19.0 INTELLIGENT TRANSPORTATION SYSTEM (ITS)

This Section 19 includes the requirements for the ITS Work for the US 550/160 Connection South Design Build Project (Project). This Work shall be completed in accordance with the Contract Documents.

19.1 Administrative Requirements

The purpose of the ITS is to inform the Roadway users and to collect various data to assist agencies in the maintenance and operation of the facility. The ITS system includes Variable Message Signs (VMS), Closed Circuit Television (CCTV) Cameras, Microwave Vehicle Radar Detector (MVRD), Road Weather Information Systems (RWIS), and Fixed Automated Spray Technology (FAST) anti-icing systems. In addition, the ITS system includes the various components that make up the communications system.

The Contractor shall be responsible for the design, furnishing, and installation of all ITS devices, the communications network, and the supporting infrastructure that is necessary to maintain the existing ITS infrastructure. All ITS elements of the Project shall comply with the requirements of this Section 19. Additionally, testing and integration shall be performed by the Contractor. The Contractor shall develop a Testing and Integration plan for the communications network and ITS equipment. An example Testing and Integration Plan is included in the Reference Documents.

19.1.1. Standards

The Contractor shall design and construct the Project in accordance with the requirements of the standards in the documents listed in Table 19-1 and those referenced in Book 3. The Contractor shall use the latest adopted edition at the time of the Proposal Due Date.

Table 19-1 Standards

Author	Title
American Association of State Highway and Transportation Officials (AASHTO)	*A Policy on Geometric Design of Highways and Streets*
AASHTO	*Roadside Design Guide*
Colorado Department of Transportation (CDOT)	*Standard Specifications for Road and Bridge Construction*
CDOT	*M&S Standards*
CDOT	*Sign Design Manual*
Federal Highway Administration (FHWA)	*Manual on Uniform Traffic Control Devices*
International Organization for Standardization (ISO)	9001
International Telecommunications Union (ITU)	Telecommunications Standardization Sector – Recommendation G.652.D
NFPA 70 (NEC®)	*National Electric Code*
Rural Utilities Service (RUS)	Specification for filled fiber optic cables
Telecommunications Industry Association (TIA)	598-D Optical Fiber Cable Color Coding

The Contractor shall also follow the latest guidance and standards provided by the following industry organizations.

American Society for Testing and Materials (ASTM)

Electronic Industries Alliance (EIA)

Insulated Cable Engineers Association (ICEA)

International Electrotechnical Commission (IEC)

Institute of Electrical and Electronics Engineers (IEEE)

19.1.2. Submittals

All submittals shall be prepared, Reviewed, and submitted in accordance with the requirements set forth in Book 2, Section 3.

The Contractor shall design the ITS 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 Colorado Department of Transportation (CDOT) approval. Infrastructure locations shall meet the requirements of CDOT.

The ITS Design Documents shall show all known Utility information.

Refer to Section 19.5 for Project Special Provisions that apply to this Section 19.

19.2 Design Requirements

19.2.1. Electrical Power

The Contractor shall provide alternating current (AC) power service to every ITS device and cabinet that does not have existing metered service. This shall include 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.

The Contractor shall be responsible for the coordination of power source work to be performed by the local electrical Utility Owner. The Contractor shall coordinate with the local electrical Utility Owner to establish the metered power sources for ITS devices. The Contractor shall perform all Work necessary to maintain existing or establish new metered power sources for ITS 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.

19.2.2. Location and Protection of ITS Elements

The Contractor shall locate all ITS infrastructure elements within the public ROW such that routine maintenance, including the use of a bucket truck, shall not require a lane closure, affect traffic operations, require complex traffic control, or reduce worker safety, unless approved otherwise by CDOT. Whenever possible, ITS elements shall not be located in the highway medians.

All existing Utilities shall be identified, and all ITS 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 ensure all equipment, including but not limited to, devices, interconnect wiring, communications devices, communications lines, power supplies, antennas, operator controls, and power service is 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 design plans shall show existing and proposed underground and overhead Utilities, and drainage facilities to aid in determining and resolving conflicts during design reviews.

19.2.3. Communications System

The communications system is used to transmit data and video to and from all existing and new ITS devices.

19.2.3.1 Design Requirements

The Contractor shall install the Verizon cellular modems required for all ITS devices. The Contractor shall coordinate all ITS device locations with CDOT. The Contractor shall provide Internet Protocol (IP) Ethernet communication to all ITS devices within the Project limits.

19.2.3.2 Material Requirements

The Contractor shall furnish all components required to achieve a fully functioning communications system to transport data and video to the CTMC in Golden, CO.

19.2.4. Variable Message Sign Boards

Variable Message Sign (VMS) boards are large dynamic displays used to provide driver information regarding weather advisories, travel times, AMBER Alerts, and construction and incident notifications.

19.2.4.1 Design Requirements

All proposed VMS on the Project shall be located at a suitable Shoulder-mounted location as Approved by CDOT ITS. Access doors shall not be located above live traffic lanes. An 8-foot-wide paved maintenance access area outside of the Shoulder shall be provided in locations where ROW permits, as determined by CDOT ITS.

The Contractor shall prepare a structural design with cross-sections for each VMS Structure for CDOT Acceptance concurrent with the Final RFC Documents submittals. The Contractor shall not reuse existing VMS sign Structures for permanent VMS installations.

VMS cantilevers shall have a minimum of 18.5 feet of vertical clearance above the highest point of the Roadway and meet the current *Manual on Uniform Traffic Control Devices* (MUTCD) standards.

The existing VMS on eastbound US 160 at Milepost (MP) 87.9 shall remain in place. An additional VMS shall be installed at the following approximate location:

1. Location #1: northbound US 550 at approximate MP 15.3 (south of CR 220).

Revisions to locations may be made with CDOT Approval.

19.2.4.2 Material Requirements

The Contractor shall furnish new VMS signs and all associated equipment necessary to achieve a fully functioning system at the locations in Section 19.2.4.1. The new VMS signs shall be designed based on the following Material requirements, at a minimum:

1. Each sign shall utilize amber Light Emitting Diode (LED) displays.
2. Each sign shall be equipped with the ability to display 3 lines of text with a character height of 18 inches.
3. Each sign shall utilize a full-matrix display.
4. Each sign shall have a walk-in cabinet.
5. Each sign shall have a minimum design life of 20 years.
6. Each VMS controller and sign shall be National Transportation Communications for ITS Protocol (NTCIP) compliant, shall provide an Ethernet interface, and shall be compatible with the Colorado Transportation Management Software (CTMS).

The requirements for the support Structure shall meet the requirements in Book 2, Section 15.

19.2.5. Closed Circuit Television (CCTV)

The CCTV cameras are used to monitor 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 (https://www.cotrip.org/home.htm) and television news agencies.

19.2.5.1 Design Requirements

The Contractor shall provide a CCTV system that provides full surveillance coverage of US 550 from ¼ mile south of the southern Project limits as defined by the Contractor's Basic Configuration to the existing Wilson Gulch roundabout at US 160. The Contractor shall install a CCTV at the existing Wilson Gulch roundabout on a 50 feet lowering device pole. The Contractor shall submit to CDOT for Approval a CCTV coverage plan with the Preliminary Design Plans submittal.

CCTV camera poles shall be placed as far away from the Roadway as possible within the ROW, while still providing full surveillance camera coverage. If any CCTV camera poles are placed within the clear zone, they shall be protected in accordance with the AASHTO *Roadside Design Guide*. The Contractor shall provide cross-section drawings, pole installation details, and foundation details for each of the CCTV locations for CDOT Review with the Preliminary Documents submittal and for CDOT Approval with the Final RFC Documents submittals. See Reference Documents for required CCTV pole details.

