall be made of an Underwriters Laboratories (UL) 94 *Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*, V-0 rated thermosetting synthetic rubber. The female barrel contacts and the male pin contacts shall be permanently and integrally encased in this rubber material to ensure protection from moisture and the environment.

All current carrying male pin and female socket/barrel contacts shall be gold-plated per ASTM B488 *Standard Specification for Electrodeposited Coatings of Gold for Engineering Uses* over nickel-plated CA 360 in accordance with SAE International AMSQQN290C *Nickel Plating (Electrodeposited)*. Male contact sizing shall be a minimum of 0.09 inches while the female contacts shall be at least 0.09 inches (inside diameter) at the contact area. All contact shall be a minimum of 0.09 inches in diameter at the contact area. Each individual female barrel contact shall have a nickel-plated CA 360 sleeve that prevents foreign matter from entering the contact area as well as preclude the possibility of the leaves of the female contact from opening beyond allowable limits and ensure a snug fit around the respective male pins. There shall be one contact that is positioned in a manner which will allow it to make first and break last providing optimum grounding performance.

Each Ethernet (IP-based) male-female connector shall include a total of 13 specifically designed contacts. Eight contacts soldered to outdoor-rated CAT5e STP wire end terminated with a shielded RJ-45 male connector and five contacts soldered to #18/1 UL lead wire – bare and numbered 1-5, which may be used for additional camera requirements including but not limited to power, alarms or grounds. All soldering shall be per IPC J STD-001E *Requirements for Soldered Electrical and Electronic Assemblies*. Each individual contact shall be rated for up to 600 volts and 7 amps, but de-rated according to the wire used in the application. For optimum weatherproofing, each male shall be self-wiping with a shoulder at the base of each male contact so that it will recess into the female block, thereby giving a rain-tight seal to each individual contact when mated. Furthermore, the wire leads from both the male and female rubber contact blocks shall be permanently and integrally molded in the synthetic rubber body. The facility manufacturing the electrical contact connector must comply with ISO 9001.

2. *Lowering Tool.* The camera lowering system shall be operated by use of a portable lowering tool. The tool shall consist of a lightweight metal frame and winch assembly with factory spooled stainless steel aircraft cable, a quick release cable connector, an adjustable safety clutch and a variable speed industrial duty electric drill motor. This tool shall be compatible with accessing the support cable through the hand hole of the pole. The lowering tool shall have the capability to be securely attached to the pole with one single bolt. The tool must support itself and the load during lowering and lifting operations. The winch assembly shall include an automatic braking system that provides a means to prevent freewheeling when loaded. One lowering tool per project shall be delivered to the Project Engineer upon project completion. The lowering tool shall have a reduction gear to

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CLOSED CIRCUIT TELEVISION POLE WITH LOWERING DEVICE

reduce the manual effort required to operate the lifting handle to raise and lower a capacity load. The lowering tool shall be provided with an adapter for operating the lowering system by a portable drill using a clutch mechanism. The lowering tool shall be equipped with a positive braking mechanism to secure the cable reel during lifting and lowering operations and prevent freewheeling. The manufacturer shall provide a variable speed, heavy-duty reversible drill motor, clutch and one lowering tool for every five camera lowering system poles provided as part of this Project. The lowering tool shall be made of durable and corrosion resistant materials, powder coated steel, galvanized steel, heavy duty aluminum or otherwise protected from the environment by industry-accepted coatings to withstand exposure to a corrosive environment.

3. *Camera Junction Box*. The camera junction box shall be used to provide both a mounting location for the CCTV camera as well as an interface compartment for wire leads from the lowering system to the CCTV camera or applicable surge suppression module. The camera junction box shall consist of a two piece clamshell design with one removable hinge side and one latch side with a single toggle bolt to facilitate easy access. The general shape of the box shall be cylindrical to minimize the effective projected area. The camera junction box shall be cast aluminum with stabilizing weights on the outside of the box to increase room on the interior. The camera junction box shall be capable of accommodating up to 40 pounds of stabilizing weights. The bottom of the camera junction box shall be drilled and tapped with a 1.5 inch National Pipe Thread (NPT) female thread to accept industry standard dome housings and must include the capability to be modified to accept a wide variety of other camera mountings. The camera junction box shall be gasketed to prevent water intrusion. The bottom of the camera junction box shall incorporate a screened and vented hole to allow airflow and reduce internal condensation.

4. *Miscellaneous*. All pulleys for the camera lowering system and portable lowering tool shall have sealed, self-lubricated bearings, oil tight bronze bearings, or sintered oil impregnated bronze bushings. The lowering cable shall be a minimum 0.125 inch diameter stainless steel aircraft cable with a minimum breaking strength of 1,740.

   All electrical and video Ethernet connections between the fixed and lowered portion of the contact block shall be protected from exposure to the weather by both a gasket on the bottom side of the bell housing enclosure as well as the “O” ring shoulders at the base of each male contact pin to prevent degradation of the power/signal contacts.

   The interface and locking components shall be made of stainless steel or aluminum. All external components of the lowering system shall be made of corrosion resistant materials, powder coated, galvanized, or otherwise protected from the environment by industry-accepted coatings to withstand exposure to a corrosive environment.

   In the event any CCTV is not properly weight balanced and plumb, the CCTV camera manufacturer shall provide weights or counterweights as necessary to assure that the alignment of pins and connectors are proper for the camera support to be raised into position without binding.

   The CCTV camera manufacturer or Contractor shall provide all applicable power and signal connectors for attachment to the bare leads and shielded RJ-45 male connectors in the pole top and camera junction boxes.

   The CCTV camera manufacturer or Contractor shall provide appropriate length of outdoor-rated CAT5e STP (stranded) cable (PoE/signal) in one continuous run from the respective equipment cabinet to the pole top junction box of each lowering system pole.

   The caisson foundation shall be in accordance with the CDOT Caisson Foundation Detail for CCTV Pole with Lowering Device.

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5. *Camera Lowering System Pole.*

A. Dimensions and Pipe Wall Thickness: Steel pole dimensions, wall thickness, and details shall be in accordance with the most recent CDOT Standard Drawing "CCTV Pole with Lowering Device".

B. Fabricator: The fabricator shall be certified under Conventional Steel Building Structures (SBD) as set forth by the American Institute of Steel Construction (AISC) Quality Certified Fabricators Program. Proof of this certification shall be supplied with its pole submittal to ensure that the fabricator has the personnel, organization, experience, procedures, knowledge, equipment, capability and commitment to fabricate quality steel pole structures.

C. Welding: All welding shall be in accordance with Sections 1 through 8 of the American Welding Society (AWS) D1.1 Structural Welding Code for Steel. Tackers and welders shall be qualified in accordance with the code. Tube longitudinal seam welds shall be free of cracks and excessive undercut, performed with automatic processes, and be visually inspected. Longitudinal welds suspected to contain defects shall be magnetic particle inspected. All circumferential butt-welded pole splices shall be ultrasonically or radiographically inspected.

D. Material Certifications: All materials and products shall be manufactured in the United States of America, and comply with ASTM or AASHTO specifications. Mill certifications shall be supplied as proof of compliance with the specifications.

E. Pole Shaft: The pole shaft should be one piece construction up to 50 feet in length, and shall conform to ASTM A595 *Standard Specification for Steel Tubes, Low Carbon* or High-Strength Low-Alloy, Tapered for Structural Use Grade A with a minimum yield strength of 55 kips per square inch or ASTM A572 Standard Specification for High- Strength Low-Alloy Columbium-Vanadium Structural Steel with a minimum yield strength of 55 kips per square inch. Poles greater than 50 feet in length shall be of multi-piece construction. All structures with pole shaft diameters of 26 inches or less shall be round; pole shaft diameters greater than 26 inches may be round or multi- sided. The shaft shall have a constant linear taper not exceeding 0.14 inch per foot, and contain only one longitudinal seam weld. Circumferential welded tube butt splices and laminated tubes are not permitted. Longitudinal seam welds within 6 inches of complete penetration pole to base plate welds shall be complete penetration welds.

F. Hand Holes for Winch Operation: A single hand hole may be provided in lieu of the dual hand holds detailed. If a single hand hole is detailed, the hand hole opening shall be designed to meet AASHTO fatigue requirements in accordance with the latest interim revisions to the code, and reinforced with a minimum 2 inch wide hot rolled steel rim. The nominal outside dimension of a single hand hole shall be 6 inches by 27 inches. The single hand hole shall have a tapped hole for mounting the portable winch thereto and include a cover. Unless otherwise noted, the bottom lip of the single hand hole shall be located on the shaft between 30 inches to 33 inches from the baseplate.

G. Pole Top Tenon: The pole shall have a custom plate mounted tenon as detailed in the most recent CDOT Standard Drawing "*CCTV Pole with Lowering Device"*.

H. Cable Supports/Electrical Cable Guides and Parking Stand (Eyebolts): Cable supports, Electrical Cable Guides and Parking Stands shall be as detailed in the most recent CDOT Standard Drawing *"CCTV Pole with Lowering Device"*.

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CLOSED CIRCUIT TELEVISION POLE WITH LOWERING DEVICE

I. Ground Lug: A ground lug shall be provided within the interior base of the pole for connection to a grounding system conforming to the requirements of Revision of Section 614 – Grounding and Bonding. A bare copper ground wire shall be provided by the Contractor between the pole's ground lug and a ground rod adjacent to the pole's caisson to provide grounding. The ground wire shall be installed in a dedicated conduit (0.5 inch diameter, minimum) within the pole caisson as provided by the Contractor. The Contractor shall bond the ground wire to the pole's ground lug and the ground rod. The Contractor shall furnish and install a copper coated steel ground rod (0.625 inch diameter and 8 feet long, minimum) and bond the ground rod to the pole's ground lug. The cabinet ground busbar and electrical disconnect (if applicable) shall be bonded to the pole's ground lug through the use of ground wire. The size of the ground wire, bonding methods, and ground rod installation, material and size shall be in conformance with Article 250 of the current edition of National Fire Protection Association (NFPA) 70 National Electric Code (NEC), unless otherwise specified by the Engineer.

J. Base Plates: At a minimum, base plates shall conform to ASTM A36 *Standard Specification for Carbon Structural Steel* or A572 Grade 50. Plates shall be integrally welded to the tubes with a telescopic welded joint or a full penetration butt weld with backup bar. Plates shall be hot dip galvanized per the requirements of the contract documents.

K. Anchor Bolts: At a minimum, anchor bolts shall conform to the requirements of ASTM F1554 *Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength* Grade 55. The upper 12 inches of the bolts shall be hot dip galvanized per ASTM A153 *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*. Each anchor bolt shall be supplied with two hex nuts and two flat washers. The strength of the nuts shall equal or exceed the proof load of the bolts.

CONSTRUCTION REQUIREMENTS

All work shall conform to the specifications referenced herein and the current edition of NFPA 70, and shall comply with applicable regulations as specified in subsection 107.01 of the CDOT Standard Specifications for Road and Bridge Construction.

Each CCTV Pole with Lowering Device shall be installed as described herein. The Contractor shall furnish and install all incidentals necessary to provide a complete working system at each location.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
COARSE WAVELENGTH DIVISION MULTIPLEXING MODULE

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Coarse Wavelength Division Multiplexing (CWDM) Module for this project shall be rack mounted and support 10 wavelengths from 1430nm to 1610nm with LC/APC Port Bulkheads, Test In Port, Test Out Port and Pass Port installed in regeneration node building or CTMC equipment racks or cabinets. The unit shall have the capabilities of passively multiplexing and de-multiplexing multiple wavelengths to and from field Ciena 3930 Ethernet switches and communications node building Ciena Ethernet Switch small form-factor pluggable optic modules.

The 10-channel CWDM modules shall be supplied with the ability of connecting a Spectrum Analyzer to the test ports to test both the incoming and outgoing wavelengths without the need of disconnecting active patch cables transmitting or receiving data.

MATERIALS

Each 10-channel CWDM module shall have twelve (12) transmit / receive ports. Ten of the 12 ports shall be for individual wavelength matching the Ethernet switch CWDM, SFP optic modules.

The bulkhead connector for each port on the CWDM module shall be of the duplex LC/APC type; simplex LC/APC type bulkhead connector ports shall not be allowed.

The 10-channel CWDM module shall have the ability of multiplexing and de-multiplexing the following wavelengths: 1430nm, 1450nm, 1470nm, 1490nm, 1510nm, 1530nm, 1550nm, 1570nm, 1590nm and 1610nm.

The 10-channel CWDM modules shall also include a chassis capable of mounting in a 19 inch communications equipment rack or cabinet. The chassis shall have an integrated cable management tray on the front side to house the optical patch cables installed from the CWDM multiplexing module ports to the Ethernet switch optic modules.

CONSTRUCTION REQUIREMENTS

The 10-channel CWDM multiplexing modules and chassis shall be installed in 19 inch equipment racks or cabinets in regeneration node buildings or the CTMC. The 10-channel CWDM multiplexing modules and chassis shall be installed adjacent to its corresponding Ciena 5150 Carrier Ethernet SAS switch. Where slots are available in existing chassis, the Contractor may utilize these slots for CWDM modules, pending approval by the Engineer.

Single mode, bend insensitive, pre-connectorized duplex patch cable with a polyurethane jacket shall be installed from the 10-channel CWDM module to the backbone termination patch panel for transmitting and receiving communications to the field Ethernet switches. Connectors for the patch cable shall be LC on the 10-channel CWDM module end and LC on the termination patch panel end.

Single mode, bend insensitive, pre-connectorized duplex patch cables with a polyurethane jacket shall be installed from each 10-channel CWDM module wavelength Tx/Rx port to the matching CWDM SFP optic module on its corresponding Ciena 5150 Carrier Ethernet SAS switch. A duplex patch cable shall be installed for each wavelength. Connectors for the patch cables shall be LC on the10-channel CWDM module end and LC on the Ethernet switch SFP optic module end.

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REVISION OF SECTION 614
COARSE WAVELENGTH DIVISION MULTIPLEXING MODULE

In communication node buildings, the patch cables shall be of sufficient length to span from the termination patch panel to the 10-channel CWDM module and from the 10-channel CWDM module to the Ciena 5150 Ethernet switch with a maximum of four (4) feet of slack for each cable. They shall be installed in a manner which will not interfere with equipment in the equipment racks and will include cable management so as not to interfere with future maintenance within the rack.

If for any reason the 10-channel CWDM module is defective or is damaged at the time of installation by the Contractor, the item shall be removed and replaced at no additional cost to the project. Modules shall also be replaced if any failures occur due to manufacturer's defect, at no additional cost to the project, prior to the final network acceptance.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
COARSE WAVELENGTH DIVISION MULTIPLEXING SFP

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project, the Coarse Wavelength Division Multiplexing SFP shall be a single wavelength CWDM SFP optic module for installation in a Ciena 3930/3931 Carrier Ethernet SDS. There shall also be a matching CWDM SFP optic module installed at the corresponding Ciena 5150 Carrier Ethernet SAS. All CWDM SFP optic modules shall be provided from a manufacturer recommended by Ciena.

MATERIALS

The Contractor shall furnish and install the CWDM SFP optic modules in the wavelengths as shown in the item table below. This table describes optic modules for installation in Ciena 3930/3931 Carrier Ethernet SDS Ethernet switches and Ciena 5150 Carrier Ethernet SAS switches. The Contractor shall be responsible for providing CWDM SFP optic modules for the corresponding Ciena 5150 Carrier Ethernet SAS switches utilized on this project.

Item Table – CWDM SFP Optic Modules for Ciena 3930 Carrier Ethernet SDS switches and Ciena 5150 Carrier Ethernet SAS switches.

Table A - CWDM SFP Optic Modules for Ciena 3930 Carrier Ethernet SDS switches and Ciena 5150 Carrier Ethernet SAS Switches

ITEM DESCRIPTION	ITEM NUMBER
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1430 NM, EXT. TEMP	XCVR-A80D43
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1450 NM, EXT. TEMP	XCVR-A80D45
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1470 NM, EXT. TEMP	XCVR-A80D47
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1490 NM, EXT. TEMP	XCVR-A80D49
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1510 NM, EXT. TEMP	XCVR-A80D51
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1530 NM, EXT. TEMP	XCVR-A80D53
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1550 NM, EXT. TEMP	XCVR-A80D55
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1570 NM, EXT. TEMP	XCVR-A80D57
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1590 NM, EXT. TEMP	XCVR-A80D59
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1610 NM, EXT. TEMP	XCVR-A80D61

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REVISION OF SECTION 614
COARSE WAVELENGTH DIVISION MULTIPLEXING SFP

If for any reason the CWDM SFP optic modules are defective or are damaged at the time of installation by either the Contractor or by Ciena, the optic module shall be removed and replaced at no additional cost to the project. CWDM SFP optic modules shall also be replaced if any failures occur due to manufacturer's defect, at no additional cost to the project prior to the final network acceptance.

CenturyLink is the Ciena Corporation qualified equipment supplier for the State of Colorado, Colorado Department of Transportation, Intelligent Transportation Systems for networking equipment and associated network materials.

For project equipment estimate quotations and purchasing, Contractors shall contact the following distributer representative:

Project equipment, equipment estimates, and purchasing distributer representative:

Keith A. Glose

Premier Account Manager

CenturyLink Government

930 15th Street, 4th Floor, Denver, Colorado 80202

Telephone: 303-992-5567 Fax: 720-578-2694

E-Mail: keith.glose@centurylink.com

Neither CenturyLink nor Ciena Corporation will be involved in the design of the project corridor network. The Contractor shall contact the CenturyLink representative for equipment quotations and purchasing purposes only. The Contractor shall not contact or rely on either CenturyLink or Ciena for network design related questions.

When requesting quotations, the Contractor shall submit to CenturyLink a complete package including the following items:

- A complete list of required equipment for purchase including materials and quantities based on the individual project specifications to achieve a complete item(s) installation.
- A PDF copy of all project specifications pertaining to the material being ordered.
- A PDF copy of all networking project plan sheets.

It is the Contractor's responsibility to provide the distributer's representative all information required pertaining to the complete network design. During the project, CenturyLink or Ciena Corporation is not responsible for any type of network design aide. All questions pertaining to the design shall be through the Project Engineer for help or clarification.

CONSTRUCTION REQUIREMENTS

For Ciena 3930/3931 Carrier Ethernet SDS switch installations, a CWDM SFP optic module(s) shall be installed in each switch for CWDM data communications. A matching CWDM SFP optic module shall be installed at its corresponding Ciena 5150 Carrier Ethernet SAS switch.

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REVISION OF SECTION 614
COARSE WAVELENGTH DIVISION MULTIPLEXING SFP

The Contractor shall ensure that the wavelengths of the CWDM SFP optic modules installed in the Ciena 3930/3931 Carrier Ethernet SDS Ethernet switches match those installed in its corresponding Ciena 5150 Carrier Ethernet SAS switch to ensure proper data communications.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
COMMUNICATIONS CABINET

Section 614 of the Standard specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing ground mounted communications cabinets.

The Communications Cabinet (for Tolling) shall be a Type M Stretch Cabinet furnished for designated tolling field device sites to house and protect tolling equipment, communications equipment and power connections. The tolling equipment will be provided by others.

The Communications Cabinet (Type 332) shall be a Type 332 cabinet and furnished for designated locations to house and protect Toll Point Uninterruptible Power Supplies (UPS) and power connections.

The Communications Cabinet (Type 332D) shall be a Type 332D cabinet and furnished for VTMS and ITS field device sites that have UPS to house and protect field equipment, communications equipment, UPS and power connections.

MATERIALS

Subsection 614.02 shall include the following:

Communications Cabinets: The nominal dimensions shall be as shown in Table 1 below. Some variance from these dimensions may be accepted at the Engineer's discretion.

Table 1 - Communications Cabinet Types

Cabinet Type	Nominal Dimensions
Communications Cabinet (for Tolling)	68" (H) × 31" (W) × 19" (D)
Communications Cabinet (Type 332)	67" (H) × 24" (W) × 30" (D)
Communications Cabinet (Type 332D)	67" (H) × 49" (W) × 30" (D)

The following items apply to all ground mounted communications cabinets:

- Communications cabinets shall be UL 508A *Industrial Control Panels* listed and conform to a NEMA Type 3R rating. Communications cabinets shall be H-32 aluminum conforming to the requirements of ASTM B209 *Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate*.
- All bolts, clamps, fasteners, hinges, latches, nuts and screws shall be stainless steel, unless an alternative corrosion proof material is approved in writing by the Department.
- A cabinet grounding stud shall be provided in the vicinity of the cabinet ground bus bar.
- All fabricated materials and added components must be free from burrs and sharp edges. Exterior seams of the cabinet shall be continuously welded with edges ground smooth to a 0.03 inch radius. All welding shall be done with gas tungsten arc welds that comply with AWS B2.1-22-015 *Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Aluminum* and C5.6 *Recommended Practices for Gas Metal Arc Welding*. All welds shall be neatly formed and free of blisters, blowholes, cracks and other irregularities. All bolts, clamps, fasteners, hinges, latches, nuts and screws shall be stainless steel, unless an alternative corrosion proof material is approved in writing by the Department.

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REVISION OF SECTION 614
COMMUNICATIONS CABINET

- The cabinet door openings shall be designed to prevent dust and moisture intrusion in conformance to NEMA 3R requirements. All flange joints shall be welded or continuously formed. The doors shall have an adequately sized, oil-resistant gasket that provides a uniform seal with the door frame surface in conformance with NEMA 3R requirements and shall be permanently bonded to the door. The door shall utilize a continuous stainless steel hinge that allows for door removal from the hinge side. Hinges shall be mounted such that the cabinet door opens out to the left, unless otherwise specified by the Department.
- Hinges shall be mounted with appropriately sized stainless steel hardware. The door shall be equipped with a hasp and staple for padlocking and Corbin #2 key lock be utilized in place of the hasp and staple if the NEMA 3R rating can be maintained. A document holder constructed of high-impact thermoplastic shall be provided for each communications cabinet and permanently mounted to the lower portion of the inside door. The Contractor shall insert a copy of the communications cabinet Bill of Materials (BOM), individual communications cabinet component specification sheets and an as built electrical/low-voltage wiring diagram of the communications cabinet in the document holder.

Warranty: The communications cabinet manufacturer shall affix a permanent label on the inside of the door that identifies the cabinet type, date of manufacture, warranty expiration date and manufacturer's name. The warranty expiration date shall be expressed in the (mm/dd/yyyy) format. The warranty shall cover all communication cabinet materials and workmanship for two (2) years after delivery of each communication cabinet.

DIN Rail: A DIN rail shall be provided with each cabinet.

Internal Cabinet Lighting: Provide a minimum of two light-emitting diode (LED) light strips per door opening to provide illumination for the entire cabinet interior. Each door opening shall also be equipped with a door switch to activate the cabinet lighting. LED light strips and door switches shall be mounted such that they do not interfere with use of rack space or other devices in the cabinet and shall be easily removable for replacement.

Ventilation: Provide independently wired, 100 CFM exhaust fans near the top of the cabinet that are controlled by independent adjustable thermostats. Provide filtered air intake ports with removable and replaceable filter on the bottom third of each access door.

Grounding Bus Bar: Equipment ground bus bars shall be provided for each Communication Cabinet. Bus bars shall be UL listed and be fabricated from solid, 110 alloy copper. Each bus bar shall accommodate a minimum of seven (7) lug positions. The equipment grounding bus bar shall provide an additional 25% lug position capacity over the amount of terminations utilized for the various Communication Cabinet applications. Multiple bus bars may be used within each Communication Cabinet, if the interior dimensions of the cabinet do not allow for the use of a larger bus bar. Each bus bar shall include insulators, stand-off brackets, snap on covers, and stainless steel mounting hardware.

Foundation: Each Communications Cabinet shall include a polymer concrete or poured concrete pad that extends at least 2'-6" beyond the cabinet base on each cabinet door side and at least 6" beyond the cabinet base on the other two sides. The cabinet base shall be sealed around the conduits.

The following items are specific to the Communications Cabinet (For Tolling) only:

Back Panel: Cabinet back panel shall be constructed of 0.10 inch Type 5052-H32 aluminum alloy unless otherwise specified by the Department. The back panel dimensions shall be approximately

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REVISION OF SECTION 614
COMMUNICATIONS CABINET

25" W x 54" H, and shall be offset from the back of the cabinet with enough air space to allow for mounting screws to be used without penetrating the external cabinet shell. Panel should mount on fixed bolts inside the cabinet. If not included, E-470 will procure side planes to be incorporated allowing for all ITS equipment to be accommodated. All associated mounting hardware for the back panel shall be included with each communications cabinet and be rated for use in NEMA 3R cabinets.

Circuit Breakers: Two 20 amp breakers and one 40 amp main breaker shall be provided with the cabinet. The breakers shall be DIN rail mountable.

Cabinet Riser: A minimum 12" high riser is required for the tolling point cabinets. The riser shall be constructed from the same material as the cabinet and shall include a connection mechanism to which the cabinet can be attached. The bottom of the riser shall be solidly connected to the pad.

The following items are specific to the Communications Cabinet (Type 332) only:

Cabinet Rack: Full-height standard Electronics Industry Alliance (EIA) 19-inch rack with a minimum of one (1) pullout drawer.

Insulation: Provide R-4 insulation on interior, sides, top and all doors.

Load Center: Each load center shall be readily accessible on the interior of the cabinet close to the door. The load center shall provide a main and a minimum of three (3) branch circuits. The neutral and ground bars shall be tied together in the load center.

Receptacles: Provide a minimum of one (1) 15-amp NEMA 15-R 120VAC duplex GFCI receptacle labeled "Convenience Outlet" and one (1) 15-amp NEMA 15-R 120VAC duplex receptacle labeled "ITS Equipment".

The following items are specific to the Communications Cabinet (Type 332D) only:

Cabinet Rack: Two (2) full-height standard Electronics Industry Alliance (EIA) 19-inch racks with a minimum of one (1) pullout drawer.

Insulation: Provide R-4 insulation on interior, sides, top and all doors.

Load Center: Each load center shall be readily accessible on the interior of the cabinet close to the door. The load center shall provide a main breaker and a minimum of four (4) branch circuits. The load center shall be Underwriters' Laboratories (UL) listed and provide a short circuit rating of 22,000 amps for main and 10,000 amps branch circuits.

Receptacles: Provide a minimum of one (1) 15-amp NEMA 15-R 120VAC duplex GFCI receptacle labeled "Convenience Outlet" and one (1) 15-amp NEMA 15-R 120VAC duplex receptacle labeled "ITS Equipment".

CONSTRUCTION REQUIREMENTS

Each communications cabinet (for tolling) shall have tapped pads to provide for the mounting of a back panel as specified herein.

Conduit accesses into the cabinet for electrical wiring, specific field device low-voltage control cabling, waveguides and fiber optic cabling, shall be plugged with a manual plug (no foam sealant is allowed).

After installation, the top of the cabinet should be approximately 5 feet above the prevailing ground line.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
COMMUNICATIONS CABINET (TYPE 2)

Section 614 of the Standard specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing communications cabinets at Intelligent Transportation System (ITS) field device locations without Uninterruptible Power Supplies (UPS) to house and protect electrical power components, DIN rails, field equipment, serial servers, communications telemetry equipment, and fiber optic termination panels. Communication Cabinet (Type 2) shall be a Caltrans 336S and shall be pole-mounted at all CCTV lowering device locations and sign structure. Ground-mounted cabinets shall include a raised polymer concrete or poured concrete pad and base.

MATERIALS

Communications Cabinets: The nominal dimensions shall be as shown in Table 1 below. Some variance from these dimensions will be accepted, at the Engineer's discretion.

Table 1 - Communications Cabinet Types

Communications Cabinet	Dimensions	Maximum Weight (w/o back panel)
Type 2	46 inches (H) × 24 inches (W) × 22 inches (D)	N / A

Communications cabinets shall be UL 508A Industrial Control Panels listed and conform to a NEMA Type 3R rating. Communications cabinets shall be H-32 aluminum conforming to the requirements of ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

All bolts, clamps, fasteners, hinges, latches, nuts and screws shall be stainless steel, unless an alternative corrosion proof material is approved in writing by the Department.

A cabinet grounding stud shall be provided in the vicinity of the ground bus mounted on the back panel as shown on the Plans.

All fabricated materials and added components must be free from burrs and sharp edges. Exterior seams of the cabinet shall be continuously welded with edges ground smooth to a 0.03 inch radius. All welding shall be done with gas tungsten arc welds that comply with AWS B2.1-22-015 Standard Welding Procedure Specification for Gas Tungsten Arc Welding of Aluminum and C5.6 Recommended Practices for Gas Metal Arc Welding. All welds shall be neatly formed and free of blisters, blowholes, cracks and other irregularities. All bolts, clamps, fasteners, hinges, latches, nuts and screws shall be stainless steel, unless an alternative corrosion proof material is approved in writing by the Department.

The cabinet door openings shall be designed to prevent dust and moisture intrusion in conformance to NEMA 3R requirements. All flange joints shall be welded or continuously formed. The doors shall have an adequately sized, oil-resistant gasket that provides a uniform seal with the door frame surface in conformance with NEMA 3X requirements and shall be permanently bonded to the door. The door shall utilize a continuous stainless steel hinge that allow for door removal from the hinge side. Hinges shall be mounted such that the cabinet door opens out to the left, unless otherwise specified by the Department. Hinges shall be mounted with appropriately sized stainless steel hardware.

The door shall be equipped with a hasp and staple for padlocking and Corbin #2 key lock be utilized in place of the hasp and staple if the NEMA 3R rating can be maintained. A document holder constructed of high-impact thermoplastic shall be provided for each communications cabinet and

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REVISION OF SECTION 614
COMMUNICATIONS CABINET (TYPE 2)

permanently mounted to the lower portion of the inside door. The Contractor shall insert a copy of the communications cabinet Bill of Materials (BOM), individual communications cabinet component specification sheets and an as- built electrical/low-voltage wiring diagram of the communications cabinet in the document holder.

Warranty: The communications cabinet manufacturer shall affix a permanent label on the inside of the door that identifies the cabinet type, date of manufacture, warranty expiration date and manufacturer's name. The warranty expiration date shall be expressed in the (mm/dd/yyyy) format. The warranty shall cover all communication cabinet materials and workmanship, including pole mounting kits, for two (2) years after delivery of each communication cabinet.

Internal Cabinet Lighting: Provide a minimum of two light-emitting diode (LED) light strips per door opening to provide illumination for the entire cabinet interior. Each door opening shall also be equipped with a door switch to activate the cabinet lighting. LED light strips and door switches shall be mounted such that they do not interfere with use of rack space or other devices in the cabinet and shall be easily removable for replacement.

Insulation: Provide R-4 insulation on interior, sides, top and all doors.

Ventilation: Provide independently wired, 100 CFM exhaust fans near the top of the cabinet that are controlled by independent adjustable thermostats. Provide filtered air intake ports with removable and replaceable filter on the bottom third of each access door.

Grounding Bus Bar: Equipment ground bus bars shall be provided for each Communication Cabinet. Bus bars shall be UL listed and be fabricated from solid, 110 alloy copper. Each bus bar shall accommodate a minimum of seven (7) lug positions. The equipment grounding bus bar shall provide an additional 25% lug position capacity over the amount of terminations utilized for the various Communication Cabinet applications. Multiple bus bars may be used within each Communication Cabinet, if the interior dimensions of the cabinet do not allow for the use of a larger bus bar. Each bus bar shall include insulators, stand-off brackets, snap on covers, and stainless steel mounting hardware.

Cabinet Layout: Each Communications Cabinet shall be physically divided into two (2) sides by a sliding aluminum backplane. The front side will house all associated ITS electronics, communication device hardware and a duplex GFCI convenience outlet. The back side will house the power and fiber resources, such as: 120V main power feeding the cabinet, the Clary power conditioner, 6-outlet power strip, equipment power supplies, the fiber termination panel and slack fiber.