19.2.5.2 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:

1. High-definition and Ethernet-based.

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

The CCTV cameras shall include weatherproof dome housing, steel pole, lowering device (as required), 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 40 feet in height above adjacent Roadway finished grade. All poles exceeding 40 feet in height shall have 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.

19.2.6. Microwave Vehicle Radar Detector (MVRD)

A microwave vehicle radar detector shall be installed at the proposed VMS location on US 550. MVRD shall measure both directions of traffic. MVRD shall not be in locations with auxiliary lanes.

19.2.7. Pull Boxes and Manholes

19.2.7.1 Design Requirements

The Contractor's design shall utilize fiberglass-reinforced, polymer concrete pull boxes and pre-cast concrete manholes as described in Section 19.5. The Contractor shall install a manhole at both the west end of the Project limits, MP 87.9 along US 160 and the east end of the Project limits, MP 89.0 along US 160. The Contractor shall install pull boxes at all ITS devices. The Contractor shall install a manhole at the US 550 and CR 220 intersection for a potential future traffic signal.

The Contractor shall not install pull boxes along fiber backbone. Manhole spacing along the fiber backbone shall be 1200 feet maximum.

Manhole/pull box spacing for electrical shall be a maximum of 200 feet.

19.2.7.2 Material Requirements

All pull boxes and manholes shall be consistent with the requirements outlined in Section 19.5. Communications pull boxes shall be 24 inches x 36 inches x 24 inches or larger, as required. Separate electrical pull boxes shall be 11 inches x 18 inches x 12 inches or larger.

19.2.8. ITS Device Cabinets

The Contractor's design shall utilize pole-mounted Type 2 cabinets at all ITS device locations. Cabinets are not required at VMS locations where communications equipment can be installed within the sign housing. The Contractor's design shall utilize pole-mounted Type 2 cabinets at VMS locations if additional devices are added to the VMS.

19.2.9. Cabling and Conductors

The Contractor shall design conductors and cables utilizing a minimum of #12 American Wire Gauge (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.

19.2.10. Conduit

19.2.10.1 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. All boxes at the devices shall have a spare, orange conduit installed for future fiber from the box to the pole. Conduits shall not exceed the National Electric Code (NEC) fill ratio requirements. Longitudinal conduits for the communications network shall be installed within the ROW and as close to the ROW line as practical.

The Contractor shall prepare a design to install a future ITS fiber backbone conduit system at the following locations:

Location #1: US 160 from MP 87.9 to MP 89.0 - Two 2-inch conduits (one orange and one blue).

Location #2: US 550 from ¼ mile south of the southern Project limits as defined by the Contractor's Basic Configuration to MP 16.5 - Two 2-inch conduits (one orange and one blue).

The following conduit colors shall be used so the contents can be easily identified. Any additional power conduits required by the Contractor shall be a different color than backbone or lateral conduits.

1. One orange lateral conduit for future fiber at each device to the nearest manhole

When a lateral is installed within the backbone duct bank, an additional conduit shall be installed for the lateral. The Contractor shall design all future fiber lateral paths to the backbone. One backbone splice per mile shall be designed and constructed on this Project.

1. Orange: one 2-inch for communication or future lateral.
2. Red: one 2-inch CDOT power conduit.

The existing VMS sign on US 160 eastbound, is not a CDOT VMS sign. The Contractor will not be able to use the existing conduit on the Project. The Contractor will be required to modify conduit and pullbox locations within the area where the existing US 550 and US 160 intersection is to be reconfigured per Book 2, Section 13.

19.2.10.2 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.

19.2.11. Fixed Automated Spray Technology (FAST) Anti-Icing/De-Icing

19.2.11.1 Design Requirements

The Contractor shall prepare a design to install FAST anti-icing/de-icing systems at the following locations in accordance with Book 2, Section 19, Appendix 1.

Location #1: Gulch A Bridge

Location #2: Gulch B Bridge

Location #3: proposed southern roundabout at the US 550 and US 160 interchange

Location #4: existing Wilson Gulch roundabout at the US 550 and US 160 interchange

The Contractor shall meet the submittal requirements of Book 2, Section 19, Appendix 1 as part of the RFC Documents submittals.

19.2.11.2 Material Requirements

The Contractor shall furnish new FAST anti-icing/de-icing equipment as described in Book 2, Section 19, Appendix 1.

19.3 Construction Requirements

The Contractor shall be responsible for furnishing and installing all ITS devices and the communications network. The Contractor shall submit product sheets and certifications for all ITS devices and Materials to CDOT for Acceptance prior to ordering and installation.

The Contractor shall notify CDOT upon installation or reinstallation of each ITS device and complete and submit a CDOT device data sheet to CDOT for Acceptance 4 weeks prior to device integration. The Contractor shall be responsible for the integration of all ITS devices back to the CTMC. CDOT ITS will be responsible for modifying the CTMS and NiceVision software to incorporate the new devices.

Because of the risk of obsolescence, equipment should not be purchased or ordered more than 6 months prior to the installation date of any piece of equipment without prior written Acceptance by CDOT.

A test lab shall be required for all devices that do not match CDOT current firmware at time of order.

Refer to Section 19.5 for construction requirements in addition to those described in the following Sections.

19.3.1 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.

19.3.2. Location and Protection of ITS Elements

The Contractor shall be responsible for locating all underground facilities to avoid or minimize conflicts. 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 element.

19.3.3. Communications System

The Contractor shall furnish and install Verizon cellular in all ITS equipment. The Contractor shall deliver modems to CDOT ITS in Golden for programming 1 month before installation dates.

19.3.4. Variable Message Signs (VMS)

The Contractor shall be fully responsible for delivering and installing all new VMS Structures. The Contractor shall deliver each VMS Structure to the installation sites and shall correct all damages that occur in the installation and delivery process. Each 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 communications system using cellular modems. The Contractor shall notify CDOT ITS using the "ITS Offline Device Notification Form."

19.3.5. Closed Circuit Television (CCTV)

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 communications system using cell modems.

19.3.6. Microwave Vehicle Radar Detectors (MVRD)

The Contractor shall furnish and install all MVRD-related equipment according to the Project Special Provisions in Section 19.5.

19.3.7. Pull Boxes and Manholes

The Contractor shall furnish and install all pull boxes and manholes according to the Project Special Provisions in Section 19.5. Pull boxes and manholes shall be placed above the freeboard requirements in the Roadside ditches per Book 2, Section 12, and shall not be placed in a known flood-prone area. A label shall be attached to each cable and conductor located within a pull box or manhole.

19.3.8. ITS Device Cabinets

The Contractor shall furnish and install the ITS Device Cabinets based on the Project Special Provisions in Section 19.5.

19.3.9. Cabling and Conductors

All cables shall be installed per the manufacturer requirements for each device or the Project Special Provisions in Section 19.5. The maximum conduit fill ratio for new conduits shall be in accordance with the NEC, latest version.

19.3.10. Conduit

The Contractor shall provide a trenching and boring Plan for CDOT Review 1 week prior to any trenching or boring Activities.

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 in Section 19.5 for detailed construction requirements for all conduit installations.

19.3.11. Fixed Automated Spray Technology (FAST) Anti-Icing/De-Icing

The Contractor shall furnish and install the FAST anti-icing/de-icing system in accordance with Book 2, Section 19, Appendix 1.

19.3.12. Testing and Integration

The Contractor shall develop and submit to CDOT five weeks prior to testing and integration, a Testing and Integration plan for Acceptance, an example of which is included in the Reference Documents, and a Network Testing Plan for Approval.

Testing and Integration shall be performed on the communications network and for all new devices, reset devices, and existing devices. Testing shall demonstrate the network and all devices operate per the manufacturer's specifications, as well as any additional requirements outlined in Section 19 and in the Project Special Provisions in Section 19.5.