Back Plane (Front and Back Sides): The back plane shall be constructed of 0.10 inch Type 5052-H32 aluminum alloy, unless otherwise specified by the Department. A two-sided back plane and associated mounting hardware shall be included with each communications cabinet and be rated for use in NEMA 3R cabinets. The backplane shall be approximately 1-inch less on each side than the inside dimensions. The back plane shall have at least 1inch of air space between the two sides to allow for mounting screws to be used from either side without protrusion through the opposing face. The backplane shall be mounted within the communications cabinet with a minimum of four screws on an adjustable sliding channel.

Outlet Box (Front and Back Sides): The communications cabinet shall contain a 4 inch square junction box attached to the backplane of the front side and near the door opposing the external service disconnect on the side wall of the back side. Each junction box shall be constructed of drawn or welded steel and have a minimum depth of 1.25 inches. Each junction box shall include knockouts and clamps for conduit and cables, as appropriate. Steel box covers shall be provided with each junction box as appropriate for a duplex receptacle or a duplex GFCI receptacle.

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REVISION OF SECTION 614
COMMUNICATIONS CABINET (TYPE 2)

A duplex NEMA 5-15R GFCI receptacle shall be provided within the outlet box mounted to the backplane of the front side. NEMA 5-15R GFCI receptacles shall be rated for 125 VAC, 0.5 HP and 15 A. It shall be of commercial grade quality and manufactured from high strength nylon.

A duplex NEMA 5-15R receptacle shall be provided on the back side within the outlet box opposing the external service disconnect. The NEMA 5-15R receptacle shall be rated for 125 VAC, 0.5 HP and 15 A. It shall be of commercial grade quality and be manufactured from high strength nylon. The NEMA 5-15 receptacle shall have two poles, three wires and include a self- grounding strap to insure ground contact.

Both duplex NEMA 5-15R and duplex NEMA 5-15R GFCI receptacles shall be UL listed.

Power Conditioner (Back Side): The power conditioner shall be installed in the cabinet to provide both fully regenerated, conditioned power with true sine wave and continuous AC outputs to controllers and communication devices, simultaneously. The power conditioner shall be designed for outdoor use, support an operating temperature range of -40°F to +165°F, be operational in humidity levels of 0% to 95% (non-condensing) and operate at an altitude ranging from sea level to two miles above sea level. It shall utilize an input voltage of 120 VAC, 40 to 70 Hz and an output voltage of 120 VAC (± 3%), user selectable 50 to 60 Hz (± 0.25%). The power conditioner shall support a maximum output of 1400W at 120 V. It shall have a total harmonic distortion not exceeding 3.0%. The power conditioner shall utilize input and output electrical connectors conforming to the IEC 60320-1 *Appliance Couplers for Household and Similar General Purposes* specification. Its dimensions shall not exceed 1.7 inches (H) × 11 inches (W) × 8.5 inches (D) and its weight shall not exceed 5 lbs. One power conditioner shall be provided with each communications cabinet.

Six Outlet Power Strip (Front Side): An integral component of the power conditioner shall be a factory-installed power strip. The power strip shall have six front facing NEMA Type 5-20R outlets. The power strip shall be rated for 20 A at 120 VAC. It shall have an energy rating of 630 Joules, clamping voltage of 500 V and EMI/RFI noise filter of 150 KHz to 100 MHz at up to 43 dB. The power strip shall have a recessed power switch and a power cord of not less than 2.5 feet. The dimensions of the power strip shall be 10 inches (L) × 1.63 inches (W).

DIN Rails (Front Side): Each communications cabinet shall utilize standard 1.38 inch DIN rails. The DIN rails shall be of steel construction with a coating for corrosion resistance. The DIN rails shall utilize 0.25 inch × 0.71 inch slots for fastening to the back panel located in each communications cabinet. The spacing of the DIN rail slots shall be 0.98 inch center-to-center. DIN rails and associated mounting hardware for attachment to the back panel shall be provided with each communications cabinet.

12 VDC Power Supply (Front Side): The 12 VDC power supply shall support an input voltage range of 85-264 VAC and frequency range of 47-63 Hz. It shall have a typical efficiency of at least 76% and typical AC current of 1.6 A at 115 VAC. The 12 VDC power supply shall provide an output voltage of 12 VDC and have a current rating of 6.3 A. It shall support an output current range of 0 to 6.3 A and have a rated power of 75 W. The 12 VDC power supply shall have overload protection of 105-150% for its rated output power and overvoltage protection for voltages of 15-

16.5 VDC. It shall be designed for an operating temperature of +14°F to +140°F and humidity levels of 20% to 90% (non-condensing). The 12 VDC power supply shall conform to the following standards: IEC 60068-2-6 Environmental Testing (Vibration) and UL 508 Industrial Control Equipment. It shall be DIN rail mountable, have dimensions not exceeding 5 inches (h) × 2.25 inches (w) × 4 inches (d) and a weight of not more than 1.5 lb. One 12 VDC power supply shall be provided with each communications cabinet.

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REVISION OF SECTION 614
COMMUNICATIONS CABINET (TYPE 2)

Load Center: Each load center shall be readily accessible and installed on the exterior of the cabinet close to the door on the back side, positioned not more than 6 feet 7 inches above the ground or as required per Article 240.24 of the NEC. The neutral from the power source or service enclosure shall be connected to the ground bar in the load center. The ground bar shall be connected to the service disconnect using a bonding strap. The ground bar shall be connected to a grounding electrode using grounding conductors conforming to the requirements of Article of the NEC. The grounding electrode shall conform to the requirements of Articles 250.52 through 250.70 of the NEC. The load center shall feed a duplex NEMA 5-15R mounted on the inside of the cabinet.

Foundation: Each Communication Cabinet (Type 2) that is to be ground-mounted shall include a polymer concrete or poured concrete pad that extends at least 2'-6" beyond the cabinet base on each cabinet door side and at least 6" beyond the cabinet base on the other two sides. There shall also be an 18" high aluminum riser. The bottom of this riser shall be solidly connected to the pad. The riser shall include connection mechanisms to which the cabinet can be attached.

CONSTRUCTION REQUIREMENTS

Each communications cabinet shall have tapped pads to provide for the mounting of a back panel as specified herein.

The cabinet backplane shall be adjusted in depth to allow mounting of a 10 inch deep Ethernet switch on the front side rack rails.

Mounting of equipment and hardware onto the back panel shall be through the use of self-tapping screws or Velcro Extreme as required per the Plans. Self-tapping screws shall be of appropriate size for the equipment or hardware being installed onto the back panel. The length of the self- tapping screw shall not exceed a ½ inch and the bit recess in the screw head shall be hexagonal.

The power conditioner and battery shall be mounted to the back plane on the back side of the cabinet such that cooling vents remain unobstructed. The power strip shall be mounted on the back panel on the front side of the cabinet as shown in the Plans.

DIN rail, and 12 V DCD power supply shall be mounted to the back panel on the front of the cabinet to allow for current and future equipment.

Conduit accesses into the cabinet for electrical wiring, specific field device low-voltage control cabling, and fiber optic cabling, shall be plugged with a manual plug (no foam sealant is allowed).

Cable management and strain relief shall be employed within the communications cabinet. Cables shall be labeled and neatly organized using cable ties and/or Velcro. Velcro shall be used on fiber optic jumper cables or bundles of cables containing fiber optic jumper cables. Unused spaces within the back panel and interior wall of the communications cabinet may be used to facilitate cable management, but installation of cable management hardware that penetrate the interior walls of the communications cabinet shall not be permitted.

REVISION OF SECTION 614
CONTROLLER CABINET FOUNDATION

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing a fiberglass porch-style traffic signal controller base in the field for 334 traffic signal controller cabinet foundations at ramp meter locations.

MATERIALS

Section 614.10 (e) shall include the following:

Controller foundations shall be preformed type and shall meet the following requirements:

Controller foundation shall be manufactured of fiberglass reinforced polymer concrete. A minimum of 4 - ½ inch x 13 Unified Coarse Thread (UNC) inserts shall be installed for mounting of the controller cabinet to the foundation. Placement of the mounting inserts shall match the mounting configuration of the controller cabinet. The foundation shall be provided with an opening to accommodate access of underground conduit into the controller cabinet. Foundation opening shall match the controller cabinet opening as closely as possible. A minimum of 4 – ½ inch x 13 UNC lifting inserts shall be installed at each corner of the controller cabinet foundation. Lifting inserts shall be designed to support the full weight of the foundation to aid in the moving and placing of the foundation. The walking surface of the foundation shall have a skid resistant surface encompassing three sides of the controller cabinet so field personnel can walk on the foundation from the front door to the back cabinet door.

REVISION OF SECTION 614
DISINCENTIVE FOR ITS OFFLINE DEVICES

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of the maintenance of Intelligent Transportation System (ITS) devices during resetting and reconfiguring for testing communication, and performing cutovers.

Offline, as used in this specification, is defined as time during which data or video is not being received by a Colorado Operations Center or ITS Traffic Management System Building.

CONSTRUCTION REQUIREMENTS

Anytime the Contractor plans to perform work on an ITS device and an outage is not planned, the Contractor shall provide CDOT ITS with a one day advance notification using the attached form. This advance notice, as well as those described below for planned outages, shall be provided to Jill Scott at jill.scott@state.co.us by the Project Engineer.

1. *Planned ITS Outages.* A "planned outage" is considered to be any loss of device functionality or communication that can be anticipated in advance due to work activities within or related to the Project. For planned outages, CDOT ITS shall be given proper advance notice as described below. All proposed equipment, power, and all temporary communications necessary for maintaining ITS devices during construction shall be constructed and put in place prior to the cutover or reset in order to minimize downtime of devices.

    A. ITS Network: The Contractor shall submit a fiber optic backbone cutover plan to CDOT ITS for review two weeks prior to performing the work, as well as a one week advance notice to CDOT ITS of any fiber optic backbone cutover work. This cutover plan shall detail how the Contractor will sequence the construction activities, so that the new backbone is installed and spliced into the existing devices and the node building such that 12-hours of downtime is not exceeded. CDOT's network fibers shall be spliced first in the sequence. The fiber optic backbone splicing shall be scheduled for an overnight shift such that the ITS network shall be fully functional by 4 AM and the remaining cable is complete by 9 AM, unless otherwise approved by the Engineer. The fiber optic backbone splicing shall be scheduled between Tuesday and Thursday, except holidays, unless otherwise approved by the Engineer.

    For work on node locations, the Engineer shall be notified about the need to shut down power in order to perform electrical wiring work at least 48 hours before the power needs to be shut down. Additionally, the Engineer shall be notified the day before the shutdown and on the morning of the day of the shutdown. Power shall be turned off in a responsible manner that will not harm existing node components. All necessary precautions and preparations shall be made and coordinated with CDOT prior to power being turned off.

    Power may not be off for a period of longer than 45 minutes unless specifically authorized by the Engineer.

    B. ITS Devices: The Contractor shall provide a 72-hour advance notice to CDOT ITS to coordinate any downtime for ITS devices for a planned outage. Allowable offline periods for ITS field devices shall be a 48-hour period scheduled between Tuesday and Thursday, excluding holidays, unless otherwise approved by the Engineer. For planned outages where CDOT ITS receives this advance notice, the Contractor shall be charged a disincentive of $50 per hour per each device that is offline beyond the 48 hour allowable offline period. ITS field

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REVISION OF SECTION 614
DISINCENTIVE FOR ITS OFFLINE DEVICES

devices covered under this special provision include, but are not limited to, CCTVs, MVRDs, RWISs, ramp meters, VMSs, and ATRs. No more than two ITS devices shall be inoperable at any one time.

For locations with new poles, all work on the new pole including installation of the cabinet, power, pull boxes, and fiber optic cables shall be advanced to the greatest possible degree of completion before any part of the existing system is disturbed. Once it becomes necessary to disturb the existing system at a given location, work at that location shall progress continuously until the new installation is up and running.

To the greatest possible degree, installation of in-cabinet elements into new cabinets shall be done at locations where no construction traffic control is required.

2. *Unplanned ITS Outages*. An "unplanned outage" is considered to be any loss of network communications or device functionality that CDOT ITS does not receive proper advance notice, as described above, or is due to the Contractor's negligence, act or omission under their control.

   A. ITS Network: If the Contractor damages a CDOT ITS fiber optic backbone, or if CDOT ITS loses communications or power to an ITS Traffic Management System Building or operations center as a result of the Contractor's negligence, act or omission under their control, the Contractor shall be charged a disincentive. This first time network disincentive rate shall be $1,000 per hour, and an additional $2,000 per hour for a communications or power outage that results in loss of data and video to an ITS Traffic Management System Building or operations center.

   This disincentive rate shall increase to $2,000 per hour the second time, and an additional $3,000 per hour for a communications or power outage that results in loss of data and video to a node building or operations center. This increase of $1,000 per hour will continue for any further outages to the CDOT Network.

   Additionally, the Contractor will be responsible for any charges involved with investigating such an outage and restoration of the ITS network to full working condition. These disincentive rates are in addition to the private industries loss of communications.

   B. ITS Devices: For unplanned outages or outages where CDOT ITS does not receive advance notification, the Contractor shall be charged a disincentive of $50 per hour per each device that is offline beginning at the time of the outage.

This disincentive is not a penalty, but is based on costs associated with the disruption of information to the traveling public.

There will be no incentive paid for this work.

The disincentive will be deducted from any monies owed to the Contractor for work performed.

In addition to those disincentives described above, the Contractor will be responsible to pay any penalties charged by private utility owners as a result of damage to their facilities.

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REVISION OF SECTION 614
DISINCENTIVE FOR ITS OFFLINE DEVICES

COLORADO DEPARTMENT OF TRANSPORTATION
TEMPORARY OFFLINE ITS DEVICE NOTIFICATION

Project Description / Location:	Project #:	Project Code (SA #):
Project Engineer:	Project Engineer Contact #:	Date:
Contractor:	Contractor Representative:	Contractor Rep Contact #:

Device Type (VMS, CCTV...)	Highway / Direction (NB I-25)	Mile Marker (241.69)	Description of Device Location (North of St. Vrain River, US-34 Interchange...)	Offline Date (10/26/15)	Estimated Down Time (48 Hours)	Online Date (10/29/15)

Contractor Notes:

Maintenance Notes:

CDOT Form # XXXX 6/15

REVISION OF SECTION 614
ETHERNET ROUTER (5160)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project, Ethernet Router shall be a Ciena 5160 Carrier Ethernet Service Aggregation Switch, utilizing SFP+ optic modules, installed in the existing County Line communication node building to aggregate local and remote Ciena 5150 Carrier Ethernet Service Aggregation Switches at 10 Gbps. The Ciena 5160 Carrier Ethernet Service Aggregation Switch shall interface to an existing Ciena 6500 Packet-Optical Platform at 10 Gbps, unless otherwise specified by CDOT.

The Ciena 5160 Carrier Ethernet Service Aggregation Switch shall have the ability to accept up to a maximum of twenty-four (24) 1Gig or 10 Gig multi-rate SFP+ ports. All XFP optic modules for Ciena 5150s that will interface with the Ciena 5160 as part of this project shall be provided by the Contractor. Additionally, the SFP+ optic module for the Ciena 5160 that is needed to interface with both the Ciena 5150 and 6500 shall also be provided by the Contractor.

A single mode, 9/125um optical attenuator to match the wavelength of the XFP optic modules shall be included and installed in the receive port of the XFP on each Ciena 5150 interfacing with the Ciena 5160, unless otherwise specified by the Engineer. Single mode, 9/125um optical attenuators to match the wavelength of the SFP+ optic module shall be included and installed in the receive port of the SFP+ on the Ciena 5160, unless otherwise specified by the Engineer. Optical attenuators shall also be provided by the Contractor.

MATERIALS

The Ciena 5160 Carrier Ethernet Service Aggregation Switch shall be configured with twenty-four (24) 10G SFP+ ports, one (1) 10/100/1000M RJ-45 management port, one (1) console port (RJ- 45, EIA-561), sixteen (16) external alarm inputs, one (1) RJ-45 sync input/output port and two (2) SMB sync input/output ports.

The Contractor shall furnish and install the Ciena 5160 Carrier Ethernet Service Aggregation Switch and associated items shown in Table A below. The Contractor shall also furnish the Ethernet switch software and maintenance licenses show in Tables B and C. Tables A, B and C describe items to be included with a single 5160 Carrier Ethernet Service Aggregation Switch.

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REVISION OF SECTION 614
ETHERNET ROUTER (5160)

Table A - Ciena 5160 Carrier Ethernet SAS Switch, Hardware Description

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
5160,(24)1G/10G SFP+, (2)SLOTS AC OR DC PLUG POWER SUPPLY	170-5160-900	1
5160, AC PLUGGABLE POWER SUPPLY, WIDE RANGE 120/240V	170-0070-900	2
AC POWER CORD, IEC C13, 5-15P,125VAC,10A, 10FT	170-0044-900	2
DB-9F TO EIA-RJ45M STANDARD, 6 FT SERIAL CONSOLE CABLE	170-0063-900	1
10/100/1000M, SFP TRANSCEIVER, RJ45 CONNECTOR, SGMII, 100 METERS, RX LOS, EXTENDED TEMPERATURE (FOR EXISTING 5150 ONLY)	XCVR-B00CRJ	AS REQUIRED
10GIG, MM XFP OPTIC, LC CONNECTOR, 300 METERS, 850 NM, EXTENDED TEMPERATURE (FOR EXISTING 5150 ONLY)	XCVR-A00Z85	AS REQUIRED
10GIG, MM SFP+, LC CONNECTOR, 300 METERS, 850 NM, EXTENDED TEMPERATURE	XCVR-S00Z85	AS REQUIRED
10GIG,SM SFP+,LC CONNECTOR, 10 KM,1310 NM, EXTENDED TEMPERATURE	XCVR-S10V31	AS REQUIRED
10 GIG, SM SFP+, LC CONNECTOR, 40 KM, 1550 NM, EXTENDED TEMPERATURE	XCVR-S40V55	AS REQUIRED
10GIG, SM SFP+, LC CONNECTOR, 80 KM, 1550 NM, EXTENDED TEMPERATURE	XCVR-S80V55	AS REQUIRED
SFP+, 10GE/FC1200, 850 NM (FOR EXISTING 6500 ONLY)*	160-9111-900*	AS REQUIRED

*Assumes 5160 will interface to a 4x10G OTR card (NTK530QA) in existing 6500; designer to confirm with CDOT.

Table B - Ciena 5160 Carrier Ethernet SAS Switch, SAS Description

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
SAOS ADVANCED ETHERNET PERPETUAL SOFTWARE LICENSE FOR 5160 SYSTEM	S70-0017-900	1
SAOS ADVANCED OAM PERPETUAL SOFTWARE LICENSE FOR 5160 SYSTEM	S70-0017-901	1
SAOS ADVANCED SECURITY PERPETUAL SOFTWARE LICENSE FOR USE WITH SAOS 6.X	170-0204-900	1
ESM CARRIER ED RIGHT TO MANAGE PERPETUAL SOFTWARE LICENSE FOR 5160 SYSTEM	S70-0018-900	1

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REVISION OF SECTION 614
ETHERNET ROUTER (5160)

Table C - Ciena 5160 Carrier Ethernet SAS Switch, Maintenance License

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
GLOBAL 5160 SMARTSUPPORT - 3 YEARS	80M-5160-SSP	1
GLOBAL 5160 STANDARD HARDWARE REPAIR 10-DAY - 3 YEARS	80M-5160-HWM	1
GLOBAL 5160 NEXT BUSINESS DAY SHIP MANAGED SPARES - 3 YEARS	80M-5160-NBS	1

All associated hardware and materials not listed in the item tables are considered subsidiary and required for a complete installation and shall be included as part of the work.

Final configuration including all IP schema design for data transport will be conducted by CDOT personnel after installation.

If field changes are made which affect the original Contractor's material order for the Ethernet switches and require any reconfiguration of the original Ethernet switch material orders, the Contractor shall ensure that the Ciena representative is contacted and made aware of such changes to alleviate any possible delays in delivery and installation. If for any reason the switch or associated materials are defective or are damaged at the time of installation by either the Contractor or by Ciena, the item shall be removed and replaced at no additional cost to the project. Items shall also be replaced if any failures occur due to manufacturer's defects, at no additional cost to the project, prior to the final acceptance.

CenturyLink is the direct contracted equipment supplier of Ciena Corporation for the State of Colorado, Colorado Department of Transportation for networking equipment and associated network materials. For project equipment estimate quotations and purchasing, Contractors shall contact the following distributer representative:

Project equipment, equipment estimates, and purchasing distributer representative:

Keith A. Glose

Premier Account Manager

CenturyLink Government

930 15th Street, 4th Floor, Denver, Colorado 80202

Telephone: 303-992-5567 Fax: 720-578-2694

E-Mail: keith.glose@centurylink.com

Neither CenturyLink nor Ciena Corporation will be involved in the design of the project corridor network. The Contractor shall contact the CenturyLink representative for equipment quotations and purchasing purposes only. The Contractor shall not contact or rely on either CenturyLink or Ciena for network design related questions.

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REVISION OF SECTION 614
ETHERNET ROUTER (5160)

When requesting quotations, the Contractor shall submit to CenturyLink a complete package including the following items:

- A complete list of required equipment for purchase including materials and quantities based on the individual project specifications to achieve a complete item(s) installation.
- A PDF copy of all project specifications pertaining to the material being ordered.
- A PDF copy of all networking project plan sheets.

It is the Contractor's responsibility to provide the distributer's representative all information required pertaining to the complete network design. During the project, CenturyLink or Ciena Corporation is not responsible for any type of network design aide. All questions pertaining to the network design shall be conducted through the Project Engineer for help or clarification.

CONSTRUCTION REQUIREMENTS

The 5160 SAS Ethernet switch shall be installed in the existing County Line communications node buildings and will be connected via fiber to local and remote 5150s. The 5160 SAS Ethernet switch shall also be connected to the existing Ciena 6500, unless otherwise specified by CDOT.

For 5160 connection to remote 5150s, the Contractor shall install single mode, bend insensitive, pre-connectorized duplex patch cables with a polyurethane jacket for connection from the fiber optic termination panel to the SFP+ optic modules in the Ciena 5160. The Contractor shall also install single mode, bend insensitive, pre-connectorized duplex patch cables with a polyurethane jacket for connection from the local 5150 XFP optic module to the SFP+ optic modules in the Ciena 5160 located in the same node building. Connectors for the patch cable shall be LC for the XFP and SFP+ optic modules and LC for the fiber optic termination panel.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
ETHERNET SWITCH 3930

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project Ethernet Switch shall be a Ciena 3930 Carrier Ethernet Service Delivery Switch (SDS) for installation in individual Intelligent Transportation Systems (ITS) device communication cabinets and/or variable message sign cabinets to transport Ethernet data to and from a regeneration node building or the CTMC and roadway ITS devices. All Ethernet switches shall be manufactured by Ciena.

The Ethernet switch shall utilize Coarse Wavelength Division Multiplexing (CWDM) and Small Form-factor Pluggable (SFP) optic modules. Each switch shall be provided with both a CWDM SFP optic module and a 1310 nm SFP optic module where a two switch per wavelength deployment is utilized (typical design). The Contractor is advised that in certain cases there are more than two switches per wavelength and when this occurs, the switch or switches in the middle shall utilize two 1310 nm SFP optic modules. Optic modules shall be provided as described in the Project Specifications, 614 – CWDM SFP and 614 – Small Form-Factor Pluggable – 1310 nm SFP as part of this specification package.

The Ethernet switches shall interface with the existing Ciena 5150 Ethernet aggregation switches located in either a regeneration node building or the CTMC.

A single mode, 9/125um CWDM wavelength independent attenuator to match the wavelength of the SFP optic modules shall be included and installed in the communications cabinet termination patch panel. Optical attenuators shall be provided as described in the Project Specification, 614 - Coarse Wavelength Division Multiplexing Attenuator.

MATERIALS

The Ethernet switch shall be configured with two (2) 1GIG/10GIG SFP ports, four (4) 100M/1000M SFP ports and two (2) 100/1000M RJ-45 Ethernet ports. User Network Interface (UNI) ports are not required as part of the Ethernet switch.

The Contractor shall furnish and install the Ethernet switch and associated items shown in Table A below. The Contractor shall also furnish the Ethernet switch software and maintenance licenses show in Tables B and C. Tables A, B and C describe items for a single Ciena 3930 SDS Ethernet switch.

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REVISION OF SECTION 614
ETHERNET SWITCH 3930

Item Table A – Ciena 3930 SDS Ethernet Switch, Typical Hardware Description

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
3930, (4) 100/1000M SFP, (2) 100/1000M RJ-45, (2) 1G/10G SFP+, EXT.TEMP, (2)SLOTS AC/DC POWER SUPPLY	170-3930-900	1
3930, AC PLUGGABLE POWER SUPPLY, WIDE RANGE 120/240V	170-0014-900	2
AC POWER CORD, IEC C15, 10 FT, OUTDOOR, NORTH AMERICA	170-0019-902	2
3930 19 INCH RACK MOUNT EARS, FOR USE WITH 1 RU CHASSIS	170-0602-903	2
10-LAMBDA CWDM MUX/DEMUX W/EXPANSION PORT, 2-SLOT LGX RACK MODULE, LC/APC CONNECTORS, MONITOR PORT (refer to 614 – CWDM Module) (for existing Ciena 5150 switches)	CWDM-EMUX10M	AS REQUIRED
12-SLOT LGX MOUNTING PANEL W/INTEGRATED FIBER MANAGEMENT, 4RU (refer to 614 – CWDM Module) (for existing Ciena 5150 switches)	CWDM-PAN012	AS REQUIRED
10/100/1000M, SFP TRANSCEIVER, RJ45 CONNECTOR, SGMII, 100 METERS, EXTENDED TEMPERATURE	XCVR-AB00CRJ	2
100M/1GIG, SM SFP OPTIC, LC CONNECTOR, 10 KM, 1310 NM, EXTENDED TEMPERATURE (refer to 614 – Small Form-factor Pluggable SFP)	XCVR-A10Y31	AS REQUIRED
100M/1GIG, SM SFP OPTIC, LC CONNECTOR, 40 KM, 1310 NM, EXTENDED TEMPERATUR (refer to 614 – Small Form-factor Pluggable SFP)	XCVR-A40Y31	AS REQUIRED
100M/1GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1**xx**0 NM, EXTENDED TEMPERATURE (refer to 614 – CWDM SFP) (for Ciena 3930 and existing Ciena 5150 switches)	XCVR-A80D**xx**	AS REQUIRED

xx – values range from 43 to 61 based on required CWDM wavelengths (1430 nm to 1610 nm)

Item Table B – Ciena 3930 SDS Ethernet Switch, Typical Software Description

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
SAOS ADVANCED ETHERNET PERPETUAL SOFTWARE LICENCE FOR 3930	S70-0001-900	1
SAOS ADVANCED OAM PERPETUAL SOFTWARE LICENCE FOR 3930	S70-0001-901	1
SAOS ADVANCED SECURITY PERPETUAL SOFTWARE LICENCE FOR USE WITH SAOS 6.X	170-0204-900	1
ESM CARRIER ED RIGHT TO MANAGE PERPETUAL SOFTWARE LICENSE FOR 3930	S70-0005-900	1

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REVISION OF SECTION 614
ETHERNET SWITCH 3930

Item Table C – Ciena 3930 SDS Ethernet Switch, Typical Maintenance License

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
SMARTSUPPORT, 3930, 3 YEARS	80M-3930-SSP	1
HARDWARE REPAIR SERVACE 10 DAY MAINTENANCE, 3930, 2 YEARS	80M-3930-HWM	1
NEXT BUSINESS DAY MANAGED SPARES, CN 3930, 3 YEARS	80M-3930-NBS	1

Matching CWDM SFP optic modules shall also be provided for existing Ciena 5150 Ethernet aggregation switches in either a regeneration node building or the CTMC to which the Ciena 3930 switches communicate since these Ciena 5150 switches are existing and not purchased as part of this project. In addition to the CWDM SFP optic modules are the required LGX mounting panels and 10-λ CWDM mux/demux rack modules. Quantities for these Ciena 5150 Ethernet aggregation switch CWDM SFP optic modules, LGX mounting panels and 10-λ CWDM mux/demux rack modules are not identified in these material tables because they are dependent on the design of the network.

Each Ethernet Switch shall be furnished and installed with a G.8032 ring protection configuration in conformance with Ciena's Ethernet Design and Configuration Services per the CDOT requirements either prior to installation or at the individual installation sites.

Preliminary configuration including all IP schema design for data transport will be conducted by CDOT personnel prior to installation. All final configurations and G.8032 configuration shall also be conducted by CDOT personnel.

If field changes are made which affect the original Contractor's material order for the Ethernet switches and require any reconfiguration of the original Ethernet switch material orders, the Contractor shall ensure that the Ciena representative is contacted and made aware of such changes to alleviate any possible delays in delivery and installation. If for any reason the switch or associated materials are defective or are damaged at the time of installation by either the Contractor or by Ciena, the item shall be removed and replaced at no additional cost to the project. Items shall also be replaced if any failures occur due to manufacturer's defects, at no additional cost to the project prior to the final acceptance.

CenturyLink is the direct contracted equipment supplier of Ciena Corporation for the State of Colorado, Colorado Department of Transportation for networking equipment and associated network materials. For project equipment estimate quotations and purchasing, Contractors shall contact the following distributer representative:

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REVISION OF SECTION 614
ETHERNET SWITCH 3930

Project equipment, equipment estimates, and purchasing distributer representative:

Keith A. Glose

Premier Account Manager

CenturyLink Government

930 15th Street, 4th Floor, Denver, Colorado 80202

Telephone: 303-992-5567 Fax: 720-578-2694

E-Mail: keith.glose@centurylink.com

Neither CenturyLink nor Ciena Corporation will be involved in the design of the project corridor network. The Contractor shall contact the CenturyLink representative for equipment quotations and purchasing purposes only. The Contractor shall not contact or rely on either CenturyLink or Ciena for network design related questions.

When requesting quotations, the Contractor shall submit to CenturyLink a complete package including the following items:

- A complete list of required equipment for purchase including materials and quantities based on the individual project specifications to achieve a complete item(s) installation.
- A PDF copy of all project specifications pertaining to the material being ordered.
- A PDF copy of all networking project plan sheets.

It is the Contractor's responsibility to provide the distributer's representative all information required pertaining to the complete network design. During the project, CenturyLink or Ciena Corporation is not responsible for any type of network design aide. All questions pertaining to the network design shall be conducted through the Project Engineer for help or clarification.

CONSTRUCTION REQUIREMENTS

The 3930 SDS Ethernet switch will be installed in a communications cabinet or variable message sign and connected via the fiber optic backbone to either a regeneration node building or the CTMC in a protected ring design. Each switch shall normally have both a CWDM SFP optic module and a 1310nm SFP optic module, except as previously noted where there are more than two switches per wavelength. Each switch shall be configured as part of creating a single carrier Ethernet diverse path sub-ring.

For connection of the switch to the optical fiber network, one (1) lateral fiber optic cable shall be terminated and patch cables shall be installed and connected to the optical ports of the switch. A total of four (4) lateral fiber strands shall be used for data communications to the switch. Two (2) lateral fiber strands shall be used for communications connecting the SFP optics carrying CWDM traffic and two (2) lateral fiber strands shall be used for communications connecting the 1310 nm SFP optics, except as noted where there are more than two switches per wavelength.

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REVISION OF SECTION 614
ETHERNET SWITCH 3930

Additional splicing is required for the CWDM optical filters at each Ciena 3930 location. The CWDM optical filters shall be used to split a single CWDM wavelength from the multiple wavelengths being transmitted along the fiber strands, including passing a 1310 nm wavelength between Ciena 3930 switch pairs. See 614 – Single Wavelength CWDM Optical Filter.

The Contractor shall provide single mode, bend insensitive, pre-connectorized duplex patch cables with a polyurethane jacket for connection from the coarse wavelength division multiplexing SFP optic module and the 1550 nm SFP optic module. Connectors for the patch cable shall be LC on the Ethernet switch end and ST on the termination end. For Ethernet switches in regeneration node buildings or the CTMC, if applicable, proposed termination panels may use LC connectors to accommodate the high termination requirements of the proposed fiber optic cable, accordingly LC-to-LC patch cables could be required at these locations.

The patch cable shall be of sufficient length to span from the termination patch panel to the Ethernet switch SFP ports with a maximum of two (2) feet of slack. They shall be installed in a manner which will not interfere with internal device equipment in the switch enclosure and will include cable management so as not to interfere with future maintenance within the enclosure.

For installations in variable message signs, the Contractor shall install an aluminum backplane on the internal structural supports of the sign housing. It shall be mounted in a location which will not interfere with internal equipment and future maintenance of the variable message sign electronics and cabling. The Ethernet switch shall not be mounted directly on to the variable message sign cabinet wall or sign support.

A field site survey for final placement of the Ethernet switch in the variable message sign cabinet shall be conducted prior to installation.

The Contractor shall arrange to provide for a certified Ciena representative either on site or via remote access through the Colorado Transportation Management Center network to aid in the configuration and installation of the Ethernet switch.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
ETHERNET SWITCH 3931

Section 614 of the Standard Specifications is hereby revised to include the following:

DESCRIPTION

For this project, at locations where installation of a Ciena 3930 Carrier Ethernet Service Delviery Switch (SDS) is infeasible due to the size of the switch, Ethernet Switch shall be a Ciena 3931 Carrier Ethernet SDS integrated in a weather proof enclosure and shall be installed on support posts, in cabinets, or attached to the side of cabinets, to transport Ethernet data to and from roadway ITS devices on this project. All Ethernet switches shall be manufactured by Ciena.

The Ethernet switch shall utilize Coarse Wavelength Division Multiplexing (CWDM) and Small Form-factor Pluggable (SFP) optic modules. Each switch shall be provided with both a CWDM SFP optic module and a 1310 nm SFP optic module where a two switch per wavelength deployment is utilized (typical design). The Contractor is advised that in certain cases there are more than two switches per wavelength and when this occurs, the switch or switches in the middle shall utilize two 1310 nm SFP optic modules. Optic modules shall be provided as described in the Project Specifications, 614 – CWDM SFP and 614 – Small Form-Factor Pluggable – 1310 nm SFP as part of this specification package.

The Ethernet switches shall interface with existing Ciena 5150 Ethernet aggregation switches located in an existing regeneration node building or the CTMC.

A single mode, 9/125um CWDM wavelength independent attenuator to match the wavelength of the SFP optic modules shall be included and installed in the communications cabinet termination patch panel. Optical attenuators shall be provided as described in the Project Specification, 614 - Coarse Wavelength Division Multiplexing Attenuator.

MATERIALS

The Ethernet switch shall be configured with two (2) 1/10GIG SFP+ ports, four (4) 100M/1000M SFP ports and two (2) 10/100/1000M RJ-45 Ethernet ports. User Network Interface (UNI) ports are not required as part of the Ethernet switch.

The Contractor shall furnish and install the Ethernet switch and associated items shown in Item Table A below. The Contractor shall also furnish the Ethernet switch software and maintenance licenses show in Item Tables B and C. Tables A, B and C describe items for a single Ciena 3931 SDS Ethernet switch.

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REVISION OF SECTION 614
ETHERNET SWITCH 3931

Item Table A – Ciena 3931 SDS Ethernet Switch, Typical Hardware Description

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
3931, PLUGGABLE SYSTEM MODULE, (2) 1/10G SFP+, (4) 100/1000 SFP, (4) 10/100/1000M RJ-45	170-3931-900	1
3931, ENCLOSURE FOR PLUGGABLE SYSTEM MODULE, (2) SLOT AC PLUGGABLE POWER SUPPLY	120-3931-900	1
CABLE ENTRY SEAL, OUTSIDE PLANT FIBER, ½ INCH	170-0074-900	1
CN 3911, (3) BAND CLAMP UAM POLE MOUNT KIT	MISC-BCPM01	1
CN 3911, UAM POLE MOUNT KIT	MISC-MKPM01	1
AC POWER CORD, IEC C15, 10FT, OUTDOOR, NORTH AMERICA	170-0019-902	2
3931, AC PLUGGABLE POWER SUPPLY, WIDE RANGE 120.240V	170-0042-900	2
10/100/1000, SFP TRANSCEIVER, RJ-45 CONNECTOR, SGMII, 100 METERS, EXTENDED TEMPERATURE	XCVR-A00CRJ	2
100M/1GIG, SM SFP OPTIC, LC CONNECTOR, 10 KM, 1310 NM EXTENDED TEMPURATURE	XCVR-A10Y31	AS REQUIRED
100M/1GIG, SM SFP OPTIC, LC CONNECTOR, 80 KM, 1**xx**0 NM EXTENDED TEMPERATURE	XCVR-A80D**xx**	AS REQUIRED

xx – values range from 43 to 61 based on required CWDM wavelengths (1430 nm to 1610 nm)

Item Table B – Ciena 3931 SDS Ethernet Switch, Typical Software Description

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
SAOS ADVANCED ETHERNET PERPETUAL SOFTWARE LICENCE FOR 3931	S70-0006-900	1
SAOS ADVANCED OAM PERPETUAL SOFTWARE LICENCE FOR 3931	S70-0006-901	1
SAOS ADVANCED SECURITY PERPETUAL SOFTWARE LICENCE FOR USE WITH SAOS 6.X	170-0204-900	1
ESM CARRIER ED RIGHT TO MANAGE PERPETUAL SOFTWARE LICENSE FOR 3931	S70-0007-900	1

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REVISION OF SECTION 614
ETHERNET SWITCH 3931

Item Table C – Ciena 3931 SDS Ethernet Switch, Typical Maintenance License

ITEM DESCRIPTION	ITEM NUMBER	QUANTITY
SMARTSUPPORT, 3931, 3 YEARS	80M-3931-SSP	1
HARDWARE REPAIR SERVACE 10 DAY MAINTENANCE, 3931, 2 YEARS	80M-3931-HWM	1
NEXT BUSINESS DAY MANAGED SPARES, CN 3931, 3 YEARS	80M-3931-NBS	1

Matching CWDM SFP optic modules shall also be provided for existing Ciena 5150 Ethernet aggregation switches in either regeneration node buildings or the CTMC to which the Ciena 3930 switches communicate since these Ciena 5150 switches are existing and not purchased as part of this project. In addition to the CWDM SFP optic modules are the required LGX mounting panels and 10-λ CWDM mux/demux rack modules. Quantities for these Ciena 5150 Ethernet aggregation switch CWDM SFP optic modules, LGX mounting panels and 10-λ CWDM mux/demux rack modules are not identified in these material tables because their use is dependent on the design of the network.

Each Ethernet Switch shall be furnished and installed with a G.8032 ring protection configuration in conformance with Ciena's Ethernet Design and Configuration Services per the CDOT requirements either prior to installation or at the individual installation sites.

Preliminary configuration including all IP schema design for data transport will be conducted by CDOT personnel prior to installation. All final configurations and G.8032 configuration shall also be conducted by CDOT personnel.

If field changes are made which affect the original Contractor's material order for the Ethernet switches and require any reconfiguration of the original Ethernet switch material orders, the Contractor shall ensure that the Ciena representative is contacted and made aware of such changes to alleviate any possible delays in delivery and installation. If for any reason the switch or associated materials are defective or are damaged at the time of installation by either the Contractor or by Ciena, the item shall be removed and replaced at no additional cost to the project. Items shall also be replaced if any failures occur due to manufacturer's defects, at no additional cost to the project prior to the final acceptance.

CenturyLink is the direct contracted equipment supplier of Ciena Corporation for the State of Colorado, Colorado Department of Transportation for networking equipment and associated network materials. For project equipment estimate quotations and purchasing, Contractors shall contact the following distributer representative:

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REVISION OF SECTION 614
ETHERNET SWITCH 3931

Project equipment, equipment estimates, and purchasing distributer representative:

Keith A. Glose

Premier Account Manager

CenturyLink Government

930 15th Street, 4th Floor, Denver, Colorado 80202

Telephone: 303-992-5567 Fax: 720-578-2694

E-Mail: keith.glose@centurylink.com

Neither CenturyLink nor Ciena Corporation will be involved in the design of the project corridor network. The Contractor shall contact the CenturyLink representative for equipment quotations and purchasing purposes only. The Contractor shall not contact or rely on either CenturyLink or Ciena for network design related questions.

When requesting quotations, the Contractor shall submit to CenturyLink a complete package including the following items:

- A complete list of required equipment for purchase including materials and quantities based on the individual project specifications to achieve a complete item(s) installation.
- A PDF copy of all project specifications pertaining to the material being ordered.
- A PDF copy of all networking project plan sheets.

It is the Contractor's responsibility to provide the distributer's representative all information required pertaining to the complete network design. During the project, CenturyLink or Ciena Corporation is not responsible for any type of network design aide. All questions pertaining to the network design shall be conducted through the Project Engineer for help or clarification.

CONSTRUCTION REQUIREMENTS

The 3931 SDS Ethernet switch shall be installed on device support posts and connected via the fiber optic backbone to a communications node building in a protected ring design. Each switch shall normally have both a CWDM SFP optic module and a 1310nm SFP optic module, except as previously noted where there are more than two switches per wavelength. Each switch shall be configured as part of creating a single carrier Ethernet diverse path sub-ring.

For connection of the switch to the optical fiber network, one (1) lateral fiber optic cable shall be terminated and patch cables shall be installed and connected to the optical ports of the switch. A total of four (4) lateral fiber strands shall be used for data communications to the switch. Two (2) lateral fiber strands shall be used for communications connecting the SFP optics carrying CWDM traffic and two (2) lateral fiber strands shall be used for communications connecting the 1310 nm SFP optics, except as noted where there are more than two switches per wavelength.

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REVISION OF SECTION 614
ETHERNET SWITCH 3931

Additional splicing is required for the CWDM optical filters at each Ciena 3931 location. The CWDM optical filters shall be used to split a single CWDM wavelength from the multiple wavelengths being transmitted along the fiber strands, including passing a 1310 nm wavelength between Ciena 3931 switch pairs. See 614 – Single Wavelength CWDM Optical Filter.

The Contractor shall provide single mode, bend insensitive, pre-connectorized duplex patch cables with a polyurethane jacket for connection from the coarse wavelength division multiplexing SFP optic module and the 1550 nm SFP optic module. Connectors for the patch cable shall be LC on the Ethernet switch end and ST on the termination end. For Ethernet switches in node buildings, if applicable, proposed termination panels may use LC connectors to accommodate the high termination requirements of the proposed fiber optic cable, accordingly LC-to-LC patch cables could be required at these locations.

The patch cable shall be of sufficient length to span from the termination patch panel to the Ethernet switch SFP ports with a maximum of two (2) feet of slack. They shall be installed in a manner which will not interfere with internal device equipment in the switch enclosure and will include cable management so as not to interfere with future maintenance within the enclosure.

Two flexible liquid tight metal conduits shall be installed from the switch enclosure to the underside of the communications cabinet for electrical power cabling, single mode patch cables and Ethernet CAT6 communications cabling.

The Contractor shall arrange to provide for a certified Ciena representative either on site or via remote access through the Colorado Transportation Management Center network to aid in the configuration and installation of the Ethernet switch.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
FIBER OPTIC CABLE (SINGLE MODE)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing backbone and lateral single mode fiber optic cables.

MATERIALS

All fiber optic cables shall be suitable for outdoor conduit installation.

All fiber optic cable shall have compatible characteristics with other proposed and existing fiber optic cables.

All optical cables furnished on this project shall meet the following fiber optic industry standards:

- International Telecommunications Union – Telecommunications Standardization Sector – Recommendation G.652.D
- Telecommunications Industry Association (TIA) – 598-D Optical Fiber Cable Color Coding
- International Organization for Standardization (ISO) – 9001
- Rural Utilities Service (RUS) – Specification for filled fiber optic cables

All cables shall be new and unused non-armored outdoor cable consisting of non-dispersion shifted, low water peak single-mode fiber strands free of surface imperfections and inclusions. Each single mode fiber strand shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be of matched clad design.

1. *Fiber Strands.* Fiber strands shall meet the following minimum characteristics:

   A. Typical core diameter of 9.0µm ± 1 µm

   B. Cladding Diameter of 125 µm ± 1 µm

   C. Core concentricity error: □□0.6 µm

   D. Cladding Noncircularity: □□1.0 %

   E. Coating Diameter (Colored): 245 ± 5 µm.

   F. Maximum Attenuation (Loose Tube): 0.35 dB//km at 1310 nm wavelength and 0.22 dB/km at 1550 nm wavelength

   G. Mode-Field Diameter: 9.20 ± 0.30 µm at 1310 nm wavelength and 10.40 ± 0.50 µm at 1550 nm wavelength

   H. Attenuation at the Water Peak: 0.32 to 0.34 dB/km at 1383 ± 3 nm wavelength

   I. Cutoff Wavelength: □□1260 nm

   J. Zero Dispersion Wavelength: 1300 nm to 1324 nm

   K. Zero Dispersion Slope: □□0.092 ps / (nm^2 □□km)

   L. Polarization Mode Dispersion: □□0.06 ps/ □km

   M. Maximum Polarization Mode Dispersion at 0.01% distribution (PMDq): 0.20 ps/□km

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REVISION OF SECTION 614
FIBER OPTIC CABLE (SINGLE MODE)

N. Maximum Fiber Dispersion: □□18□ps/(nm * km) at 1550 nm

O. Fiber Curl: □□4.0 m

P. Proof Tensile Test: 100 kpsi (0.69 GN/m^2)

The fibers shall not adhere to the inside of the buffer tube.

The coating shall be a dual layered, UV cured acrylate applied by the fiber manufacturer. The coating shall be capable of being mechanically stripped with a force of 0.3 to 2.0 lbf.

Each single mode fiber strand shall be color coded with distinct and recognizable colors in accordance with the TIA-598-D *Optical Fiber Cable Color Coding*.

2. *Buffer Tubes.*

Each backbone buffer tube shall contain 12 fiber strands and each lateral fiber cable shall have two buffer tubes with six fiber strands in each.

Optical fibers shall be placed inside a loose buffer tube.

Each buffer tube shall be color coded with distinct and recognizable colors in accordance with TIA-598-D.

If fillers are required, they shall be placed in the inner layer of the fiber optic cable. The color sequences of the buffer tubes shall begin from the inside layer of and progress outward.

Buffer tube black stripe shall be inlaid in the buffer tube material by means of co-extrusion when required.

In buffer tubes containing multiple fibers, the coloring shall be stable during temperature cycling and shall not be subjected to fading or smearing onto each other or into the buffer tube gel filling material if the fiber cable is supplied with gel filling for water blocking. Colorings shall not cause fibers to stick together.

Each buffer tube shall contain water blocking swellable yarns to prevent water from entering the individual buffer tubes. Swellable water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogeneous. It shall be free from dirt and foreign matter and not require cleaning prior to splicing and placement into the splice closure tray. All fiber strands shall be thoroughly cleaned prior to fiber splicing. All water blocking material shall be uniformly distributed throughout the buffer tubes.

Buffer tubes shall be stranded around a central member of the cable using a reverse oscillation stranding process.

The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrinkback requirements of Code of Federal Regulations (CFR) 7 CFR 1755.900 – *RUS Specification for filled fiber optic cables*.

3. *Fiber Cable.*

Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed and shall not be placed to interrupt the consecutive positioning of the buffer tubes. Fillers shall nominally match the outer diameter of fiber filled buffer tubes.

The central anti-buckling member of the cable shall consist of all dielectric, glass reinforced plastic (GRP) rod.

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REVISION OF SECTION 614
FIBER OPTIC CABLE (SINGLE MODE)

For single layer cables, a water swellable, (blocking) tape shall be applied longitudinally around the outside of the buffer tubes and fillers. The tape shall be held in place by a single polyester binder yarn. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter. Water blocking material shall be applied uniformly throughout the fiber cable to inhibit the ingress of water into the cable. Gel filled water-blocking compound shall not be allowed in the cable core interstices of the fiber optic cables.

When the fiber cable is provided with dual layer buffer tubes, both the inner and outer layer shall be provided with water swellable tape.

Binders shall be applied with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.

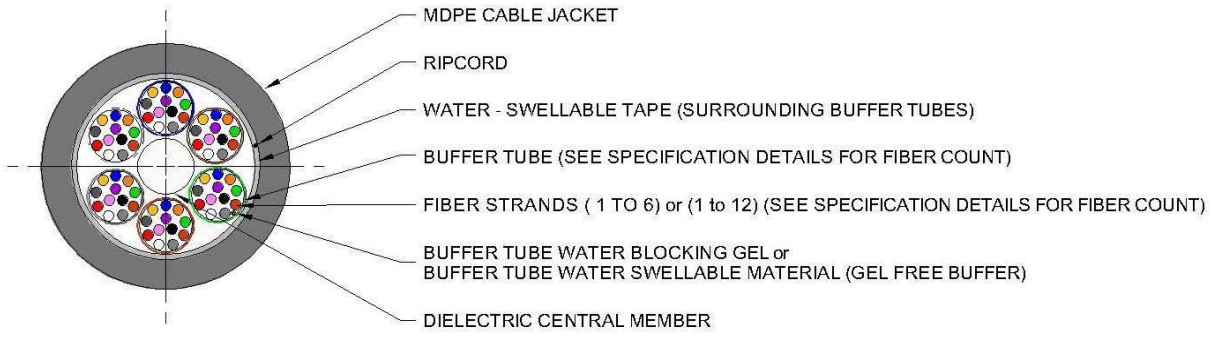
The cable shall contain at least one ripcord under the sheath for easy sheath removal.

Outer cable jacket shall have a consistent thickness throughout the entire cable length and shall be sheathed with medium density polyethylene (MDPE). Jacketing material shall be applied directly over the tensile strength members and water blocking tape. The MDPE jacket material shall be as defined by ASTM D1248, Type II, Class, Category 4 and Grades J4, E7 and E8 and shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

The cable jacket shall be free of holes, splits and blisters and be of a consistent thickness.

Cable jackets shall be marked with the manufacturer's name, sequential foot markings, fiber type and count, month and year of manufacture and a telecommunication handset symbol, as required by Section 350G of the National Electrical Safety Code (NESC). The actual length of the cable shall be within 0 to 1 percent of the length markings. The marking shall be in contrasting color to the cable jacket. The height of the marking shall be easily readable.

The Contractor shall submit to the Project Engineer a detailed fiber optic cable specification sheet from the manufacturer for approval. The specification sheet shall be highlighted describing the water blocking material used for both the cable interstices and buffer tubes. Failure to fully describe the type of water blocking material shall result in the submittal being rejected and resubmitted with all highlighted information.



Specification Detail 1

Typical Cross Section of Fiber Optic Cable to Be Provided Per This Specification

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REVISION OF SECTION 614
FIBER OPTIC CABLE (SINGLE MODE)

4. *Environmental Parameters.* The following minimum environmental parameters shall be met:
   A. Shipping, storage and operating temperature range of the cable shall be -40°F to +158°F (-40°C to +70°C)
   B. Operating temperature range of the cable shall be -40°F to +158°F (-40°C to +70°C)
   C. Installation temperature range of the cable shall be -22°F to +140°F (-30°C to +60°C)
5. *Quality Assurance.* The following minimum quality assurance requirements shall be met:
   A. All optical fibers shall be 100 percent attenuation tested in accordance with Revision of Section 614 – Test Fiber Optic Cable. The attenuation of each fiber shall be provided with each cable reel.
   B. The cable manufacturer shall be ISO 9001or TL 9000 registered.
6. *Packaging*. The following minimum packaging parameters shall be met:
   A. The complete cable shall be packaged for shipment on non-returnable wooden reels.
   B. Top and bottom ends of the cable shall be available for testing.
   C. Both ends of the cable shall be sealed to prevent the ingress of moisture.
   D. Each reel shall have a weatherproof reel tag attached identifying the reel and cable.
   E. Each cable shall be accompanied by a cable data sheet that contains significant information on the cable.
   F. The cable reels shall not be stored nor shipped on their sides.

CONSTRUCTION REQUIREMENTS

Fiber optic cable shall be used for either main backbone cable or lateral cables that connect to communications cabinets. The main backbone cable shall be terminated in a traffic management system building or network facility. Splicing shall be conducted at cable end splice locations and device splice locations as approved by the Project Engineer.

A minimum of one week prior to fiber optic work, the Contractor shall give the Project Engineer a detailed installation and splicing Method Statement and schedule. All installation, splicing, termination, and testing shall be listed on the schedule and Method Statement and revisions shall be re-submitted to the Project Engineer immediately. Installation of the fiber optic cable shall not be permitted until the Method Statement and schedule has been approved by the Engineer.

The Contractor shall be responsible for coordinating with third parties when installing and splicing proposed fiber optic cable adjacent to existing third party owned fiber optic infrastructure and when splicing proposed fiber optic cable to existing third party owned fiber optic cable. The Contractor shall keep the Project Engineer apprised of all coordination activities it performs with third parties as it pertains to this project.

The Contractor shall conform to the requirements included in the Revision of Section 614 - Test Fiber Optic Cable specification, as well as the project specific Testing & Integration Plan.

The Contractor shall provide the Engineer with two copies of the cable manufacturer's installation instructions for all fiber optic cable. All installations shall be in accordance with the manufacturer's recommendations except as otherwise directed by the Engineer. All additional costs including fiber

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FIBER OPTIC CABLE (SINGLE MODE)

optic cable associated to damages caused by the Contractor's neglect of recommended procedures shall be the Contractor's responsibility.

Fiber optic cable including both backbone cables and lateral cables shall be installed in continuous runs. The Contractor shall include a detailed installation plan with the Method Statement showing cable installation lengths and cable end splice points. The fiber cable shall be installed in reel lengths that minimize the quantity of cable end splices. Under no conditions shall fiber optic cable be cut or spliced at intermediate points without express written direction from the Engineer.

The new fiber cable shall be installed in a manner which will not interfere with the integrity of existing cable and equipment and shall be installed in a manner which will not interfere with the maintenance of the traffic signal cable, wiring, or equipment.

Blowing cable is an acceptable alternative to pulling cable. If the Contractor chooses to use this method, submittals for cable installation shall be submitted along with complete information on fiber installation equipment.

The maximum pulling tension shall be 600 pounds (2700 N) during installation (short term) and 200 pounds (890 N) long term installed.

All cables shall have a minimum bending radius based on the diameter of the cable and shall meet the following;

- Under max pulling tension – 15 (Fifteen times the cable outside diameter)
- Unloaded, not under tension – 10 (Ten times the cable outside diameter)

The fiber optic cable shall be installed in the conduit with a split-mesh cable grip to provide a firm hold on the exterior covering of the cable.

The manufacturer's recommended maximum allowable pull tension for cable pull lengths shall not be exceeded. The Contractor shall use a pulley system with a numerical readout indicating the cable tension. The pulley system shall be capable of alerting the installer when the cable pulling tension approaches the manufacturer's maximum allowable tension. The Contractor may supplement this procedure with a breakaway tension limiter set below the lowest recommended tensile limit of the cables being pulled. Intermediate pulleys shall be used at all pull boxes or manholes along the installation run to prevent cable damage.

If cable installation limits are met and the entire length cannot be installed completely from the shipping reel, installation shall be continued from the mid-point of the run. The Contractor shall first pull one-half of the cable from the reel at the mid-point through the conduit to one end of the run. The other half of the cable shall be removed from the reel and carefully placed on the ground in a figure eight pattern with a minimum loop diameter of 10 feet. While installing the remaining cable, care shall be taken to avoid dragging against the ground resulting in damage or excess bending of the cable. The Contractor shall not kink, twist or bend the cable during installation coiling and uncoiling.

The cable shall be continuously lubricated as it enters the conduit. The Contractor shall only use pulling lubricants recommended by the cable manufacturer. Liquid detergent shall not be used.

The Contractor shall furnish and install a pre-lubricated pull tape and tracer wire in the same conduit as the fiber is being installed. The pull tape and tracer wire shall conform with Revision of Section 613 – Electrical Conduit.

If the Contractor must install new cable in conduits that contain existing fiber optic cable or electrical wiring, the Contractor shall be responsible for all damage to the existing cables and wires. After this installation the Contractor shall perform a functional test of all the equipment connected by

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REVISION OF SECTION 614
FIBER OPTIC CABLE (SINGLE MODE)

the existing fiber cables and electrical wiring to ensure proper working conditions. All costs associated with equipment testing and repairs shall be included in the cost of the fiber optic cable.

If an existing fiber optic cable is damaged during construction, it shall be removed from both points of termination and replaced, at no cost to the project.

In no case shall the conduit fill ratio of new conduit exceed the requirements of the National Electrical Code.

Lateral cables shall be installed in continuous runs from the backbone splice location to the communications cabinet. Odd length cables and reel ends are acceptable for lateral cables provided they are pre-tested and free of defects and are of sufficient lengths to archive continuous runs.

Installation of lateral fiber optic cables shall include slack coil and a minimum of three strain relief locations within all communications cabinets and traffic signal cabinets.

All fiber optic cables shall include identification labels attached to the cable in each pull box, manhole or communications cabinet. The information to be included on the label shall be approved by the Engineer.

The Contractor shall coil 50 feet of each fiber cable in pull boxes and 100 feet in manholes.

At locations of Coarse Wavelength Division Multiplexing (CWDM) network equipment, the Contractor shall install and coil two separate 100-foot lateral fiber optic cables in the splice manholes. Refer to the fiber optic splicing details for more information.

Splicing of CWDM lateral fiber cables by the Contractor shall be as shown in the project plans.

Backbone and lateral buffer tubes and fiber strands shall be labeled on the splice tray prior to sealing of the closure. In the CWDM splice closure, the optical filter wavelengths shall also be labeled.

The Contractor shall ensure that all cable coils and splice canisters are attached separately to the cable management hardware inside manholes in a manner which will allow for all splice closures to be removed separately for future maintenance purposes. In Pull Boxes, all cable coils shall be attached separately to the cable management hardware in a manner which will allow for fiber optic cable to be removed separately.

The Contractor shall terminate the lateral cable at the communications cabinet in accordance with the Revision of Section 614 – Fiber Optic Termination Panel.

Prior to performing splicing and testing for CDOT traffic signals, the Contractor shall contact Joseph Pirera, CDOT Traffic Signals & Ramp Metering Supervisor (303-815-9194) to allow for traffic signal technicians to disconnect all existing optical communications equipment.

The Contractor shall submit a final documentation package. The final documentation package shall include the cable manufacturer's installation procedures, technical support documentation and material documentation. These documents shall match the original submittals provided to the Engineer.

At any time, if the Contractor damages any of the fiber optic backbone cables, the entire end-to- end (reel-to-reel) section of fiber cable shall be removed, re-installed, and re-spliced from the cable end splice point at the Contractor's expense.

At any time, if the Contractor damages any of the fiber optic backbone laterals, the entire end-to- end (reel-to-reel) section of fiber cable shall be removed, re-installed, and re-spliced from the splice point to the device communication cabinet at the Contractor's expense.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
FIBER OPTIC PRE-CONNECTORIZED CABLE

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of the installation of fiber optic pre-connectorized patch cables in communication cabinets and communications node buildings from the termination patch panel to the optical communication device optics.

MATERIALS

The measured attenuation of the connector (inclusive of coupler and mated test connector) shall not exceed an average of 0.3 dB for all connectors provided. Any connector found in excess of dB shall be rejected. Reflectance shall be less than -40 dB from 14º F to 140º F (-10ºC to +60ºC). The manufacturer shall have a program that periodically tests connectors to ensure that after 1000 re-matings, the attenuation will not change more than 0.2 dB.

The measured insertion loss shall be a maximum of 0.25 dB with a typical loss of 0.15dB. Return loss shall be a maximum of -65 dB (APC) and -55 dB (UPC) with a typical loss of -68 dB (APC) and -58 dB (UPC). The minimum cable bend radius shall be less the 15 mm.

The connector shall be able to withstand an axial pull of 25 lbs. with no physical damage to the connector and no permanent optical degradation more than 0.3 dB.

The pre-connectorized cables shall be provided with pre-connectorized connectors on both ends to match the termination patch panel bulkheads and small form-factor pluggable optic modules of the Ethernet switch. Connectors shall be terminated by the manufacturer.

The connectors shall be nickel-plated with a ceramic ferrule and shall be polished with a physical contact (PC) finish end to reduce reflection.

The cables shall contain the exact number of loose tube fibers and bulkhead connectors to connect from the termination patch panel to the optical modules. If the optical equipment transmits and receives data with a single optic, the pre-connectorized cable shall contain a single optical fiber, (simplex). When the optical device transmits and receives data with two or four optics, or a network Ethernet switch small form factor pluggable optic module, a pre-connectorized cable shall be provided with 2 (two) optical fibers (duplex) per pair of transmit and receive optics.

CONSTRUCTION REQUIREMENTS

Pre-connectorized cables shall be installed from the termination panel bulkheads to the optical modules of the communication devices.

At the communications node building, the pre-connectorized cables shall be installed in the cable management hardware attached to equipment racks. The Contractor shall provide patch cables of sufficient length to span from the fiber termination patch panel bulkheads to the communications device or network device optical port. This length shall include a maximum of four (4) feet of slack cable. Appropriate cable management shall be used.

At communication cabinets, the Contractor shall provide pre-connectorized cables of sufficient length to span from the fiber termination patch panel bulkheads to the equipment device or network device optical port. This length shall include a maximum of two (2) feet of slack cable. Appropriate cable management shall be used.

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REVISION OF SECTION 614
FIBER OPTIC PRE-CONNECTORIZED CABLE

Prior to installation, all pre-connectorized cable bulkhead connectors shall be cleaned with lint- free fiber wipes moistened with Isopropyl Alcohol 99% U.S.P. After cleaning with alcohol, the bulkhead shall be cleaned with an optical connector cleaner to ensure that all residue is removed.

Manufacturer testing reports for pre-connectorized cables shall be submitted as part of the as- built documentation. The installation location shall be noted on the test report for future reference.

At communication node buildings, pre-connectorized patch cables shall have identification labels applied on each end. Information indicating the patch panel number, device being connected and Ethernet switch port. CDOT personnel will aid in the labeling as it pertains to the proper nomenclature to be provided and/or Ethernet port connections.

At all field device locations, each cable shall have individual labels indicating the termination panel port and the data transmitting description (example: Tx or Rx).

The pre-connectorized cables shall be provided in the following lengths.

Field Device Cabinets..... 4 Feet – 0 Inch maximum

Node Buildings ..... Cable shall be of sufficient length to accommodate connection of termination patch panel bulkhead to each individual optical device while allowing for 4 feet of slack.

REVISION OF SECTION 614
FIBER OPTIC SPLICE CLOSURE

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This item includes installing fiber optic splice closures and performing splicing of both fiber optic backbone and fiber optic lateral cables.

When the project network is designed utilizing Coarse Wavelength Division Multiplexing (CWDM) network equipment, the Contractor shall provide two splice closures. Both closures shall be of the same size and shall be sized to accept both the backbone fiber optic cable and the associated fiber optic lateral cable(s).

The CWDM splicing design shall include one splice closure utilized for splicing of the backbone fiber optic cable to the lateral fiber optic cable(s) and filters. The second splice closure will be used for splicing the lateral fiber optic cable(s) to the coarse wavelength division multiplexing single wavelength filters and the lateral fiber optic cable(s) extending to the device communications cabinet or variable message sign.

MATERIALS

The fiber optic splice closures shall be furnished and installed by the Contractor.

The splice closures shall be dome type and shall meet the following minimum requirements:

- The closures shall seal, anchor and protect fiber optic cable splices.
- The closures shall have a minimum of six total cable entries.
- The closures shall be suitable for underground applications and shall be corrosion resistant, watertight and airtight.
- The closure splice trays shall have a hinged design with an upright locking mechanism for all splice trays.
- The closures shall have a sealing design that does not require glue, sealant, or new cable seals to re-enter the closure.
- The closure shall be bonded inside and outside and have an external ground lug.
- The Contractor shall include all necessary accessories to complete splicing.
- The Contractor shall include all mounting hardware.
- The splice closure shall comply with Telcordia Generic Requirement (GR) GR-771.

The closures shall be sized to provide a capacity equal to the total number of strands for all cables entering the closure.