19.3.13. Maintenance Period

The Contractor shall maintain the CDOT equipment and communications infrastructure the Contractor installs for a period of 1 year after Project Final Acceptance. CDOT ITS will pay the power and cellular bills after Project Final Acceptance.

For the duration of the 1-year maintenance period, the Contractor shall appoint a contact who is qualified in installing, maintaining, troubleshooting, and repairing the ITS equipment and communications infrastructure. That person's credentials shall be submitted to CDOT for Approval 4 weeks prior to the start of the maintenance period.

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. All backbone communication failures shall be repaired and restored within 4 hours of CDOT notifying the Contractor of the problem. The Contractor shall furnish all devices, Equipment, and Materials necessary to complete the repairs. If the ITS 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 the Retainage owed to the Contractor.

19.3.14. 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, manuals, and documentation for all ITS equipment for CDOT Acceptance prior to Final Acceptance.

19.4 Deliverables

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

Table 19-2 Deliverables

Deliverable	Review, Acceptance, or Approval	Schedule
Structural design for VMS Structures	Acceptance	Prior to the RFC Documents submittals
CCTV Coverage Plan	Approval	With the Preliminary Design Plans submittal
Cross-sections, pole installation details, and foundation details for CCTV locations	Review/ Approval	Concurrent with Preliminary Design Plans / Concurrent with the Pre-RFC Documents and Final RFC Documents submittals
Product sheets and certifications for all ITS devices and Materials	Acceptance	Prior to ordering and installation
CDOT device data sheet	Acceptance	4 weeks prior to device integration
Trenching and Boring Plan	Review	1 week prior to any trenching or boring Activities
Testing and Integration Plan	Acceptance	5 weeks prior to testing and integration
Network Testing Plan	Approval	5 weeks prior to testing and integration
Maintenance period contact's credentials	Approval	4 weeks prior to start of maintenance period
ITS equipment instructions, training, manuals, and documentation	Acceptance	Prior to Final Acceptance

19.5 Project Special Provisions

The CDOT 2017 *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 604 – Manhole (Traffic Management System)
Revision of Section 612 – Location Markers
Revision of Section 613 – Electrical Conductor Identification
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 613 – Service Meter Cabinet
Revision of Section 614 – Breakaway Tapered ITS Steel Pole

Revision of Section 614 – Closed Circuit Television
Revision of Section 614 – Closed Circuit Television Pole with Lowering Device
Revision of Section 614 – Communications Cabinet (Type 2)
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 (Non-334)
Revision of Section 614 – Variable Message Sign (LED) (Overhead)

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 CDOT.

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 CDOT) 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 CDOT) background. The Contractor shall provide the label submittal to CDOT.

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 CDOT) 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 CDOT) background. The Contractor shall provide the label submittal to CDOT 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 CONDUCTOR IDENTIFICATION

Section 613 of the Standard Specifications is hereby revised for this project as follows:

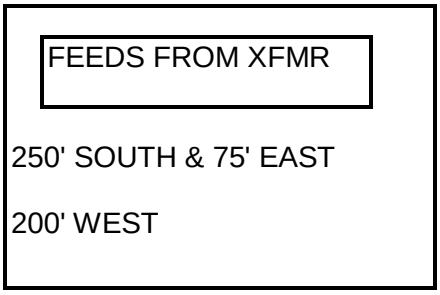
Section 613.08 shall include the following:

All electrical conductors shall be tagged as follows:

Electrical conductor cable tags shall be located below the termination in the base of the street light, in the pull box, in the pedestal and at the point of termination to existing facilities of the Local Utility Company supplying electrical service. The tags shall be attached with a cable tie. The information written on the tag shall include the direction and approximate length of cable feeds running from where to, etc.

Each incoming conductor shall be individually color coded with 1 tape mark, while outgoing conductors shall have 2 tape marks.

Example:



Uniform tags are available in a Tag Kit. The Tag Kit consists of: 100 tags, 3 part yellow with 1 hole, 100 black nylon ties and 1 black sharpie pen.

Size	2-1/2" X 5"
Standard Package	Kit
Weight, Kit, Approx.	1.5 Pounds
Color	Yellow

Electrical conductor tagging will not be paid for separately, but shall be included in the cost of the Electrical Conduit and all associated equipment installation.

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 CDOT 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 CDOT 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 CDOT 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 CDOT 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.

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 CDOT.

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 CDOT 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 CDOT 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 COMM” 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.

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 CDOT.

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 CDOT. Surface mounted pull boxes shall be attached using 3/8-inch epoxy anchors or other methods approved by CDOT. 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 613
SERVICE METER CABINET

Section 613 of the Standard Specifications is hereby revised for this project as follows:

Subsection 613.01 shall include the following:

This work consists of the installation of a Service Meter Cabinet including the preformed polymer concrete footing, meter cabinet, mounting hardware, Cabinet mounting base, power cables, UV-resistant cables and connection to the power source and all required wires and wiring to facilitate a fully functioning service meter Cabinet at locations as shown on the plans.

Add subsection 613.09 (a) as follows:

(a) Service Meter Cabinet

The Service Meter Cabinet shall be NEMA 3R and shall be UL 508 listed as industrial control panel service equipment. It shall have the ability to be padlocked at the location shown on the Service Meter Cabinet detail.

Utility metering compartment shall be protected with a hinged, pad lockable hood.

Service conductor terminations shall be accessible by a removable cover.

The Service Meter main shall be 100 amp minimum, with voltage range of

120V – 480V.

The Service Meter Cabinet shall be compatible with both ringless and ring-type meter sockets, and with 4-7 terminals.

Exterior of the Service Meter Cabinet shall be a gray powder-coated aluminum, with a thickness of 0.125 inches which is rain and dust impermeable and electrically welded and reinforced where required.

The Service Meter Cabinet shall have a swing dead front door compartment with distribution and control equipment that is secured with both a latch and a pad lockable draw latch outer door.

All nuts, bolts, screws and hinges shall be stainless steel and not visible from outside the meter Cabinet.

Service Meter Cabinet and polymer concrete foundation shall have a divider to separate the service and load conduits/ conductors.

The Service Meter Cabinet shall provide accommodation for four, single branch circuit breakers at a minimum, not including the main breaker. Circuit breakers shall be cable-in, cable-out with line on top, and load on bottom. Handle position shall be up = ON, down = OFF.

The polymer concrete foundation shall have 1/2 inch-13 unified course (UNC) through bolt inserts for mounting the Service Meter Cabinet.

The polymer foundation shall pass the most recent addition of the ANSI/SCTE 77 6.0, 6.1, 6.2, 6.3, 6.4 & 6.5 environmental test, including a five percent solution of magnesium chloride.

The divider plate between the service conduit and load conduit shall be full depth of foundation and be made of preformed polymer concrete.

All materials furnished, assembled, fabricated or installed shall be new, corrosion resistant and in strict accordance with the details shown on the Service Meter Cabinet detail and in these Technical Specifications.

Functional Characteristics:

The Service Meter Cabinet shall provide a viewing window in which the meter shall be readable while providing a vandalism resistant enclosure. Viewing window shall be comprised of bullet resistant polycarbonate resin thermoplastic.

Physical Characteristics:

Refer to the Service Meter Cabinet detail for specific dimensions and tolerances.

CONSTRUCTION REQUIREMENTS

Add Subsection 613.03(a), Service Meter Cabinet:

The Contractor shall go through the Colorado State Electrically Board to acquire the electrical installation permit prior to the installation of the meter Cabinet equipment for all CDOT owned and maintained traffic signal and lightning.

Installation shall conform to the latest edition of the National Electrical Code (NEC) and the Authority Having Jurisdiction.

The Service Meter Cabinet foundation shall be polymer concrete with fiberglass reinforcement. The pad shall be continuous cloth reinforcement on the inside and outside perimeters.

The Service Meter Cabinet shall be factory wired and inspected by CDOT prior to installation.

Construction methods shall conform to the requirements of Section 614.10 (c), Section 614.10 (d) and Section 614.10 (j).

The Contractor shall certify the records of the testing including grounding, voltage drop (within 3 percent) and other required tests as meeting specification requirements and submit the records to CDOT.

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, Luminaires 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 CDOT.

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:

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.

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.

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.

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.

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.

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.

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.

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)
- 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.

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.

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.

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 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 CDOT. 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 CDOT. 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 CDOT. 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.

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 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.

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 CDOT upon project completion. The lowering tool shall have a reduction gear to 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.

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.

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.

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"*.

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 NFPA 70 (NEC), unless otherwise specified by CDOT.

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 requirement

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 CDOT'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 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.

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 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.

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
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 CDOT 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 feet:

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

Example – Latitude _____ Longitude _____ Altitude (ft) _____

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

Example – X (easting) _____ Y (northing) _____ Z (ft) _____

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 CDOT.

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.

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.

Applicable Documents: Work performed in this section shall comply with the most current edition of the following codes and standards:

L. IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System,

M. IEEE C2 – National Electrical Safety Code,

N. NEMA GR 1 – Grounding Rod Electrodes and Grounding Rod Electrode Couplings,

O. NFPA 70 – National Electrical Code,

P. NFPA 70E – Standard for Electrical Safety in the Workplace,

Q. NFPA 780 – Standard for the Installation of Lightning Protection Systems,

R. TIA-607 – Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises,

S. UL 96 – Lightning Protection Components,

T. UL 96A – Installation Requirements for Lightning Protection Systems, and

U. UL 467 – Grounding and Bonding Equipment.

Identify to CDOT any conflicts between the requirements of codes/standards development organizations and the specifications for this project.

Submittals:

V. Provide cut-sheets of each type of product proposed for approval by CDOT prior to commencement of work.

W. 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.

    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 CDOT 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 CDOT. 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 CDOT. 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.

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 CDOT 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, CDOT, at their 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 CDOT 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.

D. 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.

E. 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 CDOT 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 CDOT.

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 CDOT. Instructions for Form 1411 are included in this special provision.

The Contractor shall request from CDOT 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 CDOT. 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.

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

The following instructions are provided for information to the Contractor. The Contractor shall direct all questions regarding form 1411 to CDOT.

1. Contractor's Engineer / Installer / Contact # / Installation Date

Fill in the name (first, last) of the Contractor's 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 CDOT, 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.

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 CDOT, 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 CDOT. 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.

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:					

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

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).

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 CDOT. 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:

Sensor Settings

A. General tab

Subnet/ID=000/Sensor ID per Plans

Location= HWY Installed Direction Mile Post and Common Name

Orientation = Direction the unit is pointing

Date& Time = Synchronize to this computer

B. Ports tab

Comm: RS-232

Baud Rate=9600 bits per second

C. Outputs tab

Legacy Protocols

a. SS105 Protocol = Off
b. RTMS protocol = Off

Lane Setup

D. Sensor Alignment: Shall show green, unless detected lanes are not parallel.

E. Lane configuration = Setup using auto-configuration and manually adjust as necessary to detect lanes

Data Setup and Collection

F. Interval Data: Interval=30 seconds

G. 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
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.

The sign shall be 18’ 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 CDOT for review and approval:

A. 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.

B. 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.

C. 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.

D. 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.

E. Certification that the LEDs were tested and binned in accordance with the CIE Test Method A.

F. Documentation and information on software as described in Appendix A of this document.

G. Documentation verifying the VMS is listed by an accredited 3rd party testing organization for conformance to UL48 and UL 1433.

H. All workmanship shall comply with IPC-A-610C, Class 2 titled "Acceptability of Electronic Assemblies"

I. Documentation providing proof printed circuit board (PCB) silicon conformal coating conformance to MIL-I-46058C Type SR and IPC-CC-830.

J. 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).

K. Documentation that the VMS conforms to the Transient Protection and Vibration of the NEMA Standard TS4, Section 2.

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.

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:

A. Positive pressure (exhaust fans are not acceptable).

B. 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.

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.

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.

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:

A. NTCIP compliant VMS controller,

B. Fold-down laptop shelf and document holder for maintaining sign,

C. Hardened communication device,

D. Display system interface circuits,

E. Local/remote control switch,

F. Sign to ground voice communication RJ-11 jack,

G. USB plug-in connection or a serial connection with a USB converter cable for the controller interface,

H. RS-232 cable (a minimum of 4 feet long to connect the controller interface to a laptop computer), and

I. 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 CDOT. This typically will be on the sign support structure pole furthest from traffic.

The controller interface cabinet shall contain the following assemblies:

A. Power-on indicator,

B. Waterproof local/remote switch,

C. Local control LED indicator,

D. RS-232cable a minimum of 4 feet long to connect the controller interface to a laptop computer,

E. 120 VAC GFI outlet, and

F. For dialup installations, an RJ-11 jack for connecting the dialup phone line shall be installed with in-line surge protection.

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 thermomagnetic 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.

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.

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.

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:

A. Pixel operational status that includes every string of every pixel,
B. Sign and ambient temperature,
C. DC power supply status,
D. 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,
E. Cooling fan status,
F. Access door alarm,
G. Communication failure log,
H. UPS status, and
I. AC surge protector status.

The controller software shall be capable of displaying the following types of messages:

A. Static messages capable of displaying any character or set of characters,
B. Full Graphic capabilities,
C. 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
D. 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.

Uninterruptable Power Supply (UPS):

The UPS system shall provide “On-Line” dual conversion control. The UPS shall be rated per the following:

A. Input Voltage: 85 VAC to 135 VAC

B. Input Frequency: 48 to 62 Hz

C. Output Voltage:120 VAC plus or minus 3 percent

D. Output Frequency: 60 Hz

E. 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°C to +40°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.

The UPS shall consist of two major components, the Electronics Module and the Battery System.

A. 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

B. 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:

A. Loss of Utility Power

B. Inverter Failure

C. 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.

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 of 100 walk-in LED VMSs. These 100 VMS shall be from 5 separate projects and operational for a minimum of 5 years.

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 CDOT.

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 CDOT. 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.

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 1, 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):

- 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 DYNAMIC MESSAGE SIGN (LED) (OVERHEAD):

- 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

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):

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 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
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:

- 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.
- 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.

SECTION 19, APPENDIX 1 - FIXED AUTOMATED SPRAY TECHNOLOGY (FAST) ANTI-ICING/DE-ICING

General Description

The Project requires a fixed automated spray technology (FAST) anti-icing/de-icing system. This provision provides for the design, installation, testing and commissioning of a FAST system or systems for the Bridges over Gulch A and Gulch B, the proposed US 550 south roundabout, and the existing roundabout at Wilson Gulch. The system shall be designed to independently operate six anti-icing/de-icing zones (existing Wilson Gulch roundabout, US 550 South roundabout, Gulch A Northbound, Gulch A Southbound, Gulch B Northbound, and Gulch B Southbound). The system shall also be designed and capable of adding up to four more anti-icing/de-icing zones in the future for ramps A, B, and C as well as the main US 550 Bridge.

Design Considerations

The design, construction, and installation of FAST Systems require specific professional design skills. At a minimum the following the following technical requirements shall be included in the design of the FAST:

- Architectural design
- Structural design
- Electrical design
- Mechanical design
- Environmental compliance
- Non-invasive Surface instrumentation
- Lighting design (Building exterior and interior)
- HVAC

The Contractor shall be responsible for all components of the system including but not limited to anti-icing/de-icing system hardware and components, conduit, storage tanks, pump house design and construction, plumbing, electrical wiring and connections, AC power source and connections and DSL/Internet communication and connections for a fully operational state of the art FAST System. The Contractor shall provide at least three examples of prior installations they have completed along with contact references for each of those projects for CDOT to be able to reach and discuss their capabilities.