CONSTRUCTION REQUIREMENTS

The Contractor shall notify the Project Engineer of proposed daily splicing locations two business days prior to splicing and also the morning of proposed splicing. The Contractor shall contact the Project Engineer at least four hours prior to sealing the closure to allow inspection.

If the Project Engineer cannot be on site to inspect the open splice closure, a minimum of eight digital pictures shall be taken at varying angles of the interior of the splice closure showing all completed work as stated in this specification. The pictures shall include exposed fiber stands (both spliced and uncut) in all splice trays, fiber tray labeling and remaining buffer tubes showing appropriate coiling. One picture shall also include the complete re-assembly of all interior parts prior to final sealing. Once the closure and fiber coils are installed in the pull box or manhole, two pictures shall be taken showing the final

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REVISION OF SECTION 614
FIBER OPTIC SPLICE CLOSURE

installation of both the closure and the coiled fiber cable attached to the fiber management hardware. All pictures shall be organized per location and shall be submitted to the Project Engineer along with all final testing result documentation.

All splices shall be performed using the fusion splicing method. The fusion splicer shall be calibrated and certified at least once within the previous year from this project. The Contractor shall present all certification documentation to the Project Engineer prior to start of fiber splicing.

The optical fibers shall be fusion spliced and shall meet the requirements in the Revision of Section 614 – Test Fiber Optic Cable special provision and the project specific Testing & Integration Plan.

The Contractor shall label each individual splice and buffer tube in all splice trays.

All unused buffer tubes and fiber strands shall remain uncut. After the fiber cable and proposed buffer tube is prepped for splicing, all fiber strands in the buffer tube shall be thoroughly cleaned. All uncut fiber strands shall be coiled in the tray. Remaining buffer tubes shall be neatly coiled, secured and stored in the storage area within the closure under the splice trays per the manufacturer's recommendations. Buffer tubes proposed for splicing shall be wrapped and secured to the splice tray with ties per the manufacturer's recommendations.

At CWDM splice locations, the completed splices and coarse wavelength division multiplexing single wavelength filters shall be secured in the splice tray foam splice chips per manufacturer's recommendations.

Bare fiber strands shall not be taped to the splice tray.

All fiber optic cables shall be secured and sealed at the closure entrances. All unused cable entries shall be plugged.

If the closure requires re-entry, it shall be conducted per the manufacturer's recommendation for re-entry and resealing. The Contractor shall use caution to prevent damage to the existing fiber strands, splices, CWDM filters, and buffer tubes inside the splice closure. When sealing the closure for a second time, the Contractor shall follow all re-entry requirements of the manufacturer.

The Contractor shall ensure that the fiber optic splice closures and associated fiber cable coils fit adequately within the manhole or pull box splice locations and shall securely mount the splice enclosure to the side of the manhole.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
FIBER OPTIC TERMINATION PANEL

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing fiber optic termination panels in communication cabinets for single mode fiber optic cables.

MATERIALS

All termination panels shall be manufactured using aluminum and shall be finished with powder coat. The termination panels shall accommodate lateral fiber optic cables. All termination panels shall be equipped with six port Straight Tip (ST) type bulkheads and be compliant with the Telcordia Technologies Generic Requirement (GR) GR-326 *Generic Requirements for Single Mode Optical Connectors and Jumper Assemblies, Latest Issue*. The manufacturer shall perform acceptance testing for insertion loss and return loss with the test certification provided with each patch panel.

All termination panels shall have a labeling scheme that is approved by the Engineer. All termination panels shall be compatible with the fiber optic cable being terminated.

The six port panels shall have hinged doors that provide access to both the fiber fan out and the termination bulkheads. The panel shall be sized to accommodate the entry of the lateral fiber optic cable, fiber fan out, and bulkheads with the access door closed. The fiber optic patch panel shall be suitable for wall mounting. Dimensions shall not exceed 5 inches wide × 6 inches long × 2 inches deep. Each fiber optic patch panel shall include a fiber adapter panel, adapters, field termination and polishing of fiber, strain relief, grommet tape, zip ties and wall mounting bracket. Terminations within the patch panel shall be polished with a physical contact (PC) finish.

24 port termination panels for lateral fiber optic cables shall be provided to accommodate 24 ports. 24 port termination panels shall be compatible with a 19-inch equipment rack. The panels shall be provided with two six port ST type bulkheads. The panel shall be provided with covers for the remaining spaces. The termination panel shall have a slide out interior.

A 144 port termination panel for the backbone fiber optic cable shall be provided at the County Line Node. This fiber optic termination panel shall be 19 inch EIA/ECA-310 compatible for mounting in a rack and be equipped with a see-through latching front cover. It shall be designed around the physical protection requirements of Telcordia GR-63 *Network Equipment Building System (NEBS) Requirements*. It shall utilize aluminum construction per the requirements of ASTM B209 *Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate*. The connector style shall be LC (duplex) with an Angled Physical Contact (APC) finish and an optical return loss meeting or exceeding -60 dB. Each fiber optic termination/splice panel shall be loaded to accommodate the termination of all fibers contained within the proposed backbone cable, unless fibers are spliced through and not landed on the termination/splice panel. The termination panel shall have the ability to remove individual bulkheads or a set of bulkheads to access and clean the backside connection for future maintenance or troubleshooting, unless connectors are factory sealed in a module with a pigtail. Pigtails shall be stranded with single mode fibers and a minimum length of 15 feet for splicing and coiling. Pigtails shall be organized in the optical splice shelf. Buffer tubes, in splice tray, shall be secured with Velcro strips unless stated another method is approved by the manufacturer. Fusion splicing shall be utilized with heat shrink sleeve protectors, therefore the splice tray capacity, splice tray slots for fusion splices and number of splice trays shall be provided to accommodate the number of backbone fiber to pigtail splices along with the size of heat shrink sleeve protectors utilized. One cable clamp shall be provided for each fiber optic termination/splice panel. All hardware shall be installed in accordance with the fiber optic termination

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REVISION OF SECTION 614
FIBER OPTIC TERMINATION PANEL

panel manufacturer's recommendations. The Contractor shall provide the Engineer with all associated documentation and manuals. The labeling scheme on the panels and fiber optic cables shall comply with TIA-606 and be consistent with CDOT's labeling code.

Bulkheads in all termination panels shall be metal. Plastic bulkheads will not be accepted.

CONSTRUCTION REQUIREMENTS

Six port termination panels for lateral fiber optic cables shall be installed at locations where either existing or proposed equipment does not allow for the installation of a 24 port termination panel.

24 port termination panels shall be installed within communications cabinets and shall be mounted in locations that allow for ease of access and shall not interfere with maintenance of the internal equipment. 24 port termination panels shall be installed in communications cabinet 19 inch equipment racks.

The Contractor shall field terminate ST type bulkhead connectors on the ends of the lateral fiber cable strands and install them on the back side of the termination panel. The terminated connectors shall be nickel-plated with a ceramic ferrule and shall be polished with a physical contact finish.

Instead of field terminating and polishing lateral fiber optic cables, the Contractor may use a single mode fiber pigtail that is factory terminated on six port ST type bulkhead and fusion splice the pigtail to the lateral fiber optic cable. If this method is used, the termination panel shall be sized and configured to accommodate splicing of the pigtail.

The Contractor shall use proper strain relief inside the termination panel for the fiber cable and fiber fan out strands per the manufacturer's recommendations. The use of tape to secure the individual fanned out strands to the bottom of the termination panel shall not be allowed. The Contractor shall allow enough slack in the terminated fiber to allow for opening and closing the termination panel without disturbing the terminated fiber.

All hardware shall be installed in accordance with manufacturer's recommendations. See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
GLOBAL POSITIONING SYSTEM (GPS)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

The Contractor shall provide Global Positioning System (GPS) Coordinate information for all device, conduit, pull box and manhole locations on this project. Coordinates of both proposed and existing devices in the project limits shall be provided.

MATERIALS

Documentation verifying the type of GPS unit being proposed for use and the specifications of the unit shall be provided to the Project Engineer for review prior to data gathering.

CONSTRUCTION REQUIREMENTS

The Contractor shall provide geodetic datum for all roadway devices, conduit, fiber optic pull boxes, and manholes within the project limits. This shall include Intelligent Transportation System devices, communications cabinets, traffic signal controller cabinets, ramp metering cabinets, automated traffic recorder cabinets, conduit, pull boxes, and fiber optic cable running line manholes.

The Contractor shall use a device designed specifically for mapping GPS information to Universal Transverse Mercator (UTM) Zone 13 coordinate system utilizing 1983 North American Datum (NAD83). Cell phones with GPS capabilities shall not be allowed for determining GPS location.

The GPS data shall be expressed in Latitude and Longitude and Universal Transverse Mercator (UTM) Zone 13 utilizing 1983 North American Datum (NAD83). Altitude shall be expresses in meters:

Latitude and Longitude shall be provided in Decimal Degree (DD) format to a precision of six decimal places.

Example – Latitude _____ Longitude _____ Altitude (m) _____

North American Datum shall be provided in coordinates to a precision of three decimal places.

Example – X (easting) _____ Y (northing) _____ X (m) _____

For data collection, the Contractor shall use the averaged waypoint. Minimum averaging time at each location shall be two minutes prior to documenting the information.

Accuracy tolerances for data collected by the GPS unit shall be within a maximum of 3 feet.

The Contractor shall completely fill in all information on the forms provided with Revision of Section 614 – ITS As-Built Documentation for submittal to the Project Engineer.

REVISION OF SECTION 614
GROUNDING AND BONDING

Section 614 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

This work consists of grounding and bonding requirements at project locations for all Intelligent Transportation System (ITS) related structures, poles, service pedestals and cabinets. The work covered in this section consists of labor, materials, and services required for a functional and unobtrusive grounding system.

1. General: Provide comprehensive grounding and bonding for ITS related equipment. CDOT's target resistance to ground value is equal to or less than 10 Ω.
2. Applicable Documents: Work performed in this section shall comply with the most current edition of the following codes and standards:
   A. IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System,
   B. IEEE C2 – National Electrical Safety Code,
   C. NEMA GR 1 – Grounding Rod Electrodes and Grounding Rod Electrode Couplings,
   D. NFPA 70 – National Electrical Code,
   E. NFPA 70E – Standard for Electrical Safety in the Workplace,
   F. NFPA 780 – Standard for the Installation of Lightning Protection Systems,
   G. TIA-607 – Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises,
   H. UL 96 – Lightning Protection Components,
   I. UL 96A – Installation Requirements for Lightning Protection Systems, and
   J. UL 467 – Grounding and Bonding Equipment.
3. Identify to the Engineer any conflicts between the requirements of codes/standards development organizations and the specifications for this project.
4. Submittals:
   A. Provide cut-sheets of each type of product proposed for approval by the Engineer prior to commencement of work.
   B. Provide a system plan, conductor routing, supports, connectors and ground rods along with connection, mounting and splicing details.

MATERIALS

Components.

1. Grounding electrodes (driven rods): Provide ground rods that meet or exceed the following requirements:
   A. Preferred: Copper-clad steel ground rods (pointed) shall not be less than 0.625 inch diameter and a minimum of eight feet in length. It shall be UL certified and have a minimum plating thickness of 10 mil copper cladding.

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REVISION OF SECTION 614
GROUNDING AND BONDING

B. Other Alternatives: Other ground rod types, such as chemical ground electrodes, may be considered based on site soil chemistry, adjacent electrically bonded structures, or if the installation must occur in a corrosive area. The Contractor shall obtain written permission from the Engineer prior to using the previously mentioned alternatives.

2. Grounding Electrode Conductor: The grounding electrode conductor shall be solid or stranded copper with a minimum size of #6 AWG, unless otherwise specified. The Contractor shall size the grounding electrode conductor in accordance with Article 250.66 of the NEC. Bare and insulated grounding electrode conductors shall be permitted, as approved by the Engineer. Insulated grounding electrode conductors shall be Type THWN and conform to the requirements of Article 310 of the NEC. Insulated grounding electrode conductors shall utilize a green jacket color. The grounding electrode conductor run shall be installed in one continuous run without a splice or joint, except as permitted in accordance with Article 250.64(C) of the NEC.

   A. For bonding between a cabinet frame and busbar, a braided ground strap shall be utilized. The braided ground strap shall consist of non-insulated tinned copper flat braid wire with a minimum width of 0.5 inches and a thickness of 0.07 inches (based on estimated #6 AWG equivalence).

3. Grounding Connectors: Grounding connectors shall be provided for attachment to grounding electrodes, ground bus and ground lugs. Grounding and bonding connections shall be made by means of a compression connector, a mechanical connector, or an exothermic weld. Mechanical and compression connectors shall have only one conductor installed unless designed or UL-listed for more conductors. Mechanical connections shall only be permitted when a compression or exothermic connection cannot be made.

4. Ground Bus: Provide copper bar stock grounding busbar. The minimum size shall be 0.25 inch thick by 2 inches high by 6 inches wide and positions for five lugs, unless otherwise specified by the Engineer. Hole patterns on the busbar shall accommodate two-hole lugs in accordance with TIA-607 and hole spacing should not be less than 0.75 inch. Busbar must be wall mountable and UL certified. Stand-off brackets shall also be included and brackets shall be manufactured from 300 series stainless steel with stainless steel bolts and lock washers.

CONSTRUCTION REQUIREMENTS

General: Install equipment, materials and devices in accordance with equipment manufacturer's written instructions and in compliance with applicable installation standards.

1. Connections:

   A. Provide exothermically welded connections below grade and in areas exposed to visible moisture.

   B. Provide heavy duty bolted clamped connections, UL listed, above grade and in areas where safety to personnel and structures dictate.

2. Installation:

   A. Install one grounding electrode. Each grounding electrode shall be installed such that at least the entire length is in contact with the soil. Where a rock bottom is encountered, the grounding electrode installation shall conform to the requirements of Article 250.53(G) of the NEC. The grounding electrode system shall be installed within CDOT right-of-way.

   B. Leave top of grounding electrode exposed for testing and for verifying quantities.

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REVISION OF SECTION 614
GROUNDING AND BONDING

C. Measure the resistance of the installed grounding electrode with respect to the surrounding soil using an earth ground resistance tester.

D. If the results exceed 10 Ω, install a second grounding electrode a minimum of one electrode length away from the first grounding electrode. The bonding jumper used to connect grounding electrodes shall be installed and sized in accordance with Article 250.53(C) of the NEC.

E. Measure the resistance of the installed grounding electrode system with respect to the surrounding soil using an earth ground resistance tester.

F. Record and report results to Engineer in writing. CDOT's target resistance to ground is equal to or less than 10 Ω, however after installing two grounding electrodes, a resistance to ground value equal to or less than 25 Ω will be accepted by CDOT. The Contractor shall be responsible for confirming the resistance to ground requirements with the various manufacturers of the equipment it procures for this project. Where manufacturers have more stringent resistance to ground requirements for operational performance and warranties, the Contractor shall be required to adhere to the manufacturer's requirements for acceptance by CDOT.

G. In the absence of low resistance soil conditions, the Engineer, at his/her sole discretion, may allow the use of the following: bentonite to fill the ground rod hole; chemical electrodes; or ground enhancement material. The Contractor shall obtain written permission from the Engineer prior to using the previously mentioned materials.

3. Surface Preparation

A. Ground Bus: An abrasive pad shall be used to remove any dirt, grease, oil and oxidation from the ground bus. A thin coating of antioxidant compound shall be applied to the connection point on the ground bus. Using stainless steel hardware, the Contractor shall tighten and torque to the value specified for the hardware grade, material and size. Only one lug shall be installed per a two-hole mounting on a bonding surface. Lugs shall not overlap or use the same mounting holes on a bonding surface. Due to thermal cycling anticipated in the field environment, the lock washer shall be substituted with flat washers and a cupped spring washer (i.e., Belleville washer), with the cup against the head of the bolt.

B. Other Surfaces: Clean the surface thoroughly where the grounding lug is to be connected. The grounding surface shall be clean of any paint, dirt, grease, oil, rust and other oxidation. A thin coating of antioxidant compound shall be applied to the connection point on the surface. Using stainless steel or silicon bronze hardware, the Contractor shall tighten and torque to the value specified for the hardware material and size. Lugs shall not overlap or use the same mounting holes on a bonding surface. The lock washer shall be substituted with flat washers and a cupped spring washer, with the cup against the head of the bolt.

C. Ground Attachment to Structures and Poles: The grounding electrode conductor shall be connected to the ground stud on a structure or within a pole using stainless steel nuts and cupped spring washers. The connector type for the grounding electrode conductor shall be a full circle connector sized appropriately for the diameter of the ground stud and the wire gauge of the conductor.

Where a ground stud does not exist on a structure or within a pole, the Contractor shall install a tapped and threaded hole to accommodate the grounding electrode conductor and screw. The connector type for the grounding electrode conductor shall be a full circle connector sized appropriately for the diameter of the screw and the wire gauge of the conductor. Stainless steel screws and cupped spring washers shall be included.

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REVISION OF SECTION 614
GROUNDING AND BONDING

D. Grounding Connectors: The lug size, configuration and material for compression connectors shall be selected based on the grounding electrode conductor size and fastening conditions. The insulation shall be trimmed back so that the bared grounding electrode conductor is slightly longer than the barrel. After applying an antioxidant compound on the exposed grounding electrode conductor, insert the conductor so that it touches the end of the barrel as viewed through the inspection port. Ensure the grounding electrode conductor remains at the end of the barrel before making the first crimp nearest the tongue end and working toward the conductor with the remaining crimps. The lug manufacturer's instructions shall be followed for the number of crimps and their location on the barrel.

For exothermic welds to the grounding electrode conductor, select the mold and weld metal applicable to the conductor size and lug configuration. Clean and dry (using a torch) the grounding electrode conductor and the mold. Insert the conductor and lug into the mold. Close the handle clamp, lock the mold and then insert the disk into the mold. Pour the weld metal into the mold and apply the starting material over the weld metal and on the lip of the mold. Close the cover and ignite using a flint igniter. After the reaction is complete, wait a minimum of 15 seconds and then open the mold and remove the finished lug connection. Clean any slag from the finished lug connection.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
ITS SYSTEM AS-BUILT DOCUMENTATION

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

The Contractor shall complete and transmit to the Project Engineer the ITS as-built documentation as part of the final submittals on the project.

MATERIALS

There are no materials requirements associated with this special provision.

CONSTRUCTION REQUIREMENTS

The Contractor shall document the as-built device, communications, and power infrastructure placement and material information. The Contractor shall clearly mark the plan sheets with red ink describing the as-built condition of all elements installed, including all changes made to fiber optic splicing. The as-built markups shall include the following information related to location markers:

1. Type of location marker installed
2. Distances between location markers
3. Distances between pull boxes and manholes to ITS devices
4. The distance and location to each CDOT utility point of service connection source point which the local utility companies have provided, including electrical power, transformer source, and telephone pedestals.

At the end of the project, the Contractor shall create a legible PDF scan of the marked up as-built drawings, and submit the hard copy and PDF to the Project Engineer.

1. The Contractor shall complete the following forms included in this special provision:
2. Form 1411—ITS Device Installation Checklist
3. ITS As-Built Documentation Form
4. Fiber Optic Cable As-Built Documentation Form

Prior to filling out forms, the Contractor shall review the forms and instructions and request all necessary clarification from the Project Engineer. Instructions for Form 1411 are included in this special provision.

The Contractor shall request from the Project Engineer electronic copies of the ITS As-Built Documentation Form and the Fiber Optic Cable As-Built Documentation Form. The Contractor shall fill out the electronic forms and provide the completed forms to the Project Engineer. The file name of the electronic forms shall include the form type, the five-digit construction subaccount number, and a description of the installation location.

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REVISION OF SECTION 614
ITS SYSTEM AS-BUILT DOCUMENTATION

Form 1411

https://www.codot.gov/library/forms/cdot-1411

COLORADO DEPARTMENT OF TRANSPORTATION

ITS DEVICE INSTALLATION CHECKLIST (one form per device)

Project Engineer:	Installer:	Installation Date:
Engineer Contact #:	Installer Contact #:	

Device Type: ☐ CCTV ☐ VMS ☐ RWIS ☐ TTI ☐ Radar ☐ ATR ☐ Other: _____

Location: Roadway:_____ (Example: I-70) Direction:_____ (E) Crossroad:_____ (Wadsworth) Mile Marker:_____ (181.6)

Latitude:_____ (Example: 39.46532) Longitude: _____ (-104.3621) Altitude (in meters): _____

Manufacturer:	Model #:
Warranty Start:	Warranty Expiration Date:

Warranty Contact Information: _____ (Example: Vendor/Phone Contact)

Maintenance Responsibility: ☐ ITS ☐ Region _____ ☐ HLT ☐ EJT

IF REGION: ☐ Maintenance ☐ Traffic

Travel Time to Device from Golden, CO (To/From): _____ minutes

Equipment Access:_____ (Example: Bucket Truck, Ladder, Ground Level)

Roadway Closure Requirements for Maintenance:_____ (Example: Shoulder, Lane, Not Applicable)

Communications: ☐ Fiber ☐ Radio ☐ CDWH ☐ CDMA ☐ T1 ☐ Dial-Up ☐ Other: _____

Additional Communication Notes:_____ (Example: Phone#, MAC Address, etc.)

Device Purpose: ☐ Regulatory ☐ Safety ☐ Mobility ☐ Data Support ☐ System Support

Pictures: ☐ Inside of Cabinet ☐ From Traveling Direction ☐ From Opposite Travel Direction
☐ Any Physical Conditions That Could Affect Maintenance

Power Provider:	Contact:	Account:
Comm Provider:	Contact:	Account:

☐ Provide Redline as builts set of where Comm and Power Source from device back to provider to ITS Maintenance
(Contact Matt Rickard (303) 512-5634 with ITS Maintenance, with 3 weeks notice, for Acceptance when both Power and Comms are complete)

Additional Notes:

CDOT Form #1411 8/12

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REVISION OF SECTION 614
ITS SYSTEM AS-BUILT DOCUMENTATION

FORM 1411 INSTRUCTIONS

The following instructions are provided for information to the Contractor. The Contractor shall direct all questions regarding form 1411 to the Project Engineer.

1. *Project Engineer / Installer / Contact # / Installation Date*

   Fill in the name (first, last) of the Project Engineer and device Installer and phone numbers for both parties. Fill in the date of installation.

2. *Device Type*

   Place a check next to the type of device being installed, or fill in the box marked "Other."

3. *Location / Roadway / Direction / Crossroad / Mile Marker*

   Fill in the name of the major roadway on which the device is installed, the direction of travel on the side of road on which the device is installed, the nearest crossroad, and highway mile marker to the nearest hundredth of a mile. For the direction of travel, odd numbered highways are always considered north-south highways and even numbered highways are always considered east-west highways.

4. *Latitude / Longitude / Altitude*

   Fill in the latitude, longitude, and altitude using the method described and the precision and accuracy defined in the special provision Revision of Section 614 – Global Positioning System (GPS).

5. *Manufacturer / Model # / Warranty Start / Warranty Expiration Date / Warranty Contact Information*

   Fill in the manufacturer name, device model number, manufacturer warranty state date, warranty expiration date, and warranty contact information. The warranty contact information shall be the name and telephone number of the party responsible for addressing warranty issues with the device.

6. *Maintenance Responsibility*

   With input from Project Engineer, check the applicable box to identify the CDOT personnel responsible for maintaining the device. If a specific CDOT region is responsible, define whether region maintenance or traffic group is responsible for maintenance.

7. *Travel Time to Device from Golden, CO*

   Use a reliable mapping tool to provide an approximate travel time in minutes (assuming no traffic) from 425 Corporate Circle, Golden, Colorado, 80401 to the device location. Google maps, Apple maps, and Bing maps are examples of reliable mapping tools.

8. *Travel Time to Device from Golden, CO*

   Briefly describe how maintenance personnel will access both the communications cabinet and device. If the communications cabinet is at ground level and the device requires a bucket truck for access, write "Cabinet ground level, device bucket truck" or something similar.

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REVISION OF SECTION 614
ITS SYSTEM AS-BUILT DOCUMENTATION

Form 1411 Instructions (Continued)

9. *Roadway Closure Requirements for Maintenance*

   Describe what portion of the paved roadway is required to be occupied by a maintenance vehicle to access the communication cabinet and device.

10. *Communications / Additional Communication Notes*

    Check the appropriate box for the type of communications used for the device, or fill in the box marked "Other." Provide additional applicable communications notes.

11. *Device Purpose*

    With input from the Project Engineer, check the applicable box to identify the purpose of the device.

12. *Pictures*

    Check that each described picture (at a minimum) has been taken and provided in a digital format to the Project Engineer. Label each picture file with the major street name, mile marker to the nearest hundredth, device type, and brief description of the picture (e.g. cabinet).

13. *Power Provider / Contact / Account*

    Insert the name of the power service provider, power company contact phone number, and account number for the device service. If no new power service was provided for the device, fill in "NA"

14. *Comm. Provider / Contact / Account*

    Insert the name of the communications service provider, communications service contact phone number, and account number for the device service. If communications is via CDOT's network, fill in "CDOT".

15. *Provide redline as-builts*

    Check the box after redline as-builts of power and communications service points are provided as described.

16. *Additional Notes*

    Fill in additional notes that are relevant to future maintenance operations.

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REVISION OF SECTION 614
ITS SYSTEM AS-BUILT DOCUMENTATION

ITS AS-BUILT DOCUMENTATION FORM

COLORADO DEPARTMENT OF TRANSPORTATION

ITS AS-BUILT DOCUMENTATION FORM

Project Engineer:		Installer:		Installation Date:	
Engineer Contact #:		Installer Contact #:			
Fiber					
Cable Size:		Cable Type:		Owner:	
Cable Manufacturer:		Cable Length:			
Fiber Marker Sequential Between Devices:					
Optical Wavelengths to Each Communication Device at the Port Level:					
Patch Panel Size:		Patch Panel Type:		Port Status (Active/Unused):	
Patch Panel Manufacturer:		Patch Position (for each fiber):			
Communication Device					
Type:		Manufacturer:			
Configuration:		Port Type:			
Fiber Strand Corresponding to Each Active Port:					
Port Wavelength:					
Splice Enclosure					
Splice Enclosure Type:		Splice Enclosure Manufacturer:			
Owner:		Installer:		Date Installed:		Location Type:	
Location Description:		Grounding Method:			
Site-Specific Comments:					
Electronic Marker					
Marker Type:		Marker Manufacturer:			
Marker Color:		Marker Frequency:			
Conduit System					
Buried Depth:		Encasement Type:			
Manufacturer:		Model:		Measured Length:	
Length Source:		Duct Bank Height:		Duct Bank Width:	
Installation Date:		Material:		Construction Status:	
Duct Availabilty:					

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REVISION OF SECTION 614
ITS SYSTEM AS-BUILT DOCUMENTATION

FIBER OPTIC CABLE AS-BUILT DOCUMENTATION FORM

COLORADO DEPARTMENT OF TRANSPORTATION

FIBER OPTIC CABLE AS-BUILT DOCUMENTATION FORM

TO NEXT PULL BOX OR MANHOLE

CABLE MEASUREMENT OUT:

PULL BOX OR MANHOLE ID:

MAJOR STREET OR HIGHWAY:

CABLE ID NUMBER:

CABLE MEASURMENT IN:

SPLICE POINT	YES	NO
CABLE END SPLICE	YES	NO
NUMBER OF LATERAL CABLES:		

CABLE MEASUREMENT OUT:

PULL BOX OR MANHOLE ID:

MAJOR STREET OR HIGHWAY:

CABLE ID NUMBER:

CABLE MEASURMENT IN:

SPLICE POINT	YES	NO
CABLE END SPLICE	YES	NO
NUMBER OF LATERAL CABLES:		

CABLE MEASUREMENT OUT:

PULL BOX OR MANHOLE ID:

MAJOR STREET OR HIGHWAY:

CABLE ID NUMBER:

CABLE MEASURMENT IN:

SPLICE POINT	YES	NO
CABLE END SPLICE	YES	NO
NUMBER OF LATERAL CABLES:		

TO NEXT PULL BOX OR MANHOLE

Page:

REVISION OF SECTION 614
MICROWAVE VEHICLE RADAR DETECTOR (334)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work shall consist of furnishing and installing microwave vehicle radar detectors in accordance with these Special Provisions at ramp meter locations with ground mounted 334 cabinets. Contractor shall order the Wavetronix SmartSensor HD, configuration software, mounting hardware, and compatible Click! DIN rail mountable components.

MATERIALS
(Pole Mounted Within 40' of Traffic Control Cabinet)

The Microwave Vehicle Radar Detector (MVRD) shall include the radar detector unit, 20' standard combination power/data cable with connector, required length of un-terminated Belden 9330 or approved equal 4 pair separately shielded 22 AWG cable to reach from pole mounted communications cabinet to traffic control cabinet, data line surge suppressor, pole mount hardware, communications cabinet, and configuration software.

The radar detection unit shall be a non-intrusive device using frequency modulated continuous wave radar technology for the gathering of vehicle information including traffic volume, lane occupancy, individual and average speed, vehicle classification, and presence. It shall have auto configuration capabilities to simultaneously identify up to ten highway lanes with the ability to detect over center median barriers and accurately detect partially occluded vehicles. Weather shall not impact the radar detection of the unit. Wind or temperature change shall not cause the device's original field installation configuration to alter over time. The radar detection unit shall include the manufacturer's recommended power/communication cable. The radar detection unit shall meet the following minimum requirements:

1. Installation Type: Side Fire or Forward Fire installation
2. Detection Zones: Up to 10 Lanes Simultaneously
3. Detection Range: 3 to 250 feet
4. Detection Zone Resolution: 1 foot
5. Time Resolution: 2.5 msec
6. Elevation 3 dB Beamwidth: 65º
7. Azimuth 3 dB Beamwidth: 7º
8. Operating Frequency: 24.0 to 24.25 GHz (K-Band)
9. Communications: RS-232 and RS-485
10. Power: 8.0 Watts at 9 to 36 Volts DC
11. Operating Temperature: -40 to +165ºF (Ambient)
12. Humidity: Up to 95% Relative
13. Shock: 10g 10ms Half Sine Wave

The communications cabinet shall be non-metallic NEMA 4x enclosure or equivalent, measuring 8 inches (H) x 6 inches (W) x 4 inches (D), and have a securable hinged door with weather proof seal to prevent

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REVISION OF SECTION 614
MICROWAVE VEHICLE RADAR DETECTOR (334)

the ingress of wind and water. The communications cabinet shall include an internal backplane with DIN rail and mounting bracket assembly for attachment to supporting pole.

The DIN rail mountable components to be installed inside the communications cabinet shall include a WX-SC-200 Click 200 data line surge suppressor with hot swappable protected busses. The Data Line surge suppressor shall provide protection for RS-232, RS-485, and DC power to the radar detection unit. Wiring for the surge suppressor shall be by means of pluggable screw terminals and include unprotected as well as protected RS-232 and RS-485 communications connectors and shall have a minimum operating temperature range of -29 to 165˚F up to 95 percent relative humidity.

MATERIALS
(mounted inside 334 traffic control cabinet)

There shall be a 19" bent rack mount DIN rail, a DIN rail mountable WX-SC-206 Click 206 .05 Amp re-settable circuit breaker and switch, a DIN rail mountable WX-SC-201 Click 201 AC to DC power converter. The power supply shall accept input voltage from 100 to 240 VAC at 45 to 65 Hz and provide 24 VDC output at 1Amp. The power supply shall have a minimum operating temperature range of -29 to 165˚F up to 95 percent relative humidity. The power supply shall provide for 100 percent power reserve for a minimum of 20 ms to protect against static voltage dips, transient failures of supply voltage, or continuous phase failures. There shall be a WX-SC- 205 Click 205 AC lightening power line surge protector DIN rail mountable with hot swappable protected busses, and a WX-SC-200 Click 200 data line surge suppressor. The surge suppressor shall provide protection for RS-232, RS-485, and DC power. Wiring for the surge suppressor shall be by means of pluggable screw terminals and include protected and unprotected RS-232 and RS-485 communications connectors. The surge suppressor shall have a minimum operating temperature range of -29 to 165˚F up to 95 percent relative humidity. The necessary number of input file-mountable WX-SC-174 Click! 174 four-channel and/or WX-SC-172 Click! 172 two- channel contact closure (loop emulator) modules with required RJ-11 patch cords shall be provided to emulate 1 primary and 1 secondary loop for each mainline lane.