The Contractor shall provide the layout, design and construction of the FAST for the Project. The FAST shall be a permanent system that automatically prevents the build-up of snow and ice on the Bridges and roundabouts by dispensing liquid anti-icing/de-icing chemicals at the appropriate times based upon roadway and environmental conditions. Once activated, the system shall dispense anti-icing/de-icing chemical by pumping the fluid through a sequence of valve-controlled nozzles at the locations designed by the Contractor. The nozzles shall be located to ensure uniform and adequate coverage of the specified area (typically 2 travel lanes wide) through direct application from the nozzles and associated vehicle tracking of the liquid. The nozzles shall be located within the median cover, truck apron, shoulders or median barrier. No system components shall be located more than 2 feet behind the edge of the traveled lane unless it is located behind a curb or in a median barrier. The center of the roundabout shall be left open for landscaping. The system shall be designed to automatically dispense liquid anti-icing/de-icing chemicals when non-invasive Road surface sensors detect that the roadway is losing friction and roadway surface temperatures correspond to freezing conditions. The system shall dispense/fire the nozzles at predetermined yet adjustable intervals until the friction sensors indicate that surface friction has been restored. The system shall spray anti-icing/de-icing chemicals only during weather condition triggers and/or when manually activated by CDOT Maintenance personnel. The anti-icing/de-icing cycle

shall be initiated automatically based on information provided by the non-invasive Road surface sensor units. It is anticipated that one non-invasive Road surface sensor will be needed for each of the six anti-icing/de-icing system zones. A programmable logic controller that can manage up to ten zones shall be required to activate the pump and operate the actuated valves in each zone independently to dispense anti-icing/de-icing liquid in a sequence to produce the appropriate coverage that allows automatic treatment of the specified Bridges and roundabout lanes.

The purpose of the system is to deliver anti-icing/de-icing liquid to the Roadway under a specified set of conditions. When those conditions are met, the system must be capable of activating automatically. Upon activation, a remote processing unit (RPU) controller opens valves in an automated sequence to spray the anti-icing/de-icing liquid over the targeted area. This sequence is termed the anti-icing/de-icing cycle. The anti-icing/de-icing cycle shall be initiated automatically, requiring no human activation, based on information provided by a non-invasive Road surface sensor above the Roadway or Bridge deck for each zone independently. The anti-icing/de-icing cycle shall also be capable of initiation by remote Internet or Computer activation offsite controlled by username and password authentication and limited to only those given security clearance by the system owner, or by manual activation directly from the anti-icing/deicing station on site (pump house). The system shall be capable of dispensing varying quantities of liquid anti-icing/de-icing agent in variable spray sequences depending on road surface conditions at the site, for example, black ice, snow, or freezing rain.

FAST Components

By definition, anti-icing/de-icing systems operate in a harsh winter environment and have long periods of inactivity and must still be in a condition of readiness to meet mission critical demands. Therefore, the Materials, components and control circuitry must meet stringent specifications and performance standards. The following criteria shall be used to establish the minimum acceptable standards and each criterion shall be met.

Pump House

The Contractor shall design and erect a pre-cast concrete or cast-in-place, pump house building or buildings to house the chemical pumps, chemicals storage tanks, process logic controller and electrical systems including the anti-icing/de-icing. The slab and foundation for the building shall be reinforced cast-in-place concrete. The contractor and the manufacturer shall develop a FAST system that considers the locations of each of the individual anti-icing/de-icing facility location while also considering the land topography, zone locations, and tanker and maintenance equipment and accessibility to the pump house. The Contractor shall also determine how many anti-icing/deicing-facilities are needed to appropriately operation the six zones of the FAST. Ideally one pump house located near the proposed US 550 South roundabout should be considered and if a second pump house is determined to be needed this may be best suited near the existing Wilson Gulch roundabout. These are suggested locations for consideration. All pump house locations shall provide adequate access for delivery and service trucks to be outside the travel lanes and shall be Approved by the Owner/CDOT.

Walls and roof shall be insulated to a minimum rating of R-8. All reinforcing steel in the structural walls, floors and ceilings shall be epoxy-coated in accordance with Section 602 of the Standard Specifications. The walls and ceilings shall be designed and constructed in a manner that will prevent any moisture or rodents from entering the building along the roof, floors or walls. The building shall have adequate ventilation to prevent any buildup of toxic or flammable gases and adequate heating to prevent freezing of water in piping. The roof shall be capable of withstanding vertical snow loading of 60 pounds per square foot or as required by the International Building Code (IBC), and the Structure shall be capable of withstanding 100 mph wind loading or as required by IBC.

The dimension of the pump house shall be sized based upon the space requirements needed to house the required equipment for the FAST including the liquid storage tanks. The storage tanks shall be sized as described in the storage section of this specification. The floor of the pump house shall be a reinforced concrete slab on grade and perfectly level where it supports the bases of the tanks, and sloping to a sump. The slab shall be designed and constructed to support the liquid weight of the filled chemical tanks. The cast-in-place floor design shall serve as a secondary containment area and shall incorporate a chemical resistant liner, to prevent leakage of chemical outside the Structure. This secondary containment area shall be sized to accommodate 100% of the designed storage tank capacity. All construction joints shall utilize waterstop in accordance with CDOT Standard Specifications or as Approved by CDOT. All precast joints shall be caulked using a Type A Silicone Sealant or equal approved by CDOT.

Aesthetics are a key part of the Project including the pump house and any above grade facilities required for the FAST. CDOT shall Approve each component of the FAST design for compliance with aesthetic requirements. Design of the aesthetics shall be the responsibility of the Contractor but shall generally fit the aesthetics of the corridor.

Precast panel units shall be securely fastened together with Type 304 stainless steel brackets with a minimum thickness of ¼ inch. All threaded fasteners shall be ½ inch minimum diameter Type 304 stainless steel bolts. Cast-in threaded anchors used for panel connections shall be compatible with stainless steel bolts, and shall be directly connected to panel forms before casting. No floating in of connection inserts is permitted.

Piping supports shall be installed to support the interior piping and valves as Approved by CDOT. Galvanized materials shall not be allowed. All exterior underground piping, shall be sized appropriately to house pressure piping, shall be schedule 80 PVC or fusible HDPE. Schedule 80 PVC shall be used in the pump house when allowed by pressure requirements identified in the pressure piping section. If schedule 80 PVC is used, all fittings shall be primed and solvent welded. Wall penetrations shall be as required for system operations and as described in the anti-icing/de-icing Chemical Storage section.

The exterior treatment of the pump house shall closely match the existing Grandview interchange aesthetics and shall be per the requirements of Book 2, Section 15.
A ventilation fan shall be provided as required by the design. The ventilation fan shall consist of an electric motor driven propeller fan with an automated actuated louver on the exterior wall of the building. The fan motor shall have an automated shut off timer and be suitable for variable speed operation. The propeller fan shall be provided with a wire guard located on the motor side. The propeller fan shall have a minimum capacity as required to meet the Structure design code and shall be fabricated from durable non-corrosive materials.

Doors, louvers, frames and transoms shall be made of steel or Approved equal and suited for exterior exposure. Anchors and hardware shall be Type 304 stainless steel. Doors, louvers, frames and all accessories and hardware shall be obtained from a single source and by a single manufacturer. Entry to the pump house shall be designed with double steel doors the use of roll up doors will not be allowed. The double steel doors shall be of heavy-duty industrial grade construction Doors and frames shall be shop primed gray and painted to match the Project Aesthetics. Doors shall have a smooth gloss surface with a minimum value of 88 in accordance with ASTM D 523 – “Standard Test Method for Specular Gloss”. The doors shall have an opening of adequate size to service and/or replace any equipment or storage tanks required for system operation. The double doors shall provide a minimum 6’ width opening. A center mullion/stile for the doors will not be allowed. Door frames and transoms shall conform to Steel Door Institute (SDI) specifications and shall be comparable in size and strength to 16 gauge hollow metal door frame. Frame profile shall be an industry standard 5-3/4 inch deep with 2 inch wide face, double rabbeted with 5/8 inch high stop or as approved by CDOT. Header to jamb joints shall be miter cut and assembled with stainless steel fasters. Frame and transom finish and color shall match doors and color

shall be consistent throughout the entire frame thickness. Frames shall be one-piece upon assembly and shall be rigid in construction.