CONSTRUCTION REQUIREMENTS

Two conduit access holes, not to exceed 1.5 inches shall be made on the bottom of the communications cabinet. One of these holes is to be used for the power/communications cable in from the sensor and the other for the power/communications cable out to the traffic control cabinet. The access holes shall be positioned at a location to ensure the proper, safe routing of wiring entering the cabinet. 3/4 inch Type 201 stainless steel strap used in conjunction with Type 201 stainless steel buckles shall be used to mount the communications cabinet to the structure so that the top of the cabinet is approximately 5 feet above surrounding grade. The communications cabinet shall be oriented such that anyone working in the cabinet has direct line of sight with oncoming traffic. The Contractor shall be responsible for any necessary modifications or additions needed to mount the communications cabinet to the structure.

0.75 inch Type 201 stainless steel strap used in conjunction with Type 201 stainless steel buckles shall be used to mount the radar detection unit at a height and angle determined by roadway off- set and detection distance in accordance with manufacturer's recommendations and shall be properly grounded per the manufacturer's specifications.

The manufacturer's recommended power/communication cable shall run on the interior of the mounting structure from the radar detection unit to the communications cabinet. A hole not to exceed 1.5 inches shall be made 12 inches below the radar detection unit to allow passage of the

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REVISION OF SECTION 614
MICROWAVE VEHICLE RADAR DETECTOR (334)

power/communications cable into the structure. The Contractor shall ensure strain relief and drip loops in the power/communication cable before the cable enters the structure in accordance with manufacture's recommendations. Two holes not to exceed 1.5 inches shall be made below the communications cabinet to allow the power/communications cables to pass from the interior of the structure to the interior of the communications cabinet. Flexible conduit shall be used to run cables from the structure to the communications cabinet.

The Contractor shall run and connect power from the structure to the 0.5A circuit breaker and power line surge protector in the 334 traffic control cabinet. The Contractor shall wire supply power, power supply, surge suppressors, breaker, and radar detection unit in accordance with the manufacture's recommendations. The radar detection unit shall be wired to support RS-232 serial communications.

All holes shall be free of burs and sharp edges prior to the installation of all cable, conduit, and conduit nipples. All cable entrances in structures, conduits, and cabinets shall be sealed and waterproofed. All wiring and electrical connections shall be performed in conformance with the latest version of the NEC.

The Contractor shall configure the radar detection unit to detect all lanes, in accordance with the manufacture's recommendations.

The units shall be environmentally hardened for outdoor use with a temperature range of -10 to +80 degrees centigrade and available in one, two or four RS-232 port units. Also included at this location, a 120 volt AC to 24 volt DC power supply shall be included. This unit shall have a slim line DIN mountable case and be mounted to DIN rail in the 334 traffic control cabinet. The Contractor shall provide units which are compatible with current Department devices installed at various locations.

See project specific Testing & Integration Plan for additional requirements for MVRDs.

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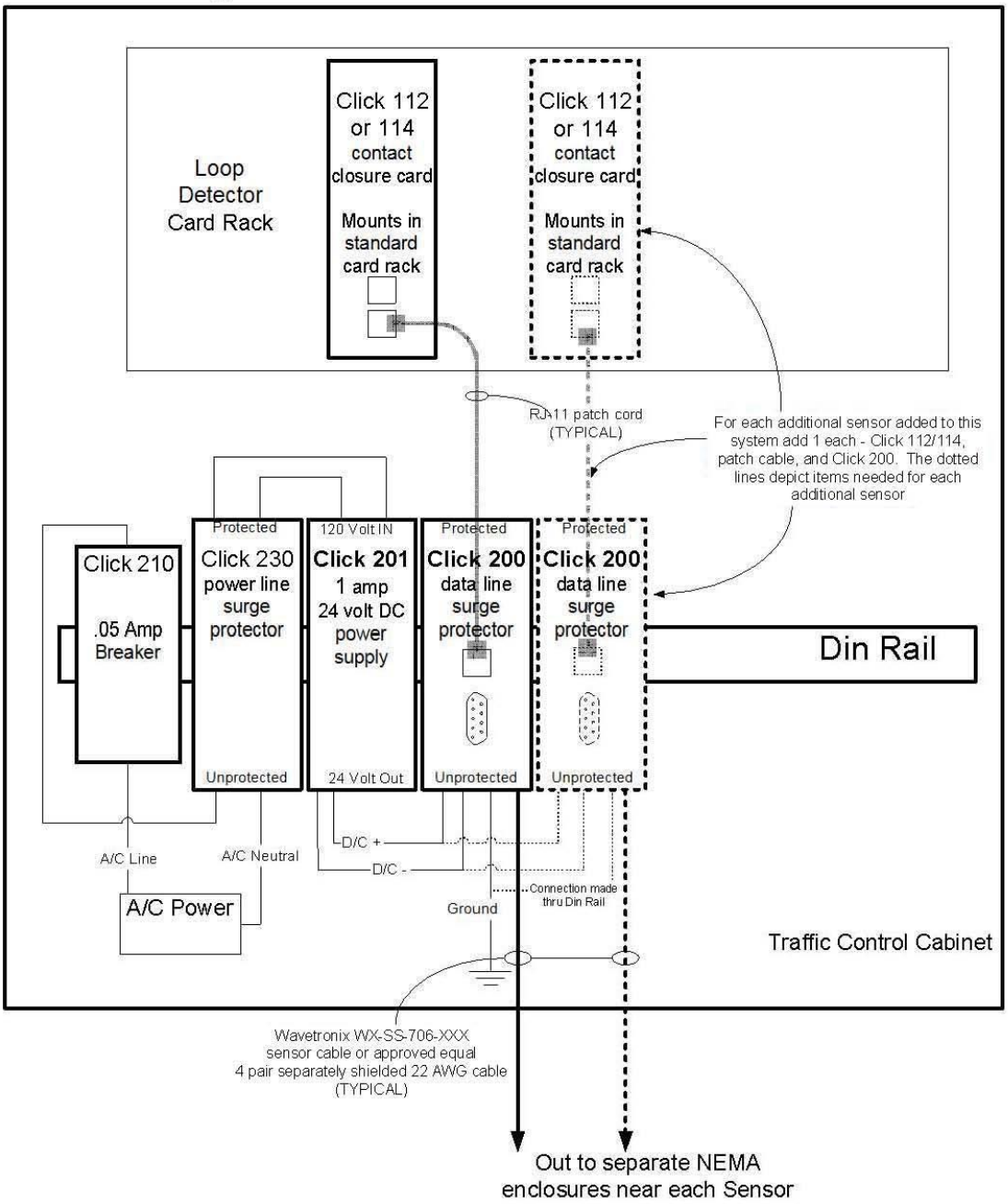
MICROWAVE VEHICLE RADAR DETECTOR (334)

Drawing showing the equipment needed in the Control Cabinet when Installing Wavetronix SmartSensors with contact closure.



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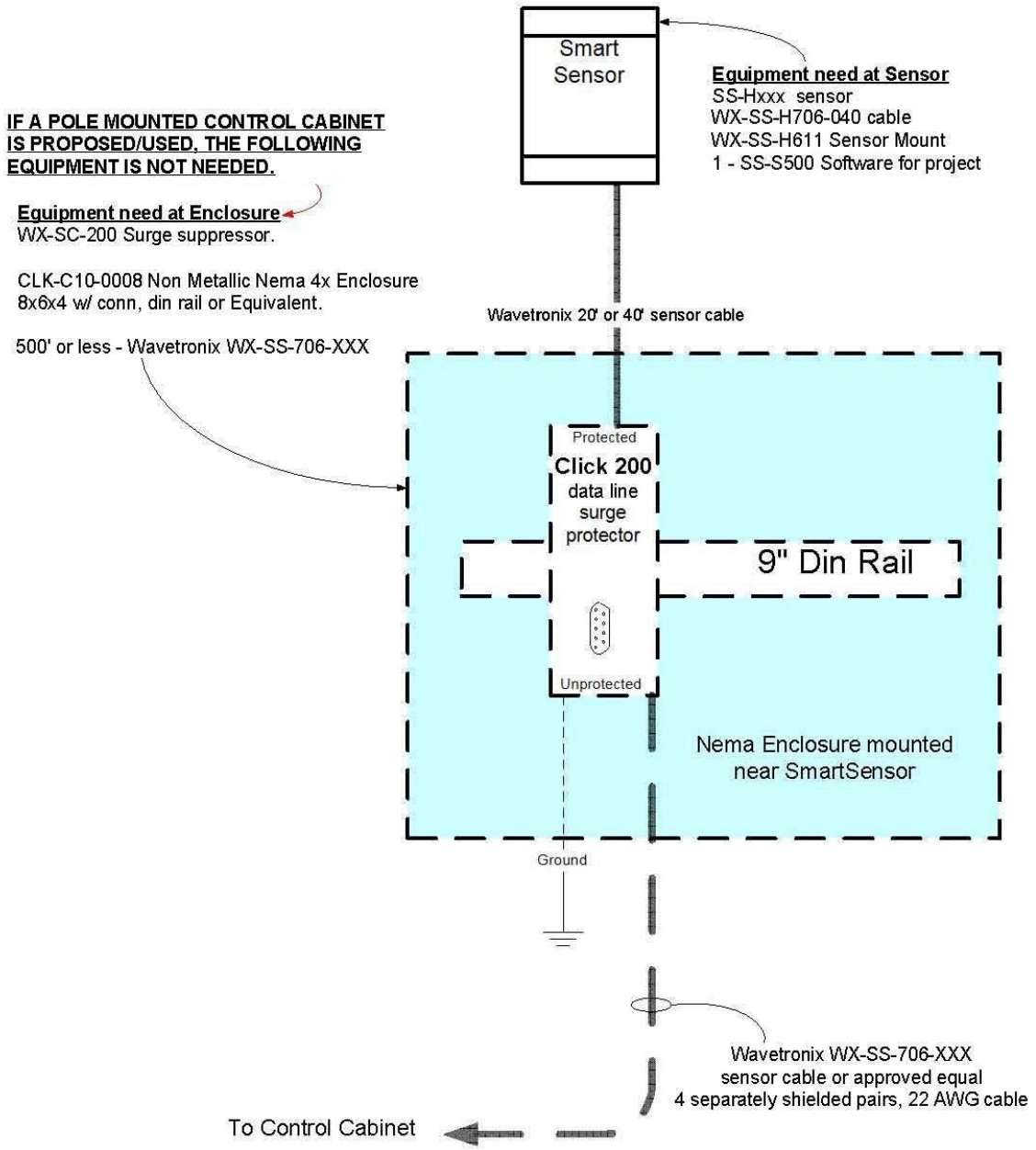
Equipment drawing for each SmartSensor located less than 500' from control cabinet (as the wire travels).



REVISION OF SECTION 614
MICROWAVE VEHICLE RADAR DETECTOR (NON 334)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work shall consist of furnishing, installing, and configuring a microwave vehicle radar detector (MVRD) in accordance with these Special Provisions at locations without ground mounted 334 cabinets. Contractor shall order the Wavetronix SmartSensor HD, configuration software, mounting hardware, and compatible Click! DIN rail mountable components.

MATERIALS

The Microwave Vehicle Radar Detector shall include: the radar detection unit with mounting hardware, manufacturer configuration software, detection unit power supply, power and communication cable, serial surge suppression, serial to Internet Protocol (IP) converter, and any additional hardware necessary for a complete and functional installation.

The radar detection unit shall be a Wavetronix SmartSensor HD, model number 101-0415 meeting the following requirements:

The radar detection unit shall include a non-intrusive device using frequency modulated continuous wave radar technology for the gathering of vehicle information including traffic volume, lane occupancy, individual vehicle and average vehicle speed, vehicle classification, and vehicle presence. It shall have auto configuration capabilities to simultaneously identify up to twelve highway lanes with the ability to detect over center median barriers and accurately detect partially occluded vehicles. Weather shall not impact the radar detection functionality of the unit. Wind or temperature change shall not cause the device's original field installation configuration to alter over time. The radar detection unit shall include necessary hardware for pole mounting.

Manufacturer configuration software shall be the latest production version and allow for device discovery, configuration, and troubleshooting.

The power and communication cable shall be the manufacturer's recommended cable for functional operation of the radar detection unit.

A WX-CLK-301 module shall be furnished and installed, along with any cabling, to convert communications from Serial to Ethernet.

The detection unit power supply shall be Wavetronix WX-CLK-201 Deutsches Institut für Normung (DIN) rail mountable hardened alternating current (AC) to direct current (DC) supply meeting the manufacturer's recommendations for functional operation. Power supplies are not required when installed at an intelligent transportation system (ITS) communications cabinet that has existing 12 volt direct current (VDC) power supplies.

Serial surge suppressor shall be Wavetronix Click WX-CLK-200. The surge suppressor shall be DIN rail mountable with hot swappable protected busses. The surge suppressor shall provide protection for RS-232, RS-485, and DC power to the radar detection unit. Wiring for the surge suppressor shall be by means of pluggable screw terminals and include unprotected RS-232 and RS-485 communications connectors. The surge suppressor shall have a minimum operating temperature range of -30 to 165˚F up to 95 percent relative humidity.

The serial to IP converter shall be an externally powered, hardened, 35 millimeter DIN mountable unit, with one RJ-45 port for connection to an Ethernet network, one screw terminal port for connection to a serial device, and one DB-9M pass through port for local communication. It shall operate in a minimum

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MICROWAVE VEHICLE RADAR DETECTOR (NON 334)

temperature range of -30 to 165°F at 0 to 90 percent non-condensing humidity. The converter shall be powered externally and run off of 9 to 30 VDC drawing a maximum of 6 watts.

It shall support RS-232, 422, and 485 serial protocols at data rates from 300 to 230 kilobits per second, with hardware and software support for request to send (RTS), clear to send (CTS), data terminal ready (DTR), data set ready (DSR), and data carrier detect (DCD) signal control lines and modem emulation. Power, Ethernet, serial signals, and diagnostic status shall be visible via individual built in light emitting diodes (LEDs).

The converter shall be capable of a 10/100 megabit per second full duplex Ethernet connection. Serial ports shall be accessible via transmission control protocol/IP (TCP/IP), user datagram protocol/IP (UDP/IP), and include software drivers for mapping the ports to Windows, Linux, and Unix operating systems using a secure encrypted connection. It shall be configurable via command line interface through the serial port and integrated web interface via Ethernet connection. It shall be capable of serial bridging across an Ethernet network when two units are used together.

The converter shall support the following protocols: http/https, SNMP, TCP & UDP/IP, ASCII, DHCP, ARP, telnet, reverse telnet, PPP, SSH, SSL/TLS, and AES. The converter shall satisfy underwriters laboratories (UL) 1950, ANSI/ISA 12.12.01-2000 – Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations, and Federal Communications Commission (FCC) part 15 (Class A).

The converter power supply shall be designed for a minimum operating temperature range of - 13°F to +158°F at humidity levels of 20 to 95 percent (non-condensing), be DIN rail mountable and meet all manufacturer recommendations. The power supply will not be required at Type 1 and Type 2 communications cabinets where a 12 VDC power supply is provided with the cabinet and there is enough capacity on the supply to power all designated 12 VDC equipment at 80 percent loading.

Additional hardware, including but not limited to the following shall be supplied by the Contractor: mounting hardware, data interconnection cables, and power cables.

CONSTRUCTION REQUIREMENTS

The radar detection unit shall be mounted with 0.75 inch Type 201 stainless steel strap and buckles at a height and angle determined by roadway off-set and detection distance in accordance with manufacturer's recommendations.

The power and communication cable shall run from the radar detection unit through the mounting structure to the communications cabinet. A hole not to exceed 1.5 inches shall be made to allow passage of the power and communications cable into the structure. The hole shall not be made below the centerline of the sensor mount, or more than two feet above the centerline of the sensor mount. The Contractor shall ensure strain relief and drip loops in the power and communication cable before the cable enters the structure in accordance with manufacture's recommendations, and seal the hole with duct seal. Flexible conduit shall be used to run cables from the structure to the communications cabinet where required. A hole not to exceed 1.5 inches shall be made below the communications cabinet to allow the power and communications cable to pass from the interior of the structure to the interior of the communications cabinet.

All holes shall be free of burs and sharp edges prior to the installation of all cable, conduit, and conduit nipples. All cable entrances in structures, conduits, and cabinets shall be sealed and waterproofed. All wiring and electrical connections shall be performed in conformance with the latest version of the National Electric Code (NEC).

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REVISION OF SECTION 614
MICROWAVE VEHICLE RADAR DETECTOR (NON 334)

The serial surge suppressor shall be installed on DIN rail inside the communication cabinet. The power and communications cable shall be terminated on the protected side of the WX-SC-200 surge suppression unit per manufacturer's recommendations. The radar detection unit shall be wired to support RS-232 and RS-485 serial communications. Power shall be wired to the manufacturer's recommended power supply or the existing 12 VDC power supply supplied in the communications cabinet. Wiring from the surge suppressor to the communication device shall be stranded Cat5e cable.

The serial to IP converter shall be installed on DIN rail inside the communication cabinet and powered from the manufacturer's approved power supply. When installed in a Type 1 or Type 2 communications cabinet, the 12 VDC power supply provided with the cabinet shall be used instead to power the converter as long as the final total load on the supply is less than 80 percent of total capacity.

The network connection from the converter to the field communication equipment shall be made with Cat5e cable using 8P8C terminations. The cable shall be long enough to connect from the field communication equipment directly to the serial device being converted to allow for future upgrade of the device to direct Ethernet communications.

The serial connection from the converter to the serial surge protector shall be made with stranded Cat5e cable. All bare wire connections shall be cleanly terminated with no stray or loose wires.

The network connection from the converter to the field communication equipment shall be made with Cat5e cable using 8P8C terminations.

The Contractor shall configure the converter with IP addresses as shown on the Plans or provided by the Engineer. Serial communication setting shall also be configured to match the serial device.

For a MVRD the settings are typically: 9600 bits per second, 8N1, no flow control; with TCP connections enabled to the serial port.

The Contractor shall utilize the latest version of manufacturer's software to verify optimal and correct sensor alignment to the roadway and configure the sensor. The Contractor shall configure the radar detection unit to detect all lanes and in accordance with the manufacture's recommendations. The Contractor shall configure the sensor for the following:

1. Sensor Settings
    - A. General tab
        - i. Subnet/ID=000/Sensor ID per Plans
        - ii. Location= HWY Installed Direction Mile Post and Common Name
        - iii. Orientation = Direction the unit is pointing
        - iv. Date& Time = Synchronize to this computer
    - B. Ports tab
        - i. Comm: RS-232
        - ii. Baud Rate=9600 bits per second
    - C. Outputs tab
        - i. Legacy Protocols
            - a. SS105 Protocol = Off
            - b. RTMS protocol = Off

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MICROWAVE VEHICLE RADAR DETECTOR (NON 334)

2. Lane Setup
   A. Sensor Alignment: Shall show green, unless detected lanes are not parallel.
   B. Lane configuration = Setup using auto-configuration and manually adjust as necessary to detect lanes
3. Data Setup and Collection
   A. Interval Data: Interval=30 seconds
   B. Data Push = OFF for output to RS-232 port

Once the device has been configured the Contractor shall verify connectivity through the serial to IP converter to the device, and connect the serial or Ethernet connection to the field communication device as appropriate. Once network connectivity have been verified, the Contractor shall confirm that the device is accessible and fully functional from the centralized software system at the CTMC.

See project specific Testing & Integration Plan for additional requirements for MVRDs.

REVISION OF SECTION 614
OPTICAL ATTENUATOR

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Coarse Wavelength Division Multiplexing Attenuator shall be installed for both CWDM and 1310nm SFP optic modules to reduce optical signal power to a receive level specified for the SFP optic modules based on the transmission loss of the corresponding link. These shall be installed at Ciena 3930/3931 Carrier Ethernet Service Delivery Switch and existing regeneration node building or CTMC Mux/DeMux locations. The attenuator shall be installed in the receive port of the equipment cabinet fiber optic termination patch panel bulkhead or Mux/DeMux. All attenuators shall be compatible with the Ciena CWDM SFP optic modules.

MATERIALS

The Contractor shall furnish and install single mode, 9/125um CWDM wavelength independent attenuators to attenuate the incoming signal to a power acceptable within the Ethernet switch SFP optic module receive range.

For testing and attenuator selection, wavelengths of SFP optic modules on this project are: 1430nm, 1450nm, 1470nm, 1490nm, 1510nm, 1530nm, 1550nm, 1570nm, 1590nm and 1610nm.

Attenuators for 1310nm wavelength SFP optic modules will not be required unless the incoming power exceeds the rated receive power of the SFP optic module, including a design margin of 6 dB (to allow for degradation over the life of the system).

The Contractor shall furnish and install a female to male plug type fiber optic attenuator. The types of fiber optic attenuators to be supplied shall match both the termination patch panel bulkhead port, the Mux/DeMux port and the fiber optic pre-connectorized patch cable connector.

The attenuators shall meet the following minimum specifications:

- Return Loss: Less than or equal to -65dB (APC)
- Attenuation Accuracy: +/-0.5 (1~10) +/-1.0(11~30)
- Polarization Dependent Loss: Less than 0.2dB
- Maximum Optical Input Power: 200mW
- Operating Temp Range: -40~80°C
- Low Polarization Dependent Loss **(**PDL**)**
- Minimum 500 connect/disconnecting tested

The attenuators to be provided shall conform to the requirements of Telcordia Technologies GR-910 *Generic Requirements for Fiber Optic Attenuators*.

CONSTRUCTION REQUIREMENTS

After all splicing and fiber optic testing is completed the Contractor shall test the optical power of the incoming, (Receive) signal at each field Ethernet switch and existing node building location. To obtain the most accurate values of optical power, the testing equipment shall be attached to the SFP optic end of the pre-connectorized patch cable.

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REVISION OF SECTION 614
OPTICAL ATTENUATOR

Once the optical power has been tested, the Contractor shall install the appropriate attenuator in the receive port to meet the receive values of the SFP optic module, including a design margin of 6 dB (to allow for degradation over the life of the system).

Prior to installation, all attenuators shall be cleaned with lint-free fiber wipes moistened with Isopropyl Alcohol 99% U.S.P. After cleaning with alcohol, the bulkhead shall be cleaned with an optical connector cleaner to ensure that all residues are removed.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
OPTICAL TRANSCEIVER

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Optical transceivers shall be installed at Intelligent Transportation System device locations for communications from the field device to a regeneration node building or the CTMC.

MATERIALS

Optical transceivers shall be provided and installed by the contractor in matched pairs and shall utilize integrated WDM, (Wavelength Division Multiplexing), optics operating at 1310/1550 nm and capable of transporting simultaneous bi-directional data on one single mode optical fiber. The unit shall support the transmission of duplex RS-232 and RS-422 data interfaces. The unit shall be transparent to data protocols used by various manufactures, providing for universal compatibility for the current system and for future expansion. It shall also require no in-field electrical or optical adjustments or in-line attenuators.

LED indicators shall provide power, data transmit and data receive status for monitoring proper system operation. The unit shall provide automatic re-settable solid-state current limiters and independent voltage regulators on each module to reduce the chance of a single point failure of the system. The module shall be hot swappable in a rack mount system to reduce complete system shut down during maintenance or repair.

Mean time between failures shall be 100,000 hours minimum. The module shall be UL and ULC listed and CE marked. The circuit board shall be UL 94 flame rated and meet all IPC standards. All PC boards shall be designated with part number, PC board number and show appropriate revision number. Housing shall be of all metal construction. All LED indicators and both electrical and mechanical connections shall be identified with silk-screened labels. The module shall have a lifetime warranty.

The Optical Transceiver shall meet the following minimum requirements:

1. Status Indicators
    A. Power: On – Red / Off – Off
    B. Data Transmit: Transmit Data – Green / No Data – Off
    C. Data Receive: Receive Data – Green / No Data – Off
2. Connectors
    A. Optical Fiber Bulkhead: ST
    B. Power: Terminal Block with Screw Clamps
    C. Data: RS 232 DB 25 female
3. Electrical Specifications
    A. Power: 12 Volt DC
    B. Current Protection: Automatic re-settable solid-state current limiters
    C. Voltage Regulation: Solid-state, independent on each board
    D. Circuit Board: UL 94 flame rated and meets all IPC standards

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OPTICAL TRANSCEIVER

E. 19 Inch Rack Mount Card: Shall be hot-swappable

4. Environmental

A. Operating Temp: –40˚C to +74˚C

B. Storage Temp: -40˚C to +85˚C

C. Relative Humidity: 0 percent to 95 percent (Non-Condensing)

CONSTRUCTION REQUIREMENTS

Optical transceivers shall be installed in the manner and locations shown on the plans. A complete installation consists of the transceiver unit, fiber optic pre-connectorized cable, power transformer and wiring transformer power to the unit.

Modular units shall be provided and installed in field communications cabinets. The placement of the unit shall allow provision for cable installation and maintenance per manufacturer's recommendations.

Rack mounted units shall be provided and installed in the devices respective regeneration node building or the CTMC.

Prior to completion of the work, the Contractor shall insure the following has been completed on all optical transceivers.

1. Each field transceiver has been connected to power per the manufacture's recommendations.
2. Each field transceiver is wired properly to the device interface.
3. Each regeneration node building/CTMC transceiver is installed in a compatible transceiver chassis and wired properly to the terminal server.
4. Communications of device data between the field and regeneration building transceiver pairs occurs with no transmitting errors.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
SERIAL TO IP CONVERTER

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing a serial to IP converter at field devices. The serial to IP converter is intended to convert serial communication data to IP for access from an Ethernet communication network.

MATERIALS

The serial to IP converter shall include the converter, power supply, Cat5e cable, and any mounting hardware, cabling, and terminations required for a fully functional installation.

Converter: The type of serial to IP converter used will vary depending on the communication requirements of the end device and corresponding control software. Converter A is required for use with a Variable Message Sign (VMS), Microwave Vehicle Radar Detector (MVRD), Diamond Counter for DTD ATR stations, or Traffic Signal (TS). Converter B is required for use with a Ramp Meter (RM) if it is to be connected to an Ethernet switch.

Converter A: The converter shall be an externally powered, hardened, 35mm DIN mountable unit, with one (1) RJ-45 port for connection to an Ethernet network, one (1) screw terminal port for connection to a serial device, and one (1) DB-9M pass through port for local communication. It shall operate in a minimum temperature range of -30 to 165°F at 0-90% non-condensing humidity. The converter shall be powered externally and run off of 9-30 V DC drawing a maximum of 6W. It shall support RS-232, 422, or 485 serial protocols at data rates from 300 to 230kbps, with hardware and software support for RTS, CTS, DTR, DSR, and DCD signal control lines and modem emulation. Power, Ethernet, serial signals, and diagnostic status shall be visible via individual built in LEDs.

The converter shall be capable of a 10/100Mbps full duplex Ethernet connection. Serial ports shall be accessible via TCP/IP, UDP/IP, and include software drivers for mapping the ports to Windows, Linux, and Unix operating systems using a secure encrypted connection. It shall be configurable via command line interface through the serial port and integrated web interface via Ethernet connection. It shall be capable of serial bridging across an Ethernet network when two units are used together.

The converter shall support the following protocols: http/https, SNMP, TCP & UDP/IP, ASCII, DHCP, ARP, telnet, reverse telnet, PPP, SSH, SSL/TLS, and AES. The converter shall satisfy UL1950, UL 1604 (Class1, Division 4), and FCC part 15 (Class A), and IEC 1004-2.

Converter B: The converter shall be an externally powered, hardened, 35mm DIN mountable unit, with two (2) RJ-45 ports for connection to an Ethernet network, two (2) screw terminal ports for connection to serial devices. It shall operate in a minimum temperature range of -34 to 165°F at 5-95% non-condensing humidity. The converter shall be powered externally and run off of 5-30 V DC drawing a maximum of 2W. It shall support RS-232, 422, or 485 serial protocols at data rates from 300 to 230kbps, with hardware and software support for RTS, CTS, DTR, DSR, and DCD signal control lines with modem emulation. Ethernet link and activity shall be visible via built in LEDs.

The converter shall be capable of a 10/100Mbps full duplex Ethernet connection with auto MDI/MDI-X, and allow multiple units to be connected together. Serial ports shall be accessible via TCP/IP, UDP/IP, and include software drivers for mapping the ports to Windows, and Linux, operating systems using a secure encrypted connection. It shall be configurable via integrated web interface through the Ethernet connection. It shall be capable of serial bridging across an Ethernet network when two units are used together. Centralized monitoring and management software shall be included for

the manufacturer. The converter shall support the following protocols: http, SNMP, TCP & UDP/IP, ASCII, DHCP, ARP, telnet, SSH, SSL/TLS. The converter shall satisfy RoHS2, UL 60950, FCC part 15 (Class A), and NEMA, IEC 1004-2, and TS2.

The converter shall be capable of a 10/100Mbps full duplex Ethernet connection with auto MDI/MDI-X, and allow multiple units to be connected together. Serial ports shall be accessible via TCP/IP, UDP/IP, and include software drivers for mapping the ports to Windows, and Linux, operating systems using a secure encrypted connection. It shall be configurable via integrated web interface through the Ethernet connection. It shall be capable of serial bridging across an Ethernet network when two units are used together. Centralized monitoring and management software shall be included for the manufacturer. The converter shall support the following protocols: http, SNMP, TCP & UDP/IP, ASCII, DHCP, ARP, telnet, SSH, SSL/TLS. The converter shall satisfy RoHS2, UL 60950, FCC part 15 (Class A), and NEMA, IEC 1004-2, and TS2.

Power Supply: The power supply shall output 12 VDC and support an input voltage range of 85- 264 VAC and frequency range of 47-63 Hz. It shall have a typical efficiency of at least 76% and typical AC current of 1.6 A at 115 VAC. The 12 VDC power supply shall provide an output voltage of 12 VDC and have a minimum current rating of 6.3 A. It shall support an output current range of 0 to 6.3A (minimum) and have a rated power of 75 W (minimum). It shall have overload protection of 105-150% for its rated output power and overvoltage protection for voltages of 15-

VDC. It shall be designed for a minimum operating temperature range of +14°F to +140°F at humidity levels of 20% to 90% (non-condensing). The 12 VDC power supply shall conform to the following standards: IEC 60068-2-6 Environmental Testing (Vibration) and UL 508 Industrial Control Equipment. It shall be DIN rail mountable, have dimensions not exceeding 5 inches (H) by 2.25 inches (W) by 4 inches (D) and a weight of not more than 1.5 pounds. A 12 AWG AC power cord with NEMA 5-15P shall be included with the power supply.

The power supply will not be required at Type 1 or Type 2 ITS cabinets where a 12 VDC power supply is provided with the cabinet and there is enough capacity on the supply to power all designated 12VDC equipment at 80% loading.

Cat 5e cable. Cable shall be an 8 wire twisted pair cable constructed of 24 AWG stranded copper wires with minimum Category 5e rating. The outer jacket shall be UV resistant PVC insulation designed for outdoor use. Shielded cable shall be used when prescribed by the manufacturer, run through conduit or enclosed structures, and when needed for equipment or electrostatic grounding. Shielded cable shall be terminated with either conductive or non-conductive male 8P8C connectors. Where shielded cable is used as an equipment ground, conductive connectors shall be used on both ends of the cable. Where shielded cable is used as an electrostatic drain, the grounded side of the connection shall be terminated with a conductive connector and the ungrounded side shall be terminated with a non-conductive connector. Unshielded cable shall be used for interconnections within the same cabinet, or where grounding and electromagnetic interference is not present. Unshielded cable shall be terminated with non-conductive male 8P8C connectors on both ends. All Cat 5e cables used for Ethernet data shall conform to the Telecommunications Industry Association (TIA)-568 *Commercial Building Telecommunications Cabling Standard* and utilize the T568B pin/pair assignments.

CONSTRUCTION REQUIREMENTS

When installed in a Type1 or Type 2 ITS cabinet, the serial to IP converter shall be mounted on DIN rail. The 12 VDC power supply provided with the cabinet shall be used to power the converter as long as the final total load on the supply is less than 80% of total capacity. If an additional power supply is needed

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REVISION OF SECTION 614
SERIAL TO IP CONVERTER

to power the converter, it shall be mounted on the DIN rail and plugged into a UPS protected outlet if available.

When installed for a VMS, the converter and power supply shall be mounted on DIN rail within 6ft of the VMS controller. For VMS signs with the controller in a ground cabinet, the converter shall be mounted on DIN rail fastened to the 19 inch cabinet rack rail. For VMS signs with the controller in the sign, the converter shall be mounted on DIN rail and fastened with an L bracket to the structural aluminum C-channel above the fold down tray approximately 5ft above the floor. The power supply for the converter shall be plugged into a UPS protected, non-GFCI outlet designated for electronic loads.

When installed in a ground cabinet for a TS or RM, the converter and power supply shall be mounted on DIN rail fastened to the 19 inch cabinet rack rail. The power supply for the converter shall be plugged into a UPS protected, non-GFCI outlet designated for electronic loads.

Stranded 16 AWG copper wires with red and black insulation should be used to wire DC power from the power supply to the converter.

The network connection from the converter to the field communication equipment shall be made with Cat5e cable using 8P8C terminations. The cable shall be long enough to connect from the field communication equipment directly to the serial device being converted and allow for future upgrade of the device to direct Ethernet communications.

The serial connection from the converter to the serial device shall be made with Cat5e cable using the termination compatible with the serial device. For 170/470 VMS controllers this will be an 8P8C termination. The Contractor shall consult with the serial device manufacturer for correct terminations and wiring. All bare wire connections shall be cleanly terminated with no stray or loose wires.

All communication cabling shall be routed cleanly and use cable tie supports every 2 feet. The cables shall be labeled on both ends indicating the device and port of the individual connection. Labels shall be self-laminating vinyl with black lettering on a white background.

The Contractor shall configure the converter with IP addresses as provided by the Engineer. Serial communication setting shall also be configured to match the serial device. In general this is as follows:

- For a 170/470 VMS controller: 9600bps, 8N1, no flow control; with TCP & UDP connections enabled to the serial port.
- For a MVRD: 9600bps, 8N1, no flow control; with TCP connections enabled to the serial port.
- For a Diamond Counter for DTD ATR Stations: 9600bps, 8N1, no flow control; with TCP connections enabled to the serial port.
- For a TS: 9600bps, 8N1, no flow control; with TCP connections enabled to the serial port.
- For a RM: 9600bps, 8N1, hardware flow control with RTS, CTS, and DCD control lines. Serial port mapping on central software is necessary for remote device communication.

After installation the Contractor shall verify local network communications directly to the converter and to the serial device. Once local communications has been verified, the Contractor shall confirm that the device is accessible and fully functional from the centralized software system on the CDOT network.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
SINGLE WAVELENGTH COARSE WAVELENGTH DIVISION MULTIPLEXING (CWDM) OPTICAL FILTER

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Single Wavelength Coarse Wavelength Division Multiplexing (CWDM) optical filter shall be manufactured specifically for use in CWDM equipment. It shall be provided and installed at all Ciena 3930/3931 Carrier Ethernet SDS Switch locations. All CWDM single channel filters shall be provided from a manufacturer recommended by Ciena.

MATERIALS

The CWDM optical filter shall have the capability of splitting a single CWDM wavelength from the multiple wavelengths being transmitted along the fiber strands including passing a 1310nm wavelength between Ethernet switch pairs. All remaining wavelengths other than those being added or dropped at the designated location shall be allowed to travel from Ethernet switch to Ethernet switch or existing regeneration node building or the CTMC to Ethernet switch.

The CWDM optical filters shall be provided with industry standard operating ranges of 1430nm to 1610nm to match wavelengths of the Coarse Wavelength Division Multiplexing Small Form-Factor Pluggable optic modules of the Ciena Ethernet switches. The individual filters shall have the following channel center wavelengths: 1430nm, 1450nm, 1470nm, 1490nm, 1510nm, 1530nm, 1550nm, 1570nm, 1590nm and 1610nm.

1310nm wavelength filters shall also be provided.

If for any reason the single wavelength filter is defective or is damaged at the time of installation by the Contractor, the filter shall be removed and replaced at no additional cost to the project. Filters shall also be replaced if failures occur do to manufacture's defect, at no additional cost to the project prior to the final network acceptance.

CenturyLink is the Ciena Corporation qualified equipment supplier for the State of Colorado, Colorado Department of Transportation, Intelligent Transportation Systems for networking equipment and associated network materials.

For project equipment estimate quotations and purchasing, Contractors shall contact the following representative:

Project equipment, equipment estimates, and purchasing distributer representative:

Keith A. Glose

Premier Account Manager

CenturyLink Government

930 15th Street, 4th Floor, Denver, Colorado 80202

Telephone: 303-992-5567 Fax: 720-578-2694

E-Mail: keith.glose@centurylink.com

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REVISION OF SECTION 614
SINGLE WAVELENGTH COARSE WAVELENGTH DIVISION MULTIPLEXING (CWDM) OPTICAL FILTER

CONSTRUCTION REQUIREMENTS

The filters shall match the industry standard wavelength of the Ethernet switch's Coarse Wavelength Division Multiplexing Small Form-Factor Pluggable (SFP) optic module and the 1310nm SFP optic module.

The CWDM optical filters shall have three (3) fiber pigtails to be fusion spliced to lateral fiber optic cable strands and secured in the foam splice chips located on the splice tray in the splice closure. The pigtails shall be provided with distinctive buffer tube colors designating "Pass", Reflect" and "Common". If the filter pigtail buffer tubes are all of the similar color, The Contractor shall color code each individual tube for future maintenance.

The filters shall be provided with the optical wavelength printed indelibly on the filter body. Bare fiber strands shall not be taped to the splice tray.

All splices and optical filter wavelengths shall be labeled on the splice tray.

If for any reason the Contractor installs or splices any single wavelength optical filter in a location which does not match the Ethernet switch coarse wavelength division multiplexing SFP optic modules, the Contractor shall replace the filter and re-splice all fibers at no additional cost to the project.

Prior to splicing of the filters, the Contractor shall submit to the Project Engineer a Microsoft Excel spreadsheet containing the following information:

1. Splice Location for the CWDM and 1310nm filters (manhole milepost).
2. Serial Number of the CWDM and 1310nm filters.
3. Wavelength of the filter.
4. Usage and color of filter pigtails.

Once the spreadsheet has been submitted and approved by the Project Engineer the splicing may begin.

The pigtails of the filters shall be labeled inside the splice closure.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
SMALL FORM-FACTOR PLUGGABLE –SFP

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

For this project the Small Form-Factor Pluggable –SFP shall be a single wavelength SFP optic module for installation in Ciena 3930/3931 switches. All SFP optic modules shall be provided from a manufacturer recommended by Ciena.

MATERIALS

The Contractor shall furnish and install the SFP optic module shown in the item table below. This table describes the optic module for installation in the Ciena 3930/3931 Switches installed on this project.

Item Table – 1310nm SFP Optic Modules for a Ciena 3930/3931 Ethernet SDS Switch.

ITEM DESCRIPTION	ITEM NUMBER
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 10 KM, 1310 NM, EXTENDED TEMPERATURE	XCVR-A10Y31
100M/1 GIG, SM SFP OPTIC, LC CONNECTOR, 40 KM, 1310 NM, EXTENDED TEMPERATURE	XCVR-A40Y31

If for any reason the SFP optic modules are defective or are damaged at the time of installation by either the Contractor or by Ciena, the optic module shall be removed and replaced at no additional cost to the project. SFP optic modules shall also be replaced if any failures occur due to manufacturer's defects, at no additional cost to the project prior to the final network acceptance.

CenturyLink is the Ciena Corporation qualified equipment supplier for the State of Colorado, Colorado Department of Transportation, Intelligent Transportation Systems for networking equipment and associated network materials. For project equipment estimate quotations and purchasing, Contractors shall contact the following representative:

Project equipment, equipment estimates, and purchasing distributer representative:

Keith A. Glose

Premier Account Manager

CenturyLink Government

930 15th Street, 4th Floor, Denver, Colorado 80202

Telephone: 303-992-5567 Fax: 720-578-2694

E-Mail: keith.glose@centurylink.com

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REVISION OF SECTION 614
SMALL FORM-FACTOR PLUGGABLE –SFP

Neither CenturyLink nor Ciena Corporation will be involved in the design of the project corridor network. The Contractor shall contact the CenturyLink representative for equipment quotations and purchasing purposes only. The Contractor shall not contact or rely on either CenturyLink or Ciena for network design related questions.

When requesting quotations, the Contractor shall submit to CenturyLink a complete package including the following items:

- A complete list of required equipment for purchase including materials and quantities based on the individual project specifications to achieve a complete item(s) installation.
- A PDF copy of all project specifications pertaining to the material being ordered.
- A PDF copy of all networking project plan sheets.

It is the Contractor's responsibility to provide the distributer's representative all information required pertaining to the complete network design. During the project, CenturyLink or Ciena Corporation is not responsible for any type of network design aide. All questions pertaining to the network design shall be conducted through the Project Engineer for help or clarification.

CONSTRUCTION REQUIREMENTS

For Ciena Carrier Ethernet switch installations, 1310nm SFP optic module shall be installed in each switch for data communications in a CWDM design between 2 adjoining Ethernet switches (and at switches located between two adjoining switches, as applicable).

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Test Fiber Optic Cable shall include Optical Time Domain Reflectometer (OTDR) tests, Coarse Wave Division Multiplexor (CWDM) OTDR tests, spectrum analysis of CWDM fiber, and optical power meter tests of all installed fiber and modified existing fiber on the project.

MATERIALS

The Contractor shall use equipment that is calibrated twice per year. A copy of the most recent certificate of calibration and all out-of-tolerance conditions shall be provided to the Project Engineer prior to the initiation of testing activities. The following equipment and information is required to perform fiber optic cable tests:

1. an OTDR (submit certification to Project Engineer)
2. A Coarse Wave Division Multiplexor OTDR (submit certification to Project Engineer)
3. An optical spectrum analyzer (submit certification to Project Engineer)
4. Optical Power Meter Equipment capable of measuring optical power in dBm (submit certification to Project Engineer)
5. a launch box (min length – 1000 feet)
6. a light source at the appropriate wavelength
7. Test jumpers shall be 3 feet to 12 feet long with connectors that are compatible with the light source and power meter and shall have the same fiber construction as the link segment being tested.

CONSTRUCTION REQUIREMENTS

Prior to splicing and testing on the project the Contractor shall submit a detailed Method Statement to the Project Engineer describing the splicing and testing plan and schedule. Discussion of the Contractor's Device Cutover Plan and a proposed Device Cutover Schedule shall be included in the Method Statement. No fiber optic splicing shall begin until the Method Statement is submitted and approved. If at any time it is determined that work began without an approved Method Statement, or the work is not following the approved Method Statement, an immediate "stop work" order will be issued and work will not resume until the Method Statement has been submitted and approved. Once the splicing and testing begins, the Method Statement shall be updated if necessary to address any changes in the original planned and approved procedures.

The Contractor shall conduct fiber optic testing at the following stages:

1. Pre-installation testing – bi-directional OTDR test of every fiber on every reel after delivery of the reel
2. Post installation and pre-splicing test – bi-directional OTDR test of every fiber of every cable after fiber is installed in the ground
3. Post-splicing tests, pre-CWDM filter splicing tests

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REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

a. Optical Power meter test from all fiber terminated in communications cabinets to a network facility for all fiber that is not used for CWDM on the project.

b. Bi-directional OTDR test of all fiber between termination point in a network facility and cable end and between termination point in a network facility and communications cabinets for fiber that is not used for CWDM on the project

c. Bi-directional CWDM OTDR test of all fiber between termination point in a network facility and cable end and between termination point in a network facility and communications cabinets for all fiber that is used for CWDM on the project

4. Post-CWDM filter splicing tests

   a. Spectrum analysis of all terminated fiber used for CWDM after filters have been spliced

   b. CWDM-OTDR

   c. Optical Power meter test and documented attenuator values

5. Re-testing of all stages above if initial test fails and after corrective action is taken

The guidelines for fiber optic cable testing include:

1. Launch box and test jumpers must be of the same fiber core size and connector type as the cable system: Single mode fiber 9.0□m (nominal) /125 □m
2. The light source and OTDR must operate within the range of 1310□10 nm and 1550±20 nm single mode nominal wavelength for testing in accordance with Telecommunications Industry Association (TIA) TIA-526-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.
3. The power meter and the light source must be set to the same wavelength during testing.
4. The OTDR and power meter must be calibrated at each of the nominal test wavelengths and traceable to the National Institute for Standards and Technology (NIST) calibration standards.
5. The calibration of the OTDR and power meter shall conform to the requirements set forth in Telecommunications Industry Association/Electronic Industries Alliance (TIA/EIA) TIA/EIA-455-226 Calibration of Optical Time-Domain Reflectometers and TIA- 455-231 Calibration of Fiber Optic Power Meters, respectively.

The Contractor shall document jacket length measurements for lateral and backbone cable at each end including splice enclosures and patch panels and at any intermediate splice points.

The Contractor shall document bare fiber slack not accounted for in jacket length.

All system connectors, adapters and jumpers shall be cleaned per manufacturer's instructions before measurements are taken.

At locations of new lateral fiber optic cable installation and at locations that require the re-installation of existing lateral fiber optic cable, the Contractor shall conduct testing from the termination panel mounted in the communications cabinet to the splicing manhole. The bi-directional test shall be conducted from the termination panel towards the splicing manhole and from the splicing manhole to the communications cabinet termination panel.

Final splicing will not begin until such time that the Contractor submits OTDR test results to the Project Engineer and the Project Engineer reviews the results.

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REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

Final OTDR testing from the communications cabinet to the corresponding node building shall be conducted after their splicing work has been completed. All issues with communications related to Contractor installation and workmanship shall be remediated by the Contractor at no additional cost to the project.

A functional test shall be made in which it is shown that each and every part of the system functions as specified or intended herein.

a. *Optical Fiber Cable Testing with OTDR.*

The Contractor shall perform an OTDR test of all fibers in all tubes on the reel prior to installation of the fiber. The test results shall be supplied to the Project Engineer prior to installation of the cable.

Fiber testing shall be performed on all terminated fibers from patch panel to patch panel and unterminated fibers from end to end. Additionally, mid entry splices into mainline cables require testing of all strands in the mainline cable before and after installation. Testing shall consist of a bi-directional end-to-end OTDR trace.

Loss numbers for the installed link shall be calculated by taking the sum of the bi-directional measurements and dividing that sum by two.

The Contractor shall use an OTDR that is capable of storing traces electronically and shall save each final trace.

The Contractor shall use a test reel of minimum length identified in the Materials section of this Special Provision. The Contractor shall indicate the length of the test reel, in feet, for all test results.

If the fiber designation is not indicated on the trace itself, the Contractor shall provide a cross-reference table between the stored trace file name and the fiber designation.

The Contractor shall record the following information during the test procedure:

1. Name and contact information of person conducting the test
2. Type of test equipment used (manufacturer, model, serial number, calibration date and valid certification of calibration)
3. Date test is being performed
4. Optical source wavelength and spectral width
5. Fiber identification
6. Start and end point locations
7. Test direction
8. Launch conditions
9. Method of calculation for the attenuation or attenuation coefficient
10. Acceptable link attenuation
11. Cable manufacturer stated index of refraction for cable being tested
12. Jacket readings in and out of each splice vault and each pull box

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REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

b. *Optical Fiber Cable Testing with Optical Power Meter.*

The Contractor shall conduct an Optical Power Meter Test of each fiber installed.

Single mode segments shall be tested in one direction at both the 1310 nm and 1550 nm wavelength.

The following information shall be recorded during the test procedure:

1. Names of personnel conducting the test
2. Type of test equipment used (manufacturer, model, serial number, calibration date and a valid certification of calibration)
3. Date test is being performed
4. Optical source wavelength and spectral width
5. Fiber identification
6. Start and end point locations
7. Test direction
8. Reference power measurement (when not using a power meter with a Relative Power Measurement Mode)
9. Measured attenuation of the link segment
10. Acceptable link attenuation

c. *Acceptable Attenuation Values.*

The Contractor shall calculate acceptable attenuation values for each fiber tested. These values represent the maximum acceptable test values.

The general attenuation equation for all single mode link segments is as follows:

Acceptable Link Attenuation = Cable Attenuation + Connector Attenuation + Splice Attenuation.

m (nominal) Single-mode Attenuation Coefficients:

1. Cable Attenuation=Cable Length (km) x (0.35 dB/km at1310 nm and 0.22 dB/km at1550 nm)
2. (No. of Mated Connections x 0.50 dB)
3. Splice Attenuation = Splices x 0.30 dB

d. *Test Procedures*

The single mode Optical Power Meter fiber test shall be conducted in accordance with TIA-526- 7.

The single mode OTDR test shall be conducted in accordance with TIA-526-7.

Testing for CWDM single wavelength filters (CWDM filter) shall be conducted in the following manner to ensure that the filter Pass, Reflect and Common pigtails are spliced to proper lateral fiber strands. Testing procedures and CWDM data flow information is included on the plans. Testing shall be conducted for all CWDM wavelengths applicable to each fiber strand used for data communications. CWDM wavelengths on this project are expressed in nanometer (nm) and include

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REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

1430 nm, 1450 nm, 1470 nm, 1490 nm, 1510 nm, 1530 nm, 1570 nm, 1590 nm, and 1610 nm. Industry standard wavelengths (e.g. 1430 nm = 1431 nm) shall be observed.

After completion of fiber optic cable installation and prior to the CWDM filter splicing, all backbone cable to lateral cable splices shall be completed in the individual Ethernet switch sub-rings. Required steps shall include:

1. The backbone end of Lateral Cable 1 shall be spliced to the fiber optic backbone cable in Splice Closure 1. Once this splice is complete no future access to Splice Closure 1 shall be made unless a re-splice is required.
2. The opposite end of Lateral Cable 1 shall be spliced to itself in Splice Closure 2 in a manner to achieve continuity in the backbone strands from the beginning of the sub- ring (first node building) to the far end of the sub-ring (next node building).
3. An OTDR test shall be conducted on the sub-ring from building to building to ensure proper splicing of Lateral Cable 1 in Splice Closure 1.

Once the OTDR test is complete the results shall be submitted to the Project Engineer for approval. After approval the splicing of CWDM filters in Splice Closure 2 may begin.

The Contractor shall be required to break the Lateral Cable 1 splices in Splice Closure 2 used in the continuity test and conduct the CWDM filter splicing per the project fiber splice plans. This will include splicing of Lateral Cable 1 and Lateral Cable 2 in Splice Closure 2 and the termination of Lateral Cable 2 in the communications cabinet.

After CWDM filter splicing, the Contractor may use one of the following methods to ensure the proper CWDM filter splicing.

1. By using a fiber identifier, testing of the incoming signal from either the upstream or downstream CWDM location, the Contractor shall show the Project Engineer that proper CWDM filter pigtail splicing has been achieved.
2. By using a spectrum analyzer to test the incoming wavelength to ensure proper splicing and wavelength of the CWDM signal.

Once all splicing of the individual sub-ring is complete the Contractor shall conduct the CWDM-OTDR and spectrum analyzer testing and submit the results to the Project Engineer. At the acceptance of these tests, the Contractor shall determine the proper optical attenuator to install in the Receive (RX) ports at both the communications termination panel and the node building termination panel. After installation one final test of optical power shall be conducted to determine if the proper signal strength is being achieved by the Ethernet switch CWDM optic.

At that point the Colorado Department of Transportation, Colorado Transportation Management Center personnel along with Ciena network engineers will configure the sub-ring into the overall CDOT ITS network. If network communications cannot be achieved, a review of the CWDM testing materials will begin.

e. *Test Acceptance*

The Contractor shall demonstrate that the tests result in acceptable attenuation values.

The Contractor, solely at the Contractor's expense, shall re-splice all fusion splices and re-terminate all terminations that have test results exceeding acceptable attenuation values. The

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REVISION OF SECTION 614
TEST FIBER OPTIC CABLE

Contractor, solely at the Contractor's expense, shall retest all fiber links that have been re-spliced and shall retest all fiber links that have been re-terminated.

The Contractor, solely at the Contractor's expense, shall bring all links not meeting the requirements of this specification into compliance.

f. *Submittals*

The Contractor shall submit test result documentation as both a hard copy and electronic copy.

After each reel test, the Contractor shall submit one hard copy of the OTDR trace for every fiber on the reel.

After installation, the Contractor shall submit two hard copies and one electronic copy of the following tests:

1. Continuity OTDR trace for every spliced fiber which the CWDM optical network will utilize.
2. OTDR trace for every fiber the high speed DWDM optical network will utilize.
3. CWDM-OTDR trace for every fiber which the CWDM optical network will utilize.
4. Spectrum analyzer test results for every fiber which the CWDM optical network will utilize.
5. OTDR traces and power meter results for all "dark" unused fiber strands in the backbone fiber optic cable from node buildings.

Hard copy traces shall be organized and bound in logical order in an 8 ½ inch x 11 inch hard cover binder.

The Contractor shall submit, after approval of the hard copy traces, electronic copies of all traces (PDF and native file format) and appropriate software, if needed, to allow reading the traces.

The Contractor shall submit one copy of the complete contract Plans, including additional drawings issued as part of all change orders, with all deviations clearly marked in color. Deviations to be noted shall include at a minimum, but not be limited to, the following:

1. Fiber Splice location
2. Fiber Splice configuration
3. Termination layout

After all splicing and fiber optic testing is completed the Contractor shall test the optical power of the incoming, (Receive) signal at each field Ethernet switch and existing node building location. To obtain the most accurate values of optical power, the testing equipment shall be attached to the SFP optic end of the pre-connectorized patch cable.

Once the optical power has been tested, the Contractor shall install the appropriate attenuator in the receive port to meet the receive values of the SFP optic module, including a design margin of 6 dB (to allow for degradation over the life of the system).

REVISION OF SECTION 614
UNINTERRUPTED POWER SUPPLY

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing a rack mounted Uninterruptible Power Supply (UPS), batteries, transfer switch, disconnect switch, and power connections in a Contractor supplied Model 332 or 332D Communications Cabinet. For toll points, the UPS system shall be capable of running essential control electronics, communications equipment, AVI Antennas, Cameras, transaction beacons, and other miscellaneous toll equipment, for at least 8 hours. The bi-directional toll layout shall also be powered by one UPS system and 332 Cabinet for up to 8 hours. For VTMS, the UPS shall be capable of running essential control electronics, communications equipment, and the electronic message sign for at least 8 hours.

The UPS system shall be designed for a hot swap of components and shall not compromise existing operation of dynamic message signs or variable message signs. The unit shall provide for RS232 communication and contact closures for alarm functions.

MATERIALS

The UPS system shall provide “On-Line” dual conversion control. The UPS shall be rated per the following:

Input Voltage	85 VAC to 135 VAC line to neutral	Input Frequency	48 to 62 Hz
Output Voltage	120 VAC +/- 3%, 1-Phase, 2 Wire plus Ground,	Output Frequency	60 Hz

Power VA required for running the toll equipment or VTMS for up to 8 hours.

The unit shall be temperature rated to operate from 0 degree C to +40 degree C.

The UPS system shall be capable of producing simultaneously-fully regenerated, conditioned power with true sine wave and continuous AC outputs with stand by capability.

The unit shall have a re-settable power event counter to record the number of power utility failures, a battery run-time counter, and temperature compensated battery charging.

The UPS System shall be capable of providing continuous, fully conditioned (both voltage and frequency), regulated, sinusoidal (AC) power to selected devices such as controllers, modems, and 5 volt power supplies, and sign face drivers.

Wiring shall comply with national electrical code (NEC) standards and approved wiring methods. Properly rated SO/SJO cords shall be allowed to allow easy replacement of the UPS System.

The interconnect cable shall be protected with abrasion-resistant nylon sheathing.

The UPS shall consist of two major components, the Electronics Module and the Battery System.

The Electronics Module shall consist of the following:

True Sine wave, high frequency inverter.

Minimum 3-stage, temperature compensated, battery charger

For connection from the Electronics Module to the Battery System, a dedicated harness shall be provided with quick-release, keyed, circular connectors, and braided nylon sleeving over all conductors.

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REVISION OF SECTION 614
UNINTERRUPTED POWER SUPPLY

Local and remote control of UPS functions

Local and remote communications capabilities

The Battery System shall consist of the following:

1. Shall meet the continuous 8 hour requirement to run sign electronics, communication equipment, and half of the sign face with all LEDs illuminated at daytime brightness levels.
2. The batteries shall be comprised of extreme temperature, deep cycle AGM/VRLA (Absorbed Glass Mat/Valve Regulated Lead Acid) batteries that have been field proven and tested by the U.S. military.
3. Batteries shall be certified to operate at extreme temperatures from -40°C to +74°C.
4. The batteries shall be provided with appropriate interconnect wiring and a corrosion- resistant mounting trays and/or brackets appropriate for the location into which they will be installed.
5. Battery construction shall include heavy-duty, inter-cell connections for low- impedance between cells and heavy-duty plates to withstand shock and vibration.
6. The UPS enclosure shall have forced air Cooling/Ventilation:
7. The UPS shall be forced air cooled by internally mounted, continuous fans.
8. Fan power shall be provided from the internal DC supply.
9. Air intake shall be through the front bottom of the unit, and air exhaust shall be out the rear top of the unit.
10. Intake and exhaust shall have bird/rodent mesh guard and filtration.
11. The thermal design, along with all thermal and ambient sensors, shall be coordinated with the protective devices before excessive component or internal cabinet temperatures are exceeded.

The UPS System shall come standard with software, RS232 interface via a DB-9F connector, and Ethernet interface via RJ-45 connector allowing full, interactive, remote computer monitoring and control of the UPS functions. The software shall allow the user to set up all operational parameters either locally or remotely and test the functionality of the unit. The unit shall be capable of sending simple network management protocol (SNMP) alarm traps upon alarm conditions and also be configurable via built in web page interface.

The UPS System Alarm Function Monitoring shall come standard with a DB-9F connector with open collectors (40 V @ 20 mA) indicating:

1. Loss of Utility Power
2. Inverter Failure
3. Low Battery

The UPS System Front Panel Controls shall come standard with Power ON, Cold (DC) Start, Alarm Silence, Battery Test, Bypass Breaker, and DC/Battery Breaker.

Reliability shall be calculated with mean time between failure (MTBF) as 100,000 hours based on component ratings.

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REVISION OF SECTION 614
UNINTERRUPTED POWER SUPPLY

CONSTRUCTION REQUIREMENTS

Contractor shall provide detailed design and installation plans for Engineer approval prior to installation. Power feeding the sign shall first terminate in the ground mounted cabinet. Non-UPS power shall pass through the cabinet to power non-UPS loads. Power required for sign backup shall feed through the UPS system. A bypass switch, rated for the designed system, shall be installed to bypass the UPS in the event of UPS failure or for system maintenance. A disconnect switch shall also be installed to disconnect UPS and line power from the sign. The Contractor shall install the DMS UPS output into the DMS power distribution panel per sign manufacture recommendations. Serial and Ethernet cables shall be installed from the UPS system ground cabinet to the sign communication device location. All wiring shall conform to the latest version of the NEC.

The UPS equipment shall include a minimum two year warranty on parts and labor. Batteries shall include a minimum two year pro rated warranty. Vendor shall be responsible for processing warranty repairs.

A repair option shall be available for UPS equipment no longer covered by the warranty period. Repair cost shall include all labor and materials necessary to complete the repair. Vendor shall be responsible for processing non-warranty repairs.

See project specific Testing & Integration Plan for additional requirements.

REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing a Light Emitting Diode Variable Message Sign (LED VMS) and associated equipment cabinets at locations. The sign shall be fully compatible with the mounting hardware and support structure.

MATERIALS

The LED VMS shall be equipped with the ability to display three lines of 18-inch tall characters and shall have a display made up of a full matrix configuration. The sign shall have a 66-70 millimeter pixel pitch. All LEDs shall have a viewing angle of 30 degrees.

a. The sign shall be 26' wide x 8.5' tall x 4' deep with an allowable variation of (+ / - 7 inches). The sign shall include a power shut off mounted to the sign structure near the controller interface cabinet. The sign shall be capable of operating without any decrease in performance over a temperature range of -34° F to +140° F with a relative humidity of 0 to 99 percent, non-condensing. The sign shall have a minimum design life of 20 years. Certifications:

   Prior to start of the installation of the LED VMS the Contractor shall provide the following certifications to the Engineer for review and approval:

   1. Certification showing that the manufacturer of the LED VMS is fully compliant with ISO 9001 as of the bid date for this project. The ISO 9001 Certification shall apply to the facility, and to the design, fabrication, installation, and maintenance of the LED VMS. The facility where this company actually designs and manufactures the LED VMS shall be ISO 9001:2000 certified a minimum of one year prior to the bid date for this project.
   2. Working drawings showing the sign housing and tilting brackets (if tilting brackets are used to achieve the required 3 degree sign face tilt) shall be sealed by an Engineer registered in the State of Colorado and shall be submitted in accordance with subsection 105.02.
   3. Certification showing that welding of the LED VMS housing is in accordance with the American Welding Society (AWS) Standards, ANSI/AWS D1.2-97. The LED VMS manufacturer's welders and welding procedures shall be certified by an ANSI/AWS Certified Welding Inspector to the ANSI/AWS D1.2-97 Structural Welding Code for Aluminum.
   4. Certification that all aluminum face materials have a coating that meets or exceeds the requirements of the American Architectural Manufacturers Association (AAMA) Specifications Publication No. 2605.
   5. Certification that the LEDs were tested and binned in accordance with the CIE Test Method A.
   6. Documentation and information on software as described in Appendix A of this document.
   7. Documentation verifying the VMS is listed by an accredited 3rd party testing organization for conformance to UL48 and UL 1433.
   8. All workmanship shall comply with IPC-A-610C, Class 2 titled "Acceptability of Electronic Assemblies"
   9. Documentation providing proof printed circuit board (PCB) silicon conformal coating conformance to MIL-I-46058C Type SR and IPC-CC-830.

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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

10. Documentation that the sign's structural integrity is in conformance to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals (Current Edition).

11. Documentation that the VMS conforms to the Transient Protection and Vibration of the NEMA Standard TS4, Section 2.

b. *Sign Housing:*

All component parts shall be easily and readily accessible by a single person for inspection and maintenance. There shall be room for a technician to work. Access shall be made by entering the side of the housing. The housing shall be weather tight, and compliant to the NEMA 3R Standard. The bottom panel of the housing shall have a minimum of four drain holes, with snap-in, drain filter plug inserts.

Any visible manufacturer's logo/trade name/reference on the VMS shall be placed on the bottom side of the access door or back panels of the VMS.

The sign housing shall be capable of withstanding a wind loading of 120 mph without permanent deformation or other damage. The sign housing shall also be designed, stamped and signed by a Professional Engineer licensed in Colorado to withstand current AASHTO specified group loading combinations including: sign weight, repair personnel and equipment, ice and wind loads. It shall also meet strength requirements for truck-induced gusts as specified in NCHRP Report 412.

The LED VMS shall be built with a forward tilt angle of three degrees toward the viewing motorists. The sign housing shall be engineered to withstand snow loading of 40 pounds per square foot, as well as the ability to be mounted in a manner that prevents the buildup of snow and creates a natural means by which snow can run off without impeding flow of traffic. The performance of the sign, including the visibility and legibility of the display, shall not be impaired due to continuous vibration caused by wind, traffic or other factors. The housing shall be designed to accommodate mounting on the rear vertical plane and shall be structurally sufficient to be mounted to the sign support structure.

The sign housing and structural components for the tilting system, if required by design, shall be structurally sufficient to perform under all applicable loading conditions including gravity, wind, traffic, weather, roadway deicers, maintenance, and other environmental factors. Working drawings showing the sign housing shall be submitted in accordance with subsection 105.02. Working drawings shall be sealed and signed by an Engineer registered in the State of Colorado.