Thresholds shall be standard saddle-type design 5 ½ inch wide by ½ inch high, made from pultruded glass fiber reinforced polymer resin, with anti-slip grooves in the top surface. Thresholds shall be secured with stainless steel anchors.

Weather stripping, sweeps and astragals shall be provided by the door manufacturer, and shall have an aluminum mill finish with neoprene seals.

Door hinges shall be stainless steel full mortise, ball bearing type with 4 ½ by 4 ½ inch template, applied with stainless steel fasteners. Closers shall be for severe service application. Kick plates shall be 18 gauge stainless steel with a brushed finish and beveled edges. Locksets and latchsets shall be heavy-duty stainless steel ball type, grade 1 severe service. Exit device shall be stainless steel RIM 19-R series with keyed dogging device to keep the latch bolt retracted when engaged. The doors shall be provided with a flush bolt for securing one of the double doors. The doors shall be supplied with cored locks. Hardware shall be furnished by the door manufacturer. Manufacturer's installation instructions shall be enclosed with hardware in the original box. The Contractor is ultimately responsible for proper installation of all hardware once received on the job site.

Install door opening assemblies in accordance with approved shop drawings, SDI-100 – "Recommended Specifications for Steel Doors and Frames", and manufacturer's printed installation instructions. Maintain plum and level tolerances specified in manufacturer's printed installation instructions. Adjust doors to swing open and shut without binding, and to remain in place at any angle without being moved by gravitational influence. Adjust door hardware to operate correctly. Clean surfaces of door opening assemblies and sight-exposed door hardware in accordance with manufacturer's maintenance instructions. Protect door opening assemblies and door hardware from damage by subsequent construction activities until final inspection.

Stair framing shall be fabricated from pultruded glass fiber reinforced polyester resin structural shapes. Stair treads shall be molded glass fiber reinforced polyester resin grating. Stair tread shall be capable of supporting a 300 lb concentrated load at midspan with no more than ¼ inch deflection. Resin shall be vinyl ester for chemical resistance. Color shall be safety yellow. Threaded fasteners shall be stainless steel bolts or expansion anchors.

A sump with a permanent sump pump and piping shall be provided from the sump to an exterior discharge. The sump pump shall be manually controlled with a switch located in a locking weatherproof NEMA box on the exterior of the building, and shall be operable when the vault is completely submerged. The minimum requirements for the pump shall be a corrosion resistant stainless steel pump with a minimum flow of 18 gpm with 20 feet of head. A check valve shall be located in the discharge line above the pump. The discharge pipe shall have a 3 inch brass cam and groove male end adapter, dust cap and retainer chain. The sump diameter shall be sized for the pump used.

Internal pump house lighting shall be provided with a minimum illumination of 10 foot-candles (108 Lux) or in accordance with OSHA Regulations for mechanical rooms whichever is greater. All fixtures required to provide the minimum lighting shall be UL listed, LED lights, with safety covers. Exterior lighting shall be provided on the pump house to illuminate the entry ways and work areas with a minimum illumination of 5 foot-candles (54 Lux). All exterior lighting shall be LED lights that are dark skies compliant with an uplight rating of zero (0) and shall have a vandal proof safety cover.

Additional exterior lights with amber, red and blue globes shall be supplied for indication of:

1. Pump operation (system active) (amber)

2. When a liquid within the pump house reaches an elevation one (1) foot above the floor of the pump house (red)
3. Low anti-icing/de-icing liquid level (blue)

These exterior lights shall be mounted in a position to be easily visible from the main highway (500 feet minimum) and shall have safety covers.

The exterior of the pump house to be buried shall be sprayed with waterproofing in accordance with the manufactures specifications before backfilling operations. Protect above ground portions from overspray if any overspray occurs it shall be cleaned and removed prior to applying structural concrete coating.

The Pump house site shall be entirely fenced with an 8' high chain link fence per the CDOT Standard Plan M-607-2 and shall have a brown vinyl coating and shall be submitted according to Book 2, Section 15. A minimum 12' wide access gate shall be provided at the front of the pump house. A 10 foot wide access Road to the building and vehicle parking area shall be provided with a minimum of a 6 inch Class 6 Aggregate Base Course and 3 inches of HMA surface. This access shall be capable of allowing a tanker delivery truck (WB-50) to be navigated so that it can renter the highway in a forwards driving direction (not backing onto the Roadway).

The Contractor shall provide to CDOT for Review, design plans for the pump house that are sealed by a Colorado Licensed Professional Engineer. Plans for the architectural, structural, mechanical, HVAC, electrical, geotechnical and civil aspects of the pump house shall be sealed by a Colorado Professional Engineer Licensed in that discipline. This plan set shall also include a site plan and elevation for the location of the pump house. The access Road shall also include a plan and profile to the pump house from the adjacent Roadway. These submittals shall follow the requirements of Book 2, Section 3. Shop drawings shall show equipment locations on a floor plan and views using isometric views.

The Contractor shall be responsible for any additional foundation investigation and foundation design for the pump house. A Colorado Registered Professional Engineer shall Approve the foundation investigation and design.

Power

All electrical and power requirements shall be designed, stamped and verified by a qualified electrical Engineer licensed in the State of Colorado. An above ground lockable Exterior NEMA weatherproof box shall be provided with labeled switches for lights, sump pump, system override and shutoff of all electrical power. The contractor shall assure consistent, non-interrupted power for the anti-icing/de-icing system. A single phase metered electrical service as required by system operation shall be installed by the contractor to a locking breaker box outside the pump house for powering the FAST system, up to 150% of actual load. The contractor must supply and install a circuit breaker panel and wire all equipment including, but not limited to the 220 volt 60 Hz pump motor ventilation fans in accordance with the NEC. In addition to system requirements, power to support lighting and operation of 120 volt power tools shall be provided. Installation of electrical components for the pump house and anti-icing/de-icing system shall be in accordance with the requirements of the National Electrical Code including clearances. A generator connection plug with a manual transfer switch shall be provided to back up at a minimum the FAST system, ventilation system, lighting and communications. The Contractor shall provide electrical power from the nearest available source as approved by CDOT utilizing underground lines. The Contractor shall be responsible for coordinating with the local electrical utility in order to make all electrical connections between the FAST system facility and the electrical source. An uninterrupted power supply (UPS) shall be provided and shall be sized to run the Communications Systems for a minimum of 8 hours.

Communications

Internet service shall be provided with a minimum of a 12Mbps download speed. The Contractor shall provide the service from the nearest available source as approved by CDOT. The Contractor shall be responsible for coordinating with the local communication utility in order to make all connections between the FAST and the internet service.

Instrumentation

Instrumentation in the pump house/vault shall include but not be limited to:

- Pressure Gauges: Analog type, liquid filled, industrial grade, all Type 316 stainless steel, minimum pressure range = 0 to 290.08 psi.

- Flowmeter Transmitter: senses flow rate in system and sends signal to RPU spray system controller. Flowmeter shall be fabricated from durable non-corrosive materials. All metallic parts shall be Type 316 stainless steel. Minimum flow rate range = 0.98 to 19.7 feet per second.

- Pressure Switch Transducer: senses pressure in system and sends signal to RPU spray system controller. All metallic parts shall be Type 316 stainless steel. Pressure range = 0 to 290.08 psi.