All parts shall be made of corrosion resistant materials, such as plastic, stainless steel or aluminum. Painted steel is not acceptable. No self-tapping screws shall be used. The exterior front face surfaces shall be finish coated by a system that meets or exceeds the AAMA Specification No. 2605. The finish shall be matte black. The main body of the sign housing shall be constructed of aluminum with a natural mill finish. All exterior seams shall be continuously welded by an inert gas process, except for the coated fascia material.

Each panel shall have a single polycarbonate sheet attached securely to the inside of the aluminum panel. The polycarbonate sheet shall cover all of the pixel openings. The polycarbonate shall be sealed to prevent water and other elements from entering the VMS. The polycarbonate shall contain UV inhibitors that protect the LED display matrix from the effects of ultraviolet light exposure and prevent premature aging of the polycarbonate itself. The use of a plastic lens system will not meet the requirements and will be cause for rejection. No louvers shall be allowed.

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REVISION OF SECTION 614
VARIABLE MESSAGE SIGN (LED) (OVERHEAD)

Polycarbonate sheets shall have the following characteristics:

- Tensile Strength, Ultimate: 10,000 PSI
- Tensile Strength, Yield: 9,300 PSI
- Tensile Strain at Break: 125%
- Tensile Modulus: 330,000 PSI
- Flexural Modulus: 330,000 PSI
- Impact Strength, Izod (1/8", notched): 17 ft-lbs/inch of notch
- Rockwell Hardness: M75, R118
- Heat Deflection Temperature Under Load: 264 PSI at 270F and 66 PSI at 288F
- Coefficient of Thermal Expansion: 3.9X10-5 in/in/F
- Specific Heat: 0.30 BTU/lb/F
- Initial Light Transmittance: 85% minimum
- Change in Light Transmittance, 3 years exposure in a Southern latitude: 3%
- Change in Yellowness Index, 3 years exposure in a Southern latitude: less than 5%

LED display modules shall mount to the inside of the VMS front face panels and be accessible from the inside of the sign housing only. No tools shall be needed for removal and replacement of VMS display modules.

The external front face panels shall have the following minimum dimensions: The perimeter panels shall be a minimum of 12 inches wide. The external front face panels shall be thermally insulated from the rest of the sign housing. The glazing, aluminum mask and the external front face panels shall be easily replaceable from within the sign housing.

The ventilation system shall be forced air. The system shall be designed to adequately cool the pixels from all sides along with the front and rear of the display module and all other internal components. The ventilation system shall have the following properties:

1. Positive pressure (exhaust fans are not acceptable).
2. The fans shall have ball or roller bearings, shall be permanently lubricated and shall require no periodic maintenance. The fans are to be positioned in such a manner so as to provide a balanced air flow to the ventilation system in the event of failure of any fan.

Access door shall be mounted to an integral doorframe that mounts to the VMS housing using non-corrosive hardware. A continuous vertical stainless steel hinge shall support the door, and the door shall open outward towards the monotube structure. In the closed position, each door shall latch to its frame with a three-point draw-roller mechanism. The latching mechanism shall include an internal handle and release lever. Door release levers shall be located so that a person with no key and no tools cannot become trapped inside the housing.

Access doors shall be framed and swing open and lock in-place open at a 90 degree angle and 110 degree angle from the VMS housing end wall. The bottom edge of each door shall be at least 3.5-inches from the bottom edge of the VMS housing. This will provide clearance for the doors to swing open over external access platform.

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The door will be fitted with an interior and exterior lockable heavy duty handle. Each exterior door shall be furnished with a handle that is pad lock ready and Corbin #2 key lock. Each door shall close around its flanged frame and compress against a closed-cell foam gasket, which adheres to the door. All doors shall contain a stop that retains the door in a 90 and 110- degree open position. When a door is open, the door and its stop shall withstand damaged by a 60 mph wind gust.

The VMS shall be equipped with an OSHA compliant safety rail assembly that when closed across an open access door will prevent service personnel from falling out of the VMS. The VMS shall have a rail assembly provided for each door in the display. The rail assembly shall require no tools to open and close.

The door shall incorporate an open/closed sensor that is detectable by the sign controller and notifies the Central system control software whenever the door is accessed.

Minimum headroom of 72-inches shall be provided in the VMS housing. This free space shall be maintained across the entire width of the VMS housing, with the exception of structural frame members. Structural members shall be designed not to obstruct the free movement of maintenance personnel throughout the VMS interior.

A level aluminum walkway shall be installed in the bottom of the VMS housing. The walkway shall be a minimum of 24-inches wide and it shall run the entire length of the housing, from access door to access door. The top surface of the walkway shall be non-slip and shall be free of obstructions that could trip service personnel. The walkway shall support a load of 300 pounds per linear foot.

The internal structural members shall be extruded aluminum and shall accommodate both the display module mountings while allowing air distribution. The display modules shall be removed and replaced without the use of tools and without disturbing adjacent modules. The sign shall have in cabinet heaters that are sufficient to elevate the temperature within the sign to 30° F above the temperature outside the sign. These heaters shall be controlled by a manually operated automatic shut-off timer in the sign and remotely from central computers.

The system power and communication lines shall each be protected by two stages of surge protection devices. The first stage shall be an arc discharge, gas discharge tube or a thyristor surge protection based unit with local and remote reporting capability. The second stage shall be metal oxide varistor (MOV) based. This second stage shall include a crowbar circuit, that when remotely enabled, shall trip the power circuit breaker when the second stage surge suppressor is activated. In both cases, tripping of each stage (or both if tripped simultaneously) of the surge protection and shall report the power surge condition to the sign controller for report to central. The crowbar shall be an option that is either enabled or disabled and is selected and downloaded from the central system control software to the sign controller. When this option is enabled, tripping of the second stage of surge protection shall prevent power from reaching any components of the sign until the surge protection has been replaced. When this option is disabled, the sign will continue to function normally after the second stage of surge protection is tripped.

c. Sign controller:

The sign controller and associated communication equipment shall be installed inside the VMS sign housing or roadside communications cabinet. Each VMS shall be controlled and monitored by its own sign controller. The sign controller shall be a stand-alone microprocessor-based system, which does not require continuous communication with VMS control software in order to perform most VMS control functions.

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The sign controller shall meet the following operational requirements:

- Communicate using embedded NTCIP protocol,
- Contain memory for storing changeable and permanent messages, schedules, and other necessary files for controller operation,
- Include a front panel user interface with graphical VFD or LCD and keypad for direct operation and diagnostics as described herein,
- Contain a minimum of three (3) NTCIP-compliant RS232 communication ports,
- Contain a minimum of one (1) NTCIP-compliant Ethernet port with RJ45 connector,
- Contain a minimum of one NTCIP-compliant RS422 communication port with RJ45 connector,
- Have the ability to play volatile messages,
- Contain VMS-specific control firmware (embedded software) that shall monitor all external and internal sensors and communication inputs and control the display modules as directed by external control software and the front panel interface, and
- Have the ability for remote firmware upgrades that error check to eliminate firmware corruption.

NTCIP shall be natively supported in the VMS controller. External protocol converter or translator devices shall not be allowed.

The sign controller shall be programmed to receive and transmit NTCIP compliant sign control commands from the central system control software and laptop computer.

The controller shall have power-up and auto-restart capabilities with programmable default actions when recovering from a power off condition. A hardware watch dog circuit shall provide automatic reset of the controller and communications device. Central control shall have ability to perform a remote command for the controller and communications device reset. The controller shall be able to accept standard UPS shutdown commands via Ethernet or serial interface.

The Controller shall perform all communication, control and feedback functions and shall not require an intermediate control device and be the only sign controller. Communication and control lines between the sign controller and the system interface circuits shall be opto- coupled.

The following shall be mounted inside the main sign housing:

1. NTCIP compliant VMS controller,
2. Fold-down laptop shelf and document holder for maintaining sign,
3. Hardened communication device,
4. Display system interface circuits,
5. Local/remote control switch,
6. Sign to ground voice communication RJ-11 jack,
7. USB plug-in connection or a serial connection with a USB converter cable for the controller interface,

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8. RS-232 cable (a minimum of 4 feet long to connect the controller interface to a laptop computer), and
9. A.C. surge protection and communication surge protection.

There shall be an outside controller interface box that shall be made of aluminum or stainless steel, be weather tight, corrosion resistant, and meet NEMA 3R standards. The separate controller interface box shall be mounted as directed by the Engineer. This typically will be on the sign support structure pole furthest from traffic.

1. The controller interface cabinet shall contain the following assemblies:
2. Power-on indicator,
3. Waterproof local/remote switch,
4. Local control LED indicator,
5. RS-232cable a minimum of 4 feet long to connect the controller interface to a laptop computer,
6. 120 VAC GFI outlet, and
7. For dialup installations, an RJ-11 jack for connecting the dialup phone line shall be installed with in-line surge protection.

d. *Electronics:*

All electronic components, except printed circuit boards, shall be commercially available, easily accessible, replaceable and individually removable using conventional electronics repair methods.

All printed circuit boards shall be sealed with a silicone conformal coating.

Components shall be arranged so they are easily accessible for testing and replacement. All circuit designs shall utilize high quality electronic components and shall provide a meantime before failure of at least 3 years.

The VMS shall contain an automatically controlled defog system that warms the VMS front face when the internal VMS relative humidity is near condensation levels. This system shall keep the front face polycarbonate panel free of fog and condensation. The heat generated by the defog system shall not damage any part of the VMS.

The sign and the controller shall be capable of operating with 120/240 VAC, 38 to 50 amp per leg, 60 Hz, single phase power. The sign shall have a 50-amp two-pole breaker (common trip) main, 120/240 VAC, single phase, four wire load center with 20 circuit capability. Each circuit in the sign shall be powered from a circuit breaker. Inside the sign housing, all 120

VAC service lines shall be independently protected by a thermo magnetic circuit breaker at the sign housing entry point. All 120 VAC wiring shall be located in conduit, pull boxes, raceways, or control cabinets as required by the National Electrical Code (NEC). No 120 VAC wiring shall be exposed within or outside of the sign housing. The sign housing shall not be considered as a raceway or control cabinet. There shall be a minimum of three GFI Duplex outlets installed inside the sign housing.

Lighting shall be provided to illuminate the interior of the sign. The lights shall be enclosed in die cast aluminum safety fixtures with twist-on bulb guards secured by a minimum of four set- screws. The lights shall be controlled by an adjustable timer.

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The VMS housing shall contain a minimum of one (1) compact fluorescent light (CFL) fixture for every eight (8) feet of VMS housing width. The lamps shall be evenly spaced across the housing ceiling and provide uniform light distribution for maintenance purposes. The light provided by the lamps shall meet the requirements of *ANSI/IESNA RP-7-01, Lighting Industrial Facilities*. Each lamp shall be rated for at least 10,000 hours of operation, have a minimum 30-watt rating, be self -ballasted, and be rated for cold weather operation down to - 20º F. Lamp housing shall be heavy duty and enclosed to protect the lamps from damage. The lamps shall have a color temperature of at least 4100ºK.

The pixels shall be amber in color and utilize precision optical performance AlInGaP II LEDs constructed of aluminum indium gallium phosphide. The brightness and color of each pixel shall be uniform over the entire face of the sign.

The brightness and color of each pixel shall be uniform over the entire face of the sign within the 30-degree cone of vision from minimum of 200 feet up to and including 1100 feet in all lighting conditions. The brightness of each LED shall be measured in accordance with CIE Test Method A, as described in CIE 127-1997, Technical Report: measurement of LEDs.

The pixel strings shall be powered from a regulated DC power source and the LED current shall be maintained at 25 plus or minus three milliamperes per string to maximize life of the pixel. The failure of an LED in one string within a pixel shall not affect the operation of any other string or pixel. The LEDs shall be capable of operating in a temperature range of –40 degrees to +100 degrees C. The LEDs shall be moisture resistant epoxy with UV-A and UV- B inhibitors. Pixel power drawn from the DC supplies shall not exceed 1.5 watts per pixel, including the driving circuitry.

A minimum of three photocells shall be installed on the sign. These devices shall permit automatic light intensity measurement of light conditions at each sign location. These photocells shall be mounted in a manner to measure front, rear and ambient light conditions. Provisions shall be made to prevent perceivable brightening of the sign due to stray headlights shining upon the photo sensors at night.

The power supplies shall be paralleled in a diode or a configuration such that one supply may completely fail and the sign will still be supplied with enough power to run 40% of all pixels.

All cables shall be securely clamped or tied in the sign housing. No adhesive attachments will be allowed.

The signs shall be capable of displaying ASCII characters 32 through 126 (including all upper and lower case letters and digits from 0 to 9) at any location in a message line.

e. *Communication:*

The sign controller shall be capable of being controlled from the central system control software and the controller interface cabinet via RS-232 serial and Ethernet communications.

The sign controller shall include separate interfaces for communication with the central system control software and the controller interface cabinet.

The communications between the sign controller and the central system control software and controller interface cabinet shall comply with the NEMA National Transportation Communications for ITS Protocol (NTCIP). The sign controller shall support all NTCIP conformance levels, conformance groups, objects, and minimum storage sizes and ranges as specified in APPENDIX A.

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In addition to the standard Management Information Base (MIB) objects, the sign shall include any additional manufacturer-specific MIB objects required to support all of the sign and central software functionality defined in this specification and in APPENDIX A.

Dial-up or hardwire multi-drop communication lines shall be protected by two stages of transient voltage suppression devices including MOVS and spark gap arrestor.

Protect low voltage communication lines (twisted pair or coaxial) with multi-stage one- pair or two-pair surge suppressors designed for high-exposure applications, providing common mode and differential mode protection, with a maximum clamping voltage of 10 volts greater than peak DC or maximum AC RMS signal voltage and peak surge current rating of 10kA.

The sign controller shall be capable of being remotely reset from the central system control software.

The sign shall provide a minimum of four (4) input and four (4) output contact closures able to receive digital and or analog signals that will allow up to 15 message activations upon contact closure events. These message activations shall permit standard NTCIP operations to occur and also permit contact closure messages to occur without message activation collisions and or message activation errors. Contact closures shall be remotely accessible using standard NTCIP MIB objects. Contact closures shall be capable of issuing NTCIP traps.

The sign controller shall provide software modules that will allow integration with CDOT Weight-in-Motion (WIM) systems.

The sign controller shall allow user-configuration of maximum and minimum temperature in which to turn fans on and off.

The sign shall have polling capability and at a minimum shall be capable of reporting the status of the following:

1. Pixel operational status that includes every string of every pixel,
2. Sign and ambient temperature,
3. DC power supply status,
4. The current state (on or off) of each pixel, including any pixel errors, in the actual, currently displayed message without disturbing the message in any way. This shall be real time and shall not be based on a previous pixel test,
5. Cooling fan status,
6. Access door alarm,
7. Communication failure log,
8. UPS status, and
9. AC surge protector status.

The controller software shall be capable of displaying the following types of messages:

1. Static messages capable of displaying any character or set of characters,
2. Full Graphic capabilities,

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3. Flashing messages with the following ranges of adjustable timing:
   a. Message time on from 0.5 to 5.0 seconds in 0.1 second increments and
   b. Message time off from 0.5 to 5.0 seconds in 0.1 second increments, and
4. Alternating messages capable with the following ranges of adjustable timing:
   a. Primary message time on from 0.5 to 5.0 seconds in 0.1 second increments,
   b. Primary message time off from 0 to 5.0 seconds in 0.1 second increments,
   c. Alternate message time on from 0.5 to 5.0 seconds in 0.1 second increments, and
   d. Alternate message time off from 0 to 5.0 seconds in 0.1 second increments.

It shall be possible to flash any character or set of characters in an alternating message at the adjustable frequencies listed above for flashing messages. The flashing period shall be a sub-multiple of the associated alternating on time. It shall also be possible to flash any character or set of characters in a static message.

The sign controller shall monitor the photo cell circuits in the sign and convert the measured light intensity into the desired pixel brightness.

f. Uninterruptable Power Supply (UPS)

The UPS system shall provide “On-Line” dual conversion control. The UPS shall be rated per the following:

1. Input Voltage: 85 VAC to 135 VAC
2. Input Frequency: 48 to 62 Hz
3. Output Voltage:120 VAC plus or minus 3 percent
4. Output Frequency: 60 Hz
5. Power: VA required to run; VMS sign control electronics, and communication equipment, allowing the sign functionality during a power outage for a minimum of 8 hours**.**

The unit shall be designed for a hot swap of components and shall not compromise existing VMS wiring. The unit shall provide for RS232 communication and contact closures for alarm functions. The unit shall be temperature rated to operate from 0 degree C to +40 degree C.

The UPS system shall be capable of producing simultaneously-fully regenerated, conditioned power with true sine wave and continuous AC outputs with stand by capability.

The unit shall have a re-settable power event counter to record the number of power utility failures, a battery run-time counter and temperature compensated battery charging.

The UPS System shall be capable of providing continuous, fully conditioned (both voltage and frequency), regulated, sinusoidal AC power to selected devices such as controllers, modems, 5 volt power supplies, and sign face drivers.

Wiring shall comply with national electrical code (NEC) standards and approved wiring methods. Properly rated SO/SJO cords shall be allowed to allow easy replacement of the UPS System.

The UPS shall be 19-inch rack mountable and shall be accompanied with 19-inch rack mountable aluminum battery shelves for installation in the VMS.

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The UPS shall consist of two major components, the Electronics Module and the Battery System.

1. The Electronics Module shall consist of the following:
   a. True Sine wave, high frequency inverter.
   b. Minimum 3-stage, temperature compensated, battery charger
   c. For connection from the Electronics Module to the Battery System, a dedicated harness shall be provided with quick-release, keyed, circular connectors, and braided nylon sleeving over all conductors.
   d. Local and remote control of UPS functions
   e. Local and remote communications capabilities
2. The Battery System shall consist of the following:
   a. Shall run sign electronics, and communication equipment, for a minimum of 8 hours.
   b. The batteries shall be comprised of extreme temperature, deep cycle AGM/VRLA (Absorbed Glass Mat/Valve Regulated Lead Acid) batteries that have been field proven and tested by the U.S. military.
   c. Batteries shall be certified to operate at extreme temperatures from -40'C to +74'C.
   d. The batteries shall be provided with appropriate interconnect wiring and a corrosion-resistant mounting trays and/or brackets appropriate for the location into which they will be installed.
   e. The interconnect cable shall be protected with abrasion-resistant nylon sheathing.
   f. Battery construction shall include heavy-duty, inter-cell connections for low- impedance between cells and heavy-duty plates to withstand shock and vibration.

The UPS System shall come standard with software, RS232 interface via a DB-9F connector (optional SNMP Adapter for TCP/IP protocols) allowing full, interactive, remote computer monitoring and control of the UPS functions. The software shall allow the user to set up all operational parameters either locally or remotely and test the functionality of the unit.

The UPS Alarm Function Monitoring shall come standard with a DB-9F connector with open collectors (40 V @ 20 mA) indicating:

1. Loss of Utility Power
2. Inverter Failure
3. Low Battery

The UPS Front Panel Controls shall come standard with Power ON, Cold (DC) Start, Alarm Silence, Battery Test, Bypass Breaker and DC/Battery Breaker.

Reliability shall be calculated with mean time between failures (MTBF) of 100,000 hours based on component ratings.

g. *Manufacturer Qualifications*

The manufacturer shall supply experience documentation showing that the manufacturer has been in business, under the current corporate name, designing and manufacturing Interstate LED Variable Message Signs for a minimum of 5 years; and that the manufacturer has in operation a minimum

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of 100 walk-in LED VMSs. These 100 VMS shall be from 5 separate projects and operational for a minimum of 5 years.

h. *Warranty*

The Contractor shall ensure that the manufacturer can warranty the sign and sign controller for a minimum of 3 years for all parts returned to the factory, and full telephone technical support at no additional charge to the Department. The technical support shall include access to a trained service representative who can respond within 24 hours to questions related to all VMS related equipment problems and maintenance issues. The technical support shall include lifetime post warranty telephone and technical support access.

The UPS equipment shall include a minimum two year warranty on parts and labor. Batteries shall include a minimum two year pro rated warranty. Vendor shall be responsible for processing warranty repairs.

A repair option shall be available for UPS equipment no longer covered by the warranty period. Repair cost shall include all labor and materials necessary to complete the repair. Vendor shall be responsible for processing non-warranty repairs.

CONSTRUCTION REQUIREMENTS

Contractor shall be fully responsible for the delivery of the sign to the installation site and any damages that occur in the installation delivery process.

The LED VMS shall be installed in accordance with manufacturer's recommendations. A qualified factory representative shall be available on site to ensure proper installation and testing.

The Contractor shall be responsible for locating the nearest electrical power and telephone sources and connecting those sources to the appropriate terminations with the LED VMS. The Contractor shall cooperate with the local electrical and telephone utilities to establish a service accounts at the direction of the Engineer.

A minimum of five copies of the operations manual detailing the electrical schematics, operation and maintenance of the VMS system, including spare software copies, shall be provided. Additional copies may be requested by the Engineer. One copy of the manual shall remain inside the sign housing or control cabinet. One copy shall be mailed to the Colorado Transportation Management Center at 425 C Corporate Circle, Golden, Colorado 80401.

As part of the VMS submittals, the Contractor shall note the firmware that is planned to be used.

See project specific Testing & Integration Plan for additional requirements for VMSs.

Appendix A

NTCIP Requirements

This portion of the specification defines the detailed NTCIP requirements for the Variable Message Signs covered by the project specifications.

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. In many cases, the standard is more widely known by its original NEMA assigned number, in these cases, the NEMA number is also identified. The content of the NEMA standard is identical to that of the NTCIP standard.

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Each NTCIP Component covered by these project specifications shall implement the most recent version of the standard that is at the stage of Recommended or higher as of January, 01, 2011, including any and all Approved or Recommended Amendments to these standards as of the same date. It is the ultimate responsibility of the vendor to monitor NTCIP activities to discover any more recent documents.

General Requirements:

Subnet Level

NTCIP Components may support additional Subnet Profiles at the vendor's option. At any one time, only one Subnet Profile shall be active on a given serial port of the NTCIP Component. If the NTCIP Component has a serial port that supports multiple Subnet Profiles, the NTCIP Component shall be configurable to allow the field technician to activate the desired Subnet Profile and shall provide a visual indication of the currently selected Subnet Profile.

Transport Level

Each NTCIP Component shall comply with NTCIP 2202, (NEMA TS 3.Internet). NTCIP Components may support additional Transport Profiles at the manufacturer's option. Response datagrams shall use the same Transport Profile used in the request. Each NTCIP Component shall support the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

Application Level

Each LED VMS shall comply with NTCIP 2301, (NEMA TS 3.AP-STMF), as a Managed Agent and shall meet the requirements for Conformance Level 1 (NOTE – see Amendment to standard). Simple network management protocol (SNMP) shall be required and simple transportation management protocol (STMP) shall not be required. An NTCIP Component may support additional Application Profiles at the manufacturer's option. Responses shall use the same Application Profile used by the request. Each NTCIP Component shall support the receipt of Application data packets at any time allowed by the subject standards.

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 Time for any object or group of objects shall be 200 milliseconds.

The vendor's software shall implement all mandatory objects of the mandatory conformance group defined in NTCIP 1201, (NEMA TS 3.4) Global Object Definitions:

> Configuration Conformance Group – Section 3.1 Security Conformance Group (new in Amendment 1)

The vendor's software shall implement the mandatory objects of the optional conformance groups defined in NTCIP 1201, (NEMA TS 3.4), Global Object Definitions:

> Time Management Conformance Group – Section 3.3 TimeBase Event Schedule Conformance Group – Section 3.4 Report Conformance Group – Section 3.5

The vendor's software shall implement all mandatory objects of all mandatory conformance groups defined in NTCIP 1203, (NEMA TS 3.6) Object Definitions for DYNAMIC MESSAGE SIGN (LED) (OVERHEAD)s:

> Sign Configuration Conformance Group – Section 4.1 Message Table Conformance Group – Section 4.6 Sign Control Conformance Group – Section 4.7

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The vendor's software shall implement all mandatory objects of the optional conformance groups defined in NTCIP 1203, (NEMA TS 3.6), Object Definitions for DYNAMIC MESSAGE SIGN (LED) (OVERHEAD)s:

GUI Appearance – Section 4.2 Font Definition – Section 4.3

DMS Sign Configuration – Section 4.4 MULTI Configuration – Section 4.5 Default Message – Section 4.8 MULTI Error – Section 4.10 Illumination/Brightness – Section 4.11 Scheduling – Section 4.12

Auxiliary I/O – Section 4.13 Sign Status – Section 4.14 Status Error – Section 4.15

Pixel Error Status – Section 4.16 Fan Error Status – Section 4.18 Temperature Status – Section 4.17

The vendor's software shall implement the following optional objects defined in NTCIP 1203, (NEMA TS 3.6):

dmsMessageBeacon – Section 2.6.1.1.1.8.6

dmsSWReset – Section 2.7.1.1.1.1

dmsMessageTimeRemaining – Section 2.7.1.1.1.4

dmsShortPowerRecoveryMessage – Section 2.7.1.1.1.8

dmsLongPowerRecoveryMessage – Section 2.7.1.1.1.9

dmsShortPowerLossTime – Section 2.7.1.1.1.10

dmsResetMessage – Section 2.7.1.1.1.11

dmsCommunicationsLossMessage –Section 2.7.1.1.1.12

dmsTimeCommLoss – Section 2.7.1.1.1.13

dmsPowerLossMessage – Section 2.7.1.1.1.14

dmsEndDurationMessage – Section 2.7.1.1.1.15

dmsMultiOtherErrorDescription – Section 2.7.1.1.1.20

dmsStatDoorOpen – Section 2.11.1.1.1.6

fanFailures – Section 2.11.2.1.1.8

fanTestActivation – Section 2.11.2.1.1.9

tempMinCtrlCabinet – Section 2.11.4.1.1.1

tempMaxCtrlCabinet – Section 2.11.4.1.1.2

tempMinAmbient – Section 2.11.4.1.1.3

tempMaxAmbient – Section 2.11.4.1.1.4

tempMinSignHousing – Section 2.11.4.1.1.5

tempMaxSignHousing – Section 2.11.4.1.1.6

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The vendor's software shall implement the following tags (opening and closing where defined) of MULTI as defined in NTCIP 1203, (NEMA TS 3.6), Object Definitions for DYNAMIC MESSAGE SIGN (LED) (OVERHEAD)s:

MULTI Tag

1. Field
2. Flash
3. Font
4. Hexadecimal Character
5. Justification Line
6. Justification Page
7. Moving Text
8. New Line
9. New Page
10. Page Time
11. Spacing – Character

The Field Tag shall support the following field ID's:

Field	Tag ID	Description
1	1	Time, 12-hour format (no AM/PM indicator)
2	2	Time, 24-hour format
3	3	Temperature in degrees Celsius
4	4	Temperature in degrees Fahrenheit
5	7	Day of week
6	8	Day of month
7	9	Month of year
8	10	Year, 2-digits
9	11	Year, 4-digits

Sizes and Ranges

All objects required by these procurement specifications shall support all values within its standardized range. The standardized range is defined by a size, range, or enumerated listing indicated in the object's SYNTAX field and/or through descriptive text in the object's DESCRIPTION field of the relevant standard. The following provides the current listing of known variances for this project:

Object	**Reference**	**Minimum Project Requirements**
NTCIP 1201 (TS 3.4)		
moduleTableEntry	2.2.3	Shall contain at least one row with module Type equal to 3 (software). The module Make shall specify the name of the manufacturer; the module Model shall specify the manufacturer's name of the component and the model Version shall indicate the model version number of the component.
communityNamesMax	2.8.2	Shall be at least 4.
maxTimeBaseScheduleEntries	2.4.3.1	7

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maxDayPlans	2.4.4.1	7
maxDayPlanEvents	2.4.4.2	7
maxEventLogConfigs	2.5.1	50
eventConfigMode	2.5.2.3	2,3,and 4
maxEventLogSize	2.5.3	200
maxEventClasses	2.5.5	7
maxGroupAddress	2.7.1	1
maxEventLogSize	2.5.3	200
maxEventClasses	2.5.5	7
maxGroupAddress	2.7.1	1

NTCIP 1203 v0239b (TS 3.6)

dmsNumPermanentMsg	5.6.1	100
dmsMaxChangeableMsg	5.6.3	100
dmsFreeChangeableMemory	5.6.4	500 MB
dmsMaxVolatileMsg	5.6.6	100
dmsFreeVolatileMemory	5.6.7	500 MB
dmsMsgMultiString	5.6.8.3	See attached table
dmsControlMode	5.7.1	2,4,5
numFonts	5.4.1	10
maxFontCharacters	5.4.3	127
DMSCharacterHeightPixels	5.3.1	7
DMSCharacterWidthPixels	5.3.2	5
DMSSignHeightPixels	5.3.3	27
DMSSignWidthPixels	2.3.1.1.1.4	105
DMSHorizontalPitch	5.3.5	66-70 mm
DMSVerticalPitch	5.3.6	66-70 mm
defaultBackgroundColor	5.5.1	0 (black)
defaultJustificationLine	5.5.9	2,3,4
defaultJustificationPage	5.5.11	2,3,4
defaultFlashOn	5.5.3	0.5 to 5.0
defaultFlashOff	5.5.5	0.5 to 5.0

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defaultPageOnTime	5.5.13	0.5 to 5.0
defaultPageOffTime	5.5.15	0.5 to 5.0
defaultCharacterSet	5.5.21	eightBit (2)
dmsMaxNumberPages	5.5.24	6
dmsColorScheme	5.5.22	1 (monochrome1bit)
dmsSupportedMultiTags	5.5.23	See Section 614 more Multi Tags details.

Documentation

The Software shall be supplied with full documentation and a CD-Rom containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

1. Relevant version of each official standard MIB Module referenced by the device functionality.
2. If the device does not support the full range of any given object within a Standard MIB Module, a vendor 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. The filename of this file shall be identical to the standard MIB Module, except that it will have the extension ".man".
3. A MIB Module in ASN.1 format containing any and 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.
4. A MIB containing any other objects supported by the device.

The vendor shall allow the use of any and all of this documentation by any party authorized by CDOT for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

REVISION OF SECTION 614
VARIABLE TOLL MESSAGE SIGN (VTMS)

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and installing a Light Emitting Diode Variable Toll Message Sign (LED VTMS). The LED VTMS shall be equipped with the ability to display 7 characters of text at a height of 18-inch tall characters. The pixel matrix shall be a minimum of 7x35. The sign shall include a power shut off mounted to the sign structure near the controller interface cabinet. The sign shall be capable of operating without any decrease in performance over a temperature range of -34° F to +140° F with a relative humidity of 0 to 99 percent, non-condensing. The sign shall have a minimum design life of 20 years.

MATERIALS

a. *Certifications:* Prior to start of the installation of the LED VTMS the Contractor shall provide the following certifications to CDOT for Approval:

1. Certification showing that the manufacturer of the LED VTMS is fully compliant with ISO 9001 as of the bid date for this project. The ISO 9001 Certification shall apply to the facility, and to the design, fabrication, installation, and maintenance of the LED VTMS. The facility where this company actually designs and manufactures the LED VTMS shall be ISO 9001:2000 certified a minimum of one year prior to the bid date for this project.
2. Working drawings showing the sign housing shall be sealed by an Engineer registered in the State of Colorado and shall be submitted in accordance with subsection 105.02.
3. Certification showing that welding of the LED VTMS housing is in accordance with the American Welding Society (AWS) Standards, ANSI/AWS D1.2-97. The LED VMS manufacturer's welders and welding procedures shall be certified by an ANSI/AWS Certified Welding Inspector to the ANSI/AWS D1.2-97 Structural Welding Code for Aluminum.
4. Certification that all aluminum face materials have a coating that meets or exceeds the requirements of the American Architectural Manufacturers Association (AAMA) Specifications Publication No. 2605.
5. Certification that the LEDs were tested and binned in accordance with the CIE Test Method A.
6. Documentation and information on software as described in Appendix A of this document.
7. Documentation verifying the VTMS is listed by an accredited 3rd party testing organization for conformance to UL48 and UL 1433.
8. All workmanship shall comply with IPC-A-610C, Class 2 titled "Acceptability of Electronic Assemblies".
9. Documentation providing proof PCB silicon conformal coating conformance to MIL-I- 46058C Type SR and IPC-CC-830.
10. Documentation that the sign's structural integrity is in Conformance to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals (Third Draft).

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REVISION OF SECTION 614
VARIABLE TOLL MESSAGE SIGN (VTMS)

11. Documentation that the VMS conforms to the Transient Protection and Vibration of the NEMA Standard TS4, Section2.

b. *Sign Housing:* All component parts shall be easily and readily accessible by a single person for inspection and maintenance. The housing shall be weather tight, and compliant to the NEMA 3R Standard.

All parts shall be made of corrosion resistant materials, such as plastic, stainless steel or aluminum. Painted steel is not acceptable. No self-tapping screws shall be used. The exterior front face surfaces shall be finish coated by a system that meets or exceeds the AAMA Specification No. 2605. The finish shall be matte black. The main body of the sign housing shall be constructed of aluminum with a natural mill finish. All exterior seams shall be continuously welded by an inert gas process, except for the coated fascia material.

The glazing shall be constructed of clear polycarbonate sheets with surfaces that resist hazing from UV light. The glazing shall be protected by a coated 0.090 inch aluminum mask with apertures punched directly in front of each pixel. The coating shall meet or exceed the AAMA Specification No. 2605.

For surge protection, the system power shall be protected by two stages of transient voltage suppression devices. Tripping of each stage (or both if tripped simultaneously) of the surge protection shall cause the sign controller to call central and report the error condition (for dialup operation) or report the error condition to central on the next poll (for multi-drop operation). There shall be an option that is either enabled or disabled and is selected and downloaded from the central system control software to the sign controller. When this option is enabled, tripping of the second stage of surge protection shall prevent power from reaching any components of the sign until the surge protection has been replaced. When this option is disabled, the sign will continue to function normally after the second stage of surge protection is tripped.

c. *Sign controller:* The sign controller shall be installed into the Communications Cabinet on the side of the road. The sign controller shall allow for control and monitoring of multiple VTMS inserts. The sign controller shall be a stand-alone microprocessor-based system, which does not require continuous communication with VTMS control software in order to perform most VTMS control functions.

The sign controller shall meet the following operational requirements:

1. Communicate using embedded National Transportation Communications for ITS Protocol (NTCIP) protocol
2. Contain memory for storing changeable and permanent messages, schedules, and other necessary files for controller operation
3. Include a front panel user interface with graphical VFD or LCD and keypad for direct operation and diagnostics as described herein
4. Contain a minimum of two (2) NTCIP-compliant RS232 communication ports
5. Contain a minimum of one (1) NTCIP-compliant Ethernet port with RJ45 connector
6. Have the ability to play volatile messages
7. Contain VMS-specific control firmware (embedded software) that shall monitor all external and internal sensors and communication inputs and control the display modules as directed by external control software and the front panel interface

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REVISION OF SECTION 614
VARIABLE TOLL MESSAGE SIGN (VTMS)

8. Ability for remote firmware upgrades that error check to eliminate firmware corruption

NTCIP shall be natively supported in the VTMS controller. External protocol converter or translator devices shall not be allowed. The sign controller shall be programmed to receive and transmit NTCIP compliant sign control commands from the central system control software and laptop computer. The controller shall have power-up and auto-restart capabilities with programmable default actions when recovering from a power off condition. A hardware watch dog circuit shall provide automatic reset of the controller and communications device. Central control shall have ability to perform a remote command for the controller and communications device reset. The controller shall be able to accept standard UPS shutdown commands via Ethernet or serial interface.

The Controller shall perform all communication, control and feedback functions and shall not require an intermediate control device and be the only sign controller. Communication and control lines between the sign controller and the system interface circuits shall be opto- coupled.

d. *Electronics:* All electronic components, except printed circuit boards, shall be commercially available, easily accessible, replaceable and individually removable using conventional electronics repair methods.

All Printed Circuit Boards (PCBs) shall be completely conformal coated with a silicone resin that meets the IPC CC-830 standard. The exception for this coating shall be the pixels on the front of the PCB of the LED motherboards and any components in sockets.

All integrated circuits shall be individually replaceable. Components shall be arranged so they are easily accessible for testing and replacement. All circuit designs shall utilize high quality electronic components and shall provide a meantime before failure of at least 3 years.

The sign and the controller shall be capable of operating with 120/240 VAC, 20 amp per leg, 60 Hz, single phase power. Each circuit in the sign shall be powered from a circuit breaker. Inside the roadside cabinet, all 120 VAC service lines shall be independently protected by a thermo-magnetic circuit breaker at the sign housing entry point. All 120 VAC wiring shall be located in conduit, pull boxes, raceways, or control cabinets as required by the National Electrical Code (NEC). No 120 VAC wiring shall be exposed within or outside of the sign housing.

The pixels shall be red/green/amber in color and utilize precision optical performance AlInGaP II LEDs (for red LEDs) or InGaN LEDs (for green LEDs) constructed of aluminum indium gallium phosphide. The brightness and color of each pixel shall be uniform over the entire face of the sign within the 30-degree cone of vision from minimum of 200 feet up to and including 1,100 feet in all lighting conditions. Each pixel shall be 40 candelas at 20mA as measured by the sum of the brightness of the individual LEDs in each pixel. The brightness of each LED shall be measured in accordance with CIE Test Method A, as described in CIE 127-1997, Technical Report: Measurement of LEDs.

Each pixel shall contain two strings of LEDs. The pixel strings shall be powered from a regulated DC power source and the LED current shall be maintained at 25 plus or minus three milliamperes per string to maximize life of the pixel. The failure of an LED in one string within a pixel shall not affect the operation of any other string or pixel. The LEDs shall be capable of operating in a temperature range of –40 degrees to +100 degrees C. The LEDs shall be moisture resistant epoxy with UV-A and UV-B inhibitors.

Pixel power drawn from the DC supplies shall not exceed 1.5 watts per pixel, including the driving circuitry.

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REVISION OF SECTION 614
VARIABLE TOLL MESSAGE SIGN (VTMS)

A minimum of one photocell shall be installed on the sign. This device shall permit monitoring of light conditions at each sign location and automatic selection of light intensity levels. The method or algorithm used to calculate the intensity level shall be determined by the manufacturer and tested under real-world lighting conditions.

The power supplies shall be paralleled in a diode OR configuration such that one supply may completely fail and the sign will still be supplied with enough power to run 40% of all pixels. The power supply shall be located inside the roadside cabinet and not in the sign. The Contractor shall work with the Vendor to determine proper cabling requirements from the cabinet to the sign.

All cables shall be securely clamped/tied in the sign housing. No adhesive attachments will be allowed.

The signs shall be capable of displaying ASCII characters 32 through 126 (including all upper and lower case letters and digits from 0 to 9) at any location in a message line.

The Contractor shall be responsible for locating the nearest electrical power and CDOT communication sources and connecting those sources to the appropriate terminations with the LED VTMS. The Contractor shall cooperate with the local electrical and communication utilities to establish a service accounts at the direction of the Engineer.

e. *Communication:* The sign controller shall be capable of being controlled from the central system control software and the controller interface cabinet via RS-232 serial and Ethernet communications.

The sign controller shall include separate interfaces for communication with the central system control software and the controller interface cabinet.

The communications between the sign controller and the central system control software and controller interface cabinet shall comply with the NEMA NTCIP. The sign controller shall support all NTCIP conformance levels, conformance groups, objects, and minimum storage sizes and ranges as specified in APPENDIX A.

In addition to the standard Management Information Base (MIB) objects, the sign shall include any additional manufacturer-specific MIB objects required to support all of the sign and central software functionality defined in this specification and in APPENDIX A.

Dial-up or hardwire multi-drop communication lines shall be protected by two stages of transient voltage suppression devices including MOVS and spark gap arrestor.

The sign controller shall be capable of being remotely reset from the central system control software.

The sign controller shall allow user-configuration of maximum and minimum temperature in which to turn fans on and off.

The sign shall have polling capability and at a minimum shall be capable of reporting the status of the following:

1. Pixel operational status that includes every string of every pixel
2. Sign and ambient temperature
3. DC power supply status

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REVISION OF SECTION 614
VARIABLE TOLL MESSAGE SIGN (VTMS)

4. The current state (on or off) of each pixel, including any pixel errors in the actual, currently displayed message without disturbing the message in any way. This shall be real time and shall not be based on a previous pixel test.
5. Communication failure log
6. UPS status
7. AC surge protector status

The controller software shall be capable of displaying static messages, including any character or set of characters

It shall be possible to flash any character or set of characters in an alternating message at the adjustable frequencies listed above for flashing messages. The flashing period shall be a sub-multiple of the associated alternating on time. It shall also be possible to flash any character or set of characters in a static message.

The sign controller shall monitor the photo cell circuits in the sign and convert the measured light intensity into the desired pixel brightness.

MANUFACTURER QUALIFICATIONS

The manufacturer shall supply experience documentation showing that the manufacturer has been in business, under the current corporate name, designing and manufacturing freeway LED Variable Message Signs of a similar type for a minimum of 5 years; and that the manufacturer has in operation a minimum of 100 LED VMS. These 100 VMS shall be from 5 separate projects and operational for a minimum of 5 years.

WARRANTY

Standard Warranty. The contractor shall ensure that the manufacturer can warranty the product for a minimum of 3 years for all parts returned to the factory, and full telephone technical support at no additional charge to the Department. The technical support shall include access to a trained service representative who can respond within 24 hours to questions related to all VTMS related equipment problems and maintenance issues.

CONSTRUCTION REQUIREMENTS

Contractor shall be fully responsible for the delivery of the sign to the installation site and any damages that occur in the installation and delivery process.

The LED VTMS shall be installed in accordance with manufacturer's recommendations. A qualified factory representative shall be available on site to ensure proper installation and testing.

A minimum of five copies of the operations manual detailing the electrical schematics, operation and maintenance of the VTMS system, including software copies, shall be provided. Additional copies may be requested by CDOT. One copy of the manual shall remain inside the sign controller cabinet on the side of the road. One copy shall be delivered to the CDOT construction project engineer.

See project specific Testing & Integration Plan for additional requirements for VTMSs.

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REVISION OF SECTION 614
VARIABLE TOLL MESSAGE SIGN (VTMS)

Appendix A

NTCIP Requirements

This portion of the specification defines the detailed NTCIP requirements for the Variable Message Signs covered by the project specifications.

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. In many cases, the standard is more widely known by its original NEMA assigned number, in these cases, the NEMA number is also identified. The content of the NEMA standard is identical to that of the NTCIP standard.

Each NTCIP Component covered by these project specifications shall implement the most recent version of the standard that is at the stage of Recommended or higher as of Sunday, April 03, 2001, including any and all Approved or Recommended Amendments to these standards as of the same date. It is the ultimate responsibility of the vendor to monitor NTCIP activities to discover any more recent documents.

General Requirements:

Transport Level

Each NTCIP Component shall comply with NTCIP 2202 (NEMA TS 3.Internet). NTCIP Components may support additional Transport Profiles at the manufacturer's option. Response datagrams shall use the same Transport Profile used in the request. Each NTCIP Component shall support the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

Application Level

Each VMS shall comply with NTCIP 2301 (NEMA TS 3.AP-STMF) as a Managed Agent and shall meet the requirements for Conformance Level 1 (NOTE – See Amendment to standard). SNMP shall be required and STMP shall not be required. An NTCIP Component may support additional Application Profiles at the manufacturer's option. Responses shall use the same Application Profile used by the request. Each NTCIP Component shall support the receipt of Application data packets at any time allowed by the subject standards.

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 Time for any object or group of objects shall be 200 milliseconds.

The vendor's software shall implement all mandatory objects of the mandatory conformance group defined in NTCIP 1201, (NEMA TS 3.4) Global Object Definitions:

- Configuration Conformance Group – Section 3.1
- Security Conformance Group (new in Amendment 1)

The vendor's software shall implement the mandatory objects of the optional conformance groups defined in NTCIP 1201 (NEMA TS 3.4) Global Object Definitions:

- Time Management Conformance Group – Section 3.3
- TimeBase Event Schedule Conformance Group – Section 3.4
- Report Conformance Group – Section 3.5

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REVISION OF SECTION 614
VARIABLE TOLL MESSAGE SIGN (VTMS)

The vendor's software shall implement all mandatory objects of all mandatory conformance groups defined in NTCIP 1203, (NEMA TS 3.6) Object Definitions for Variable Message Signs:

- Sign Configuration Conformance Group – Section 4.1
- Message Table Conformance Group – Section 4.6
- Sign Control Conformance Group – Section 4.7

The vendor's software shall implement all mandatory objects of the optional conformance groups defined in NTCIP 1203 (NEMA TS 3.6) Object Definitions for Variable Message Signs:

- GUI Appearance – Section 4.2
- Font Definition – Section 4.3
- VMS Sign Configuration – Section 4.4
- MULTI Configuration – Section 4.5
- Default Message – Section 4.8
- MULTI Error – Section 4.10
- Illumination/Brightness – Section 4.11
- Scheduling – Section 4.12
- Auxiliary I/O – Section 4.13
- Sign Status – Section 4.14
- Status Error – Section 4.15
- Pixel Error Status – Section 4.16
- Fan Error Status – Section 4.18
- Temperature Status – Section 4.17

The vendor's software shall implement the following optional objects defined in NTCIP 1203, (NEMA TS 3.6):

- dmsMessageBeacon – Section 2.6.1.1.1.8.6
- dmsSWReset – Section 2.7.1.1.1.1
- dmsMessageTimeRemaining – Section 2.7.1.1.1.4
- dmsShortPowerRecoveryMessage – Section 2.7.1.1.1.8
- dmsLongPowerRecoveryMessage – Section 2.7.1.1.1.9
- dmsShortPowerLossTime – Section 2.7.1.1.1.10
- dmsResetMessage – Section 2.7.1.1.1.11
- dmsCommunicationsLossMessage – Section 2.7.1.1.1.12
- dmsTimeCommLoss – Section 2.7.1.1.1.13

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VARIABLE TOLL MESSAGE SIGN (VTMS)

- dmsPowerLossMessage – Section 2.7.1.1.1.14
- dmsEndDurationMessage – Section 2.7.1.1.1.15
- dmsMultiOtherErrorDescription – Section 2.7.1.1.1.20
- dmsStatDoorOpen – Section 2.11.1.1.1.6
- fanFailures – Section 2.11.2.1.1.8
- fanTestActivation – Section 2.11.2.1.1.9
- tempMinCtrlCabinet – Section 2.11.4.1.1.1
- tempMaxCtrlCabinet – Section 2.11.4.1.1.2
- tempMinAmbient – Section 2.11.4.1.1.3
- tempMaxAmbient – Section 2.11.4.1.1.4
- tempMinSignHousing – Section 2.11.4.1.1.5
- tempMaxSignHousing – Section 2.11.4.1.1.6

The vendor's software shall implement the following tags (opening and closing where defined) of MULTI as defined in NTCIP 1203 (NEMA TS 3.6) Object Definitions for Variable Message Signs:

MULTI Tag

1. Field
2. Flash
3. Font
4. Hexadecimal Character
5. Justification Line
6. Justification Page
7. Moving Text
8. New Line
9. New Page
10. Page Time
11. Spacing – Character

The Field Tag shall support the following field ID's:

Field	Tag ID	Description
1	1	Time, 12-hour format (no AM/PM indicator)
2	2	Time, 24-hour format
3	3	Temperature in degrees Celsius

4	4	Temperature in degrees Fahrenheit
5	7	Day of week
6	8	Day of month
7	9	Month of year
8	10	Year, 2-digits
9	11	Year, 4-digits

Sizes and Ranges

All objects required by these procurement specifications shall support all values within its standardized range. The standardized range is defined by a size, range, or enumerated listing indicated in the object's SYNTAX field and/or through descriptive text in the object's DESCRIPTION field of the relevant standard. The following provides the current listing of known variances for this project:

Object	Reference	Minimum Project Requirements
NTCIP 1201 (TS 3.4)		
moduleTableEntry	2.2.3	Shall contain at least one row with module Type equal to 3 (software). The module Make shall specify the name of the manufacturer, the module Model shall specify the manufacturer's name of the component and the model Version shall indicate the model version number of the component.
communityNamesMax	2.8.2	Shall be at least 4.
maxTimeBaseScheduleEntries	2.4.3.1	7
maxDayPlans	2.4.4.1	7
maxDayPlanEvents	2.4.4.2	7
maxEventLogConfigs	2.5.1	50
eventConfigMode	2.5.2.3	2,3,and 4
maxEventLogSize	2.5.3	200
maxEventClasses	2.5.5	7
maxGroupAddress	2.7.1	1
NTCIP 1203 (TS 3.6)		
dmsNumPermanentMsg	2.6.1.1.1.1	50
dmsMaxChangeableMsg	2.6.1.1.1.3	50
dmsFreeChangeableMemory	2.6.1.1.1.4	50KB
dmsMaxVolatileMsg	2.6.1.1.1.6	50

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REVISION OF SECTION 614
VARIABLE TOLL MESSAGE SIGN (VTMS)

dmsFreeVolatileMemory	2.6.1.1.1.7	50KB
dmsMsgMultiString	2.6.1.1.1.8.3	See attached table
dmsControlMode	2.7.1.1.1.1	2,4,5
numFonts	2.4.1.1.1.1	4
maxFontCharacters	2.4.1.1.1.3	127
vmsCharacterHeightPixels	2.3.1.1.1.1	5
vmsCharacterWidthPixels	2.3.1.1.1.2	7
vmsSignHeightPixels	2.3.1.1.1.3	3
vmsSignWidthPixels	2.3.1.1.1.4	10
vmsHorizontalPitch	2.3.1.1.1.5	70mm
vmsVerticalPitch	2.3.1.1.1.6	70mm
defaultBackgroundColor	2.5.1.1.1.1	0 (black)
defaultForegroundColor	2.5.1.1.1.2	9 (amber)
defaultJustificationLine	2.5.1.1.1.6	2,3,4
defaultJustificationPage	2.5.1.1.1.7	2,3,4
defaultFlashOn	2.5.1.1.1.3	0.5 to 5.0
defaultFlashOff	2.5.1.1.1.4	0.5 to 5.0
defaultPageOnTime	2.5.1.1.1.8	0.5 to 5.0
defaultPageOffTime	2.5.1.1.1.9	0.5 to 5.0
defaultCharacterSet	2.5.1.1.1.10	eightBit (2)
numActionTableEntries	2.9.1.1.1.1	15

Documentation

Software shall be supplied with full, electronic documentation containing ASCII versions of the following 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 vendor 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. The filename of this file shall be identical to the standard MIB Module, except that it will have the extension ".man".
- A MIB Module in ASN.1 format containing any and 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.

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REVISION OF SECTION 614
VARIABLE TOLL MESSAGE SIGN (VTMS)

- A MIB containing any other objects supported by the device.

The vendor shall allow the use of any and all of this documentation by any party authorized by CDOT for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

REVISION OF SECTION 614
WEATHER MONITORING SYSTEM

Section 614 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing, installing, and commissioning a Weather Monitoring Station (WMS) at locations shown on the Plans. The WMS shall be specifically designed to collect and distribute real time atmospheric and roadway pavement conditions to a centralized computer system compatible with existing Colorado Department of Transportation (CDOT) ITS infrastructure. Centralized CDOT server/s will poll the WMS for data on preset time intervals, from two to ten minutes, to transfer and update data. Data from the WMS shall comply with standard National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) and seamless integrate with the existing CDOT WMS communication servers and software.

The Contractor shall submit detailed descriptions (technical cut sheets) of all components comprising the WMS; along with vendor/manufacturer experience in supplying and installing WMS to CDOT or other agencies. The Contractor shall also provide written justification of the selection process used in the selection of a WMS vendor/manufacturer. Such justification shall assure that CDOT receives a state of the art WMS from a responsible vendor/manufacturer that is compatible with the existing statewide WMS system currently in place. CDOT may require the Contractor to document the proposed WMS can provide interoperability and connectivity to the existing statewide WMS system. The WMS equipment vendor chosen by the Contractor must have at least ten (10) successful WMS installations in North America. As part of the equipment approval process, CDOT may ask the Contractor to provide contact information from at least three (3) other agencies to verify said WMS installations were successful.

After completion of the equipment installation, the equipment manufacturer representative shall perform all final system checks, sensor alignments, software setup, and software configuration to provide a fully operational WMS. The equipment vender shall provide a limited, on-site warranty covering all equipment for a 12-month period from the WMS commissioning date.

MATERIALS

The WMS shall include a remote processing unit, an air temperature/relative humidity sensor, a wind speed/direction sensor, a non-intrusive road surface condition sensor, a non-intrusive road surface temperature sensor, all mounting/attachment hardware, cables, test equipment, manufacturer site commissioning, and server configuration necessary for a full and complete installation.

Remote Processing Unit (RPU)

The RPU shall gather, process, and store data from all connected sensors; and allow for remote data collection by centralized server/s upon polled request utilizing standard NTCIP protocols. The RPU shall utilize a modular design consisting of a main data management unit and secondary communications units that are used to power and connect to sensors at the WMS site.

The main data management unit shall utilize a Linux based operating system capable of multi-tasking operations to optimize data acquisition from all connected devices. The RPU shall have in-built GPS for real-time clock synchronization and location definition.

The RPU shall utilize solid-state components for robust operation. The RPU shall support standardized communication protocols for sensors from various manufactures. The RPU shall have the capability to be remotely configured and reset from a web-based interface.

The RPU shall include a minimum of two (2) 10/100 Ethernet ports and six (6) serial ports configurable for RS-232, RS-485 2 wire or RS-485 isolated 4 wire operating at full or half duplex from 300 to 115,200bps.

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REVISION OF SECTION 614
WEATHER MONITORING SYSTEM

All circuitry of the RPU, the voltage inputs, the sensor inputs, and the communications ports shall be designed and tested to provide replaceable transient voltage and surge protection. The RPU shall also include lightning protection and power auto reset circuit breakers for all data channels and serial ports.

All RPU electronics shall be capable of operating in a minimum temperature range of -40°F to 140°F and 5-90% RH non-condensing.

The RPU shall operate within a conventional commercial AC utility power range of 90-260 VAC at 55-65 Hz and shall use no more than 60 Watts of continuous power. The RPU shall have the capability of being modified to utilize solar power or other power sources in place of conventional commercial electric power. Solar powered RPU sites shall operate a minimum of 72 hours without sunlight or solar charging of the batteries. A solar powered RPU shall operate within a power range of 12-32 VDC.

The RPU shall support full software configuration via a web-based user interface. The RPU shall be capable of communications via serial RS-232, RS-485 2 wire or RS-485 isolated 4 wire utilizing PPP or PMPP protocols or 10/100 Ethernet connection utilizing TCP/IP protocol. The RPU hardware and software provided shall be compliant with the most current Federal standard NTCIP ESS protocols.

At minimum the RPU shall be capable of collecting data from the following:

- 1 wired air temperature/relative humidity sensor
- 1 wired ultrasonic wind speed/direction sensor
- 1 non-intrusive pavement condition sensor
- 1 non-intrusive pavement temperature sensor

The RPU shall include an IP66 rated lockable stainless steel AISI 316 powder coated enclosure that is resistant to weather, sunshine, de-icing chemicals, corrosion and damage from falling debris (ice, small rocks and tree branches) and vandalism. The enclosure shall be capable of being mounted on poles with an outer diameter range of 6 inches to 24 inches or WMS fold-over tower and have rubber flanges located at the bottom which provides cabling access. The enclosure shall house all RPU electronics, power supplies, and communication equipment and not exceed dimensions of 24 inches height by 20 inches width by 8.25 inches depth.

Air Temperature/Relative Humidity Sensor

The air temperature/relative humidity sensor shall accurately measure outside ambient air temperature and relative humidity. System dew point temperature shall be calculated from the air temperature and relative humidity. The sensor shall be protected by UV stabilized white thermoplastic solar/wind-radiation shield and satisfy IP66 rating. The air temperature/relative humidity sensor shall have an air temperature sensing element that measures a minimal temperature range of -40°F to 140°F. The air temperature/relative humidity sensor shall have a relative humidity sensing element that measures a range of 0 to 100%RH. The air temperature/relative humidity sensor shall operate in a minimal temperature range of -40°F to 140°F. The sensor shall operate within a power range of 7–30 VDC and use no more than 5 watts of power. The sensor shall provide RS-485 2 wire serial data communication interface. The Contractor is responsible for using correct communication protocol based on RPU to sensor connection and the maximization of communications reliability. The Contractor shall use shield twisted pair cable and is responsible for ordering the correct length based on planned installation. The sensor shall include all mounting hardware.

Ultrasonic Wind Speed/Direction Sensor

The ultrasonic wind sensor shall accurately measure wind speed and direction without any moving parts. The sensor shall have an operating range of 0 to 145 mph, with a survival operation limit of 190 mph. The sensor shall have a method of heating to allow accurate measurements of wind speed and direction in

subfreezing conditions. Accuracy of measured wind speed shall be within 3% of actual wind speed. Wind speed direction operating azimuth shall be measurable from 0 to 360°, with an accuracy of +/- 2°, and resolution of 1°. The sensor shall be resistant to contamination and corrosion and satisfy IP66 and IP67 ratings. The sensor shall include provisions to deter animal perching or nesting. The sensor shall operate in a minimal temperature range of -40°F to 140°F. The sensor shall operate within a power range of 9-40 VDC and use no more than 30 watts of power. The sensor shall utilize 0 to 5000 mV analog output and also provide RS-232, RS-422 or RS-485 2 wire serial data communication interfaces. The Contractor is responsible for using correct communication protocol based on RPU to sensor connection to maximize communications reliability. The Contractor shall use shield twisted pair cable and is responsible for ordering the correct length based on planned installation. The sensor shall include any extension and all mounting hardware required to mount at standard height of 33 feet.

Non-Intrusive Pavement Condition Sensor/s

The non-intrusive pavement condition sensor shall utilize infrared technology to accurately measure presence of water, ice, slush, snow and frost. The sensor shall also measure the level of grip or friction coefficient of the roadway. The sensor shall operate in a minimum temperature range of -40°F to 140 °F at 0 to 100% RH. The sensor shall operate within a power range of 9-30 VDC and use no more than 4 watts of power. The sensor shall be capable of accurate measurements at distances of 7-50 feet from the roadway. The sensor shall provide RS-232 or RS-485 4 wire serial data communication interfaces. The Contractor is responsible for using correct communication protocol based on RPU to sensor connection and the maximization of communications reliability. The Contractor shall use shield twisted pair cable and is responsible for ordering the correct length based on planned installation. If the WMS is greater than 25 feet from the white edge line of the roadway being measured then the non-intrusive pavement condition sensor shall be separately mounted on breakaway pole. The sensor shall include all mounting hardware.

Quantity of non-invasive pavement condition sensor/s and desired sensor detection location shall be provided on the Plans or by the Project Engineer.

Non-Intrusive Pavement Temperature Sensor/s

The non-intrusive pavement temperature sensor shall utilize Class 1 laser technology to accurately measure infrared radiation emitted by roadway surface to calculate temperature. The sensor shall operate in a minimum temperature range of -40°F to 140 °F at 0 to 100% RH. The sensor shall operate within a power range of 9-30 VDC and use no more than 0.05 watts of power. The sensor shall be capable of accurate measurements at distances of 7-50 feet from the roadway. The sensor shall provide RS-232 or RS-485 4 wire serial data communication interfaces. The Contractor is responsible for using correct communication protocol based on RPU to sensor connection and the maximization of communications reliability. The Contractor shall use shield twisted pair cable and is responsible for ordering the correct length based on planned installation. If the WMS is greater than 25 feet from the white edge line of the roadway being measured then the non-intrusive pavement temperature sensor shall be separately mounted on breakaway pole. The sensor shall include all mounting hardware.

Quantity of non-invasive pavement temperature sensor/s and desired sensor detection location shall be provided on the Plans or by the Project Engineer.

The Contractor shall install the WMS in accordance with the WMS vendor's recommendations, CDOT plans and standard specifications and all federal, state and local codes and requirements. The Contractor will be responsible for providing all traffic control/safety work zones for the installation of the roadway sensors in accordance with the CDOT traffic control requirements.

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REVISION OF SECTION 614
WEATHER MONITORING SYSTEM
CONSTRUCTION REQUIREMENTS

WMS RPU and sensors mounting structures may include:

- WMS fold-over tower
- Variable message sign (VMS)
- Light standard metal pole
- Fiberglass pole
- Lowering device pole

Dependent on location and type of mounting structure additional mounting materials for sensors may be required to achieve accurate measurements. Contractor shall install all WMS RPU and sensors per vendor's recommendations.

For new installations the Contractor shall install a 120 VAC electrical supply from the power source shown on the plans to a location near the RPU. The Contractor shall connect the 120 VAC service to the RPU power disconnects. The primary power should be connected to the RPU with resettable overcurrent protection rated for 20 amps, with voltage surge protection. Replacement and installation of RPU and sensors at existing locations shall be powered via uninterrupted power supply (UPS) when available.

The air temperature/relative humidity sensor shall be mounted per manufacturer's recommendations at the standard meteorological height of approximately 6 feet above ground level in a UV stabilized white thermoplastic solar/wind-radiation shield.

The ultrasonic wind sensor shall be mounted per manufacturer's recommendations at the standard meteorological height of approximately 33 feet above ground level at the top of the WMS tower. The sensor shall be mounted such that birds are not able to perch or nest on the sensor. The sensor shall be configured & calibrated to function as designed with the RPU.

The non-intrusive pavement condition sensor shall be mounted per manufacturer's recommendations at a height and angle that will allow measurement of the middle of the closest lane of travel. If the WMS is greater than 25feet from the white edge line of the roadway being measured then the sensor shall be mounted on a breakaway pole installed 15 feet from the same white edge line. Conduit and pull boxes shall be installed between the WMS and pole to connect the sensor to the WMS RPU.

The non-intrusive pavement temperature sensor shall be mounted per manufacturer's recommendations at a height and angle that will allow measurement of the middle of the closest lane of travel. If the WMS is greater than 25 feet from the white edge line of the roadway being measured then the sensor shall be mounted on a breakaway pole installed 15feet from the same white edge line. Conduit and pull boxes shall be installed between the WMS and pole to connect the sensor to the WMS RPU.

Cables for all sensors shall enter through the bottom rubber flanges of the enclosure and connect to the RPU electronics.

All sensors installed on lowering device poles shall be mounted such that they don't interfere with the operation of the lowering system or device being lowered.

Any sensors installed on existing lowering device poles shall be mounted such that they don't interfere with the operation of the lowering system, devices or sensors.

The Contractor is responsible for connecting the WMS to communication infrastructure provided by the project where applicable.

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REVISION OF SECTION 614
WEATHER MONITORING SYSTEM

After completion of the equipment installation, the equipment manufacturer representative shall perform all final system checks, sensor alignments/calibration, sensor setup, RPU configuration including site communication setup, and central server configuration to provide a fully operational WMS. If Contractor requests remote configuration via VPN, contractor shall complete and submit CDOT access form four (4) weeks in advance for approval.

The existing CDOT owned WMS server utilizes the Windows Server 2003 Operating System, and will collect sensor data from all RPUs in the system, including this new site. The Colorado Transpiration Management Center (CTMC) server will poll the RPU to ask for data on a preset time interval, typically every ten minutes, or as specified by CDOT to transfer and refresh its data. CDOT users will access the WMS data via any PC running a commercial web browser which is connected to the CDOT statewide WAN.

All associated hardware required for a complete installation is considered subsidiary and is and shall be included as part of the work.

Warranty

The Contractor shall ensure that the manufacturer can warranty the product for a minimum of 1 year for all parts returned to the factory and 1 year telephone technical support at no additional charge to the Department. The technical support shall include access to a trained service representative who can respond within 24-hours to questions related to all WMS related equipment problems and maintenance issues. This one-year service shall also include an eight (8) hour training session for CDOT staff.