- Ultrasonic Level Sensor or Bubbler/Air Pressure Sensor: device to detect the level of chemical in the storage tanks. The level sensor shall be connected to an alarm horn mounted on the exterior of the pump house to alert personnel filling the tanks when the tanks are full. The level sensor shall also send signals to a digital level display located in the housing for the chemical fill tube on the exterior of the pump house as well as to the remote sensing location.

Additional instrumentation shall be added, as required, for additional specialized equipment as shown on the plan sheets and Approved by CDOT.

Anti-icing/de-icing Chemical Storage

Storage tanks for the anti-icing/de-icing chemical shall be cylindrical tanks of sufficient size and quantity to accommodate a minimum of 50 system activations per zone, at a rate of 40 gallons per lane mile. Storage tanks shall be sized to fit through the designed door entries. Each tank shall have an entry port through the top with a minimum dimension of 1.3 feet and with a removable cover. The tank shall be vented at the top. Vent openings shall be covered with type 304 stainless steel wire cloth with mesh opening size 0.5 inch by 0.6 inch, using 0.009 inch diameter wire. The tank shall be rated for a maximum fluid specific gravity of 1.5 or greater and shall be made from an approved polymer or glass fiber-reinforced epoxy material. Any metal components of the tank shall be Type 316 stainless steel. Galvanized steel shall not be permitted.

A fill pipe through the wall shall be supplied with a 3 inch brass cam and groove male end with dust cap and retainer. The size shall be shown in the design and Accepted in accordance with Book 2, Section 3.

Either a locking dust cap or a locking cover mechanism shall be provided to secure the fill pipe from vandalism. All fill piping on the exterior of the pump house and through the wall shall be extra strong red brass. The Piping system shall function as shown in the design. In addition to the exterior connection, a connection on the interior of the pump house shall also be provided with similar requirements. A strainer/filter shall be included in the fill piping as well as an approved venting mechanism. The strainer screen shall be non-corrosive and compatible with the anti-icing/de-icing chemical with a mesh size of 1/8 inch and shall be easily accessible for cleaning and/or replacement. One spare screen and gasket shall be supplied. All fill piping valves shall be PVC True Union type valves. Tanks shall be prevented from flotation or movement due to vault flooding. The system shall be designed to prevent siphoning or gravity draining of the storage tanks in the event of pump or valve failure if the storage system is located above the spray discharge system.

System Supply Pump

The Contractor shall provide a pump or pumps of appropriate size to assure proper operation of the designed system zones (Gulch A Bridge Southbound, Gulch A Bridge Northbound, Gulch B Bridge Southbound, Gulch B Bridge Northbound, Proposed US 550 South roundabout, and existing Wilson Gulch roundabout). The pump or pumps shall have adequate pumping capacity to operate all supported zones and shall be able to be activated individually or simultaneously. The pump and housing shall be type 316 stainless steel with seals and bearings appropriate for exposure to chloride-based chemicals, magnesium chloride, potassium acetate, calcium magnesium acetate or CMA, CMA with potassium or CMAK, and other anti-icing/de-icing chemicals. Electric motor to be single phase 220 volt 60 Hz and appropriate for the system design and use in corrosive environments. Pump shall be capable of refilling any individual accumulator, if applicable, within the finished system within 10 seconds. The pump shall be located three (3) feet above the floor and supported on structural FRP (Fiber-Reinforced Plastic) supports. Wall and Pump connections to the FPR support and the FRP supports themselves shall be designed for static and dynamic loading. Wall support is preferred. The pump shall be self-priming or compatible with storage tank elevations to ensure effective operation. Valves and piping shall be supplied for initial pump priming as required. A pressure relief valve shall be attached to the pump discharge with an over-pressure line routed back to the storage tanks. All pump designs and specifications used on this project shall be submitted to and Approved in accordance with Book 2, Section 3.

Valve Units

Valve units shall control the flow of anti-icing/de-icing chemical from the main supply line or accumulator to each spray nozzle. Valve units shall consist of controlled motor driven ball valves and electronic control cards or system. Solenoid valves shall not be allowed. Valves and control cards/system shall operate on a 24-volt system. Each control card/system shall have the capability to independently control the operation of multiple valves through a signal cable. The control cards/system shall allow each valve to be remotely activated using different spray programs from the controller. Each control card/system shall be addressable allowing individual control. The control cards/system shall have remote fault testing.

Valve Boxes

All valves shall be installed in NEMA 3R compliant electrical enclosures that are pre-cast polymer concrete, stainless steel, or composite plastic and firmly attached in the deck, curb, or bridge barrier as approved by CDOT. Valve boxes shall be recessed ¼ inch to ½ inch below the top of the pavement or deck. Four extra valves shall be supplied for each Bridge and roundabout installation. For each line, the valve box located furthest from the pump shall contain an accessible valve to purge the line with clean water at the end of the season, or when switching chemicals. Purge valves shall also be located at low points in the system as necessary for purging of the system.

Valve/Sensor Control Cable

Shielded cable shall be used for all valve and pavement sensor systems.

Nozzles

Puck (roundabout) and bridge barrier mounted nozzles shall be the only type of nozzles used on this project. The nozzles and feeds shall be built into the bridge barrier during the barrier construction. All nozzles (puck and barrier) shall be removable for cleaning or replacement without the need for removing the entire nozzle assembly and shall be capable of withstanding high-volume interstate traffic and snow plowing activities conducted with tandem wheeled maintenance trucks. The nozzle assemblies shall be designed appropriately to provide spray coverage over all the driving lanes. Nozzles shall be adjustable for cross slopes or super elevation of the Roadway as required. Bridge nozzles shall be located in the

bridge barrier so as to not be affected by traffic wear and plowing operations. Puck type nozzles shall be located outside the traveled lanes in the paved shoulder areas or as recommended by the manufacturer and approved by CDOT. Puck nozzles shall not be located on any stripe lines. Puck type nozzle assemblies shall be recessed 1/8 inch to ¼ inch from the top of pavement or as recommended by the manufacturer. The overall thickness of puck type nozzles shall not exceed 2 ¾ inches in order to be installed in a 3 inch thick asphalt mat. Bridge barrier nozzle assemblies shall be recessed 1/8 inch to ¼ inch from the vertical surface of the concrete bridge barrier and approximately 8 inches to 10 inches above the Roadway surface or as recommended by the manufacturer and approved by CDOT. The spray nozzle shall be durable (UV proof under direct sunlight, weather proof, and traffic rated), flush mounted to the assembly, and non-mechanical. All metallic components of the spray nozzle shall be type 316 stainless steel. Spray nozzles and assemblies shall be fabricated in such a manner that the spray nozzle direction and angle can be adjusted and secured in the field after the nozzle assembly is permanently embedded in the Bridge deck or Roadway surface. Puck type nozzles shall be affixed to the surrounding asphalt mat with a black colored epoxy, or equivalent material Approved by CDOT. Care shall be taken during installation to avoid damaging the underlying waterproofing membrane on the Bridge Structures. Any damage to the waterproofing membrane shall be repaired at the Contractor's expense. A shop drawing for the location and pattern of nozzles for each individual zone, shall be submitted in accordance with Book 2, Section 3. The number and pattern of nozzles shall be designed for required coverage of all traveled lanes and Approved by CDOT. In determining the extent of coverage, the phenomenon of vehicle tracking of chemicals may be considered. The maximum spacing for nozzles shall be forty feet.

Pressure Piping

The system shall be designed for range of anti-icing/de-icing chemicals (S.G. = 1.00-1.40) the flexibility to be adjusted for anti-icing/de-icing chemicals of different specific gravities such as Calcium Chloride ($CaCl_2$), Magnesium Chloride ($MgCl_2$), Sodium Chloride (NaCl), Calcium Magnesium Acetate (CMA), Potassium Acetate (KAc), CMA/KAc blend (CMAK) shall be included in the design.

Chemical pressure pipe within the pump house shall be beta polypropylene (PP) rigid pipe with socket-fused joints, rated for 120% of system pressure or better. All pressure fittings for PP with bends within the mechanical building shall be brass. The use of PVC valves. All PVC valves shall be true union type and brass valves shall be supplied with unions on either side of the valve to aid in repair or replacement. Schedule 80 PVC shall be used in the building when allowed by pressure requirements. The use of a primer is required prior to the application of PVC cement.

Chemical pressure hose, outside the pump house, shall be routed within a protective conduit system, Schedule 80 PVC, where embedded in concrete or buried in the ground. All new and existing conduit runs for the anti-icing/de-icing system shall have a #10 AWG stranded copper conductor placed inside the conduit and attached and spliced within affected pull boxes for locating purposes. Where PVC piping will be exposed to the elements (air and sunlight outside the building), the contractor shall use rigid metal conduit that is PVC coated. All 90 degree bends in the PVC conduit runs shall be rigid metal conduit that is PVC coated. No single PVC conduit run shall have more than 270 degrees of bends between pull boxes. All hose pressure connections, joints, elbows, fixed points, and pipe clamps shall be type 316 stainless steel. All pressure hose shall be Gates Duro Flex ¾ inch I.D. 300 p.s.i. multi-purpose hose or approved equal rated for 120% of the anticipated system pressure to the nozzle.

Protective conduit pipes shall be cast in place or secured to bridge members as approved by CDOT. Contractor shall coordinate locations of cast-in-place carrier conduits prior to construction. A buried conduit pipe shall be used to pass a carrier pipe underneath the approach Roadway to service those installations with nozzles on both sides of the bridge approaches. Conduit and all fittings, connections, elbows, and mounting hardware shall be in accordance with the CDOT Specifications, and shall be sized as required for system operation.

The system shall be designed to dampen and absorb the forces of water hammer due to the opening and closing of valves while under operating pressures. All pressure hoses, valves and valve enclosures shall have permanent printed labels affixed to match the piping schematic and operation table.
Any mechanical or glued fittings not within the pump house shall be housed in easily accessible weatherproof boxes, vaults or manholes. Pressure piping will not be allowed within the interior of box and tub Bridge girders.

System Controller

A microprocessor-based RPU spray system controller shall control the anti-icing/de-icing system with capacity for multiple spray zones (10 minimum), multiple spray nozzles in each zone (number of nozzles to be determined), and the ability to monitor pump functions, system pressures and flow characteristics, as well as tank fluid levels. The RPU spray system controller shall be able to interpret between various signals from multiple non-invasive surface and atmospheric sensors to initiate different spray programs in each zone individually or simultaneously to apply measured amounts of liquid anti-icing/de-icing chemical to the Roadway surface. The control of the application of anti-icing/de-icing chemical shall be fully automated, with provisions for operator intervention and notification. The automated control system shall include non-invasive pavement and atmospheric sensor technology. The RPU spray system controller shall be capable of storing and running multiple software programs for automatic spray activation sequences. The RPU spray system controller shall be capable of varying the length of time each valve is opened, thus varying the quantity of liquid anti-icing/de-icing agent that is applied to the Roadway surface, and shall be able to change the length of time for pauses between sprays, according to different conditions on the Roadway surface. Fully automatic operation shall have manual override capability, with the options for manual pushbutton operation from the pump house and computer activation from a Windows MS Office based PC software. The system shall include surge protection for the incoming communications line and RPU. The RPU shall detect failures of system components and initiate automatic system shutdown in the event of a failure.

The RPU spray system controller shall be contained within a waterproof stainless steel, fiberglass or aluminum housing with lockable lid located inside the pump house located at an elevation above the secondary liquid containment system that is easily accessible to a user. The contractor shall be able to demonstrate a minimum of five years of proven field operation of the RPU spray system controller software in automated liquid anti-icing/de-icing spray systems.

The System RPU shall have a data logger and be NTCIP 9001 compatible for connection to future equipment. The controller shall have the capability to record time, pavement sensor data and times of system operation. The controller shall be able to automatically activate the system when the surface and atmospheric sensors indicate that the surface friction, temperatures and moisture conditions are appropriate for activation. The system shall be connected via secured internet connection to CDOT's wide area network through a central computer located at the Region Headquarters, from which the system shall be capable of remote control of operation and monitoring. The data and current information from the System RPU shall be accessible via a web-based system and shall be Microsoft Office compatible.

Conduit for Sensor and Power Cable

Sensor control cable and power cable shall be shielded and routed within a separate conduit system from the pressure hose conduits. The conduits shall be schedule 80 PVC where imbedded in the ground or concrete. Where PVC piping will be exposed to the elements (air and sunlight outside the building), the contractor shall use rigid metal conduit that is PVC coated. All 90 degree bends in the PVC conduit runs shall be rigid metal conduit that is PVC coated. No single PVC conduit run shall have more than 360degrees of bends between pull boxes. Conduit and all fittings, connections, elbows, and mounting hardware shall be in accordance with CDOT Specifications, and shall be sized as required for system operation or applicable code.

Anti-icing/de-icing Chemical

The system shall be able to safely store and apply the commonly encountered liquid anti-icing/de-icing chemicals. Those liquid chemical include but are not limited to: Calcium Chloride ($CaCl_2$), Magnesium Chloride ($MgCl_2$), Potassium Acetate (KAc), Sodium Chloride (NaCl), Calcium Magnesium Acetate (CMA), CMA/KAc blend (CMAK).

Non-Invasive Road Surface Sensors and Poles

The contractor installed system shall include but not be limited to:

Poles

- The non-invasive sensor and supplemental equipment shall be mounted on a break-away pole approximately 30 feet high or as required for automated system functioning. The pole with mounted equipment shall be capable of withstanding a wind load of 100 mph. The pole shall be grounded with two ground rods, each 8 feet in length and connected with #6AWG ground cable. The sensor equipment, mounting pole and foundation drawings shall be submitted for Approval in accordance with Book 2, Section 3.

Sensors

The non–invasive Road surface sensor are to operate and report conditions as follows:

- Shall accurately determine road surface condition and road surface temperature on the road surface from a distance of 6 feet to 50 feet.
- Shall accurately determine road surface condition of an area with a diameter of 10 inches on the road surface from a distance of 30 feet.
- Shall accurately determine road surface temperature of an area with a diameter of 30 inches on the road surface from a distance of 30 feet with an accuracy of +/- 0.5 deg. F at or near 32 degrees F.
- Shall accurately determine road surface condition and road surface temperature of an area on the road surface when installed at an angle of between 30 deg. and 85 deg. from the horizontal.
- Shall accurately determine road surface condition, road surface temperature (+/- 0.5 deg. F) and road surface friction of an area on the road surface when monitoring any type of road surface.
- Shall distinguish, measure and independently report the thickness of water, frost, snow and ice in any mixture of these on the Road surface.
- Shall provide a water equivalent of snow up to 0.78 inches
- Shall calculate and report a level of tire grip that correlates with the coefficient of friction.
- Shall detect the onset of slippery conditions and shall detect ice layers as thin as 30 microns
- Shall automatically measure lens contamination and warn when cleaning is necessary.
- Shall provide a road surface temperature resolution of +/- 0.2 F
- Shall provide a road surface temperature accuracy of 0.5 deg. F at ambient temperatures of 32F.
- Shall provide stable operation over a temperature range of -40C to +60C or -40F to 140F.

- All sensors will be compliant with Vibration Standard IEC 68-2-6 Global Outdoor, 2G.

System Central Computer

The system shall be supplied with a central computer from a major manufacturer capable of effectively running the supplied client software for remote operation of the FAST, which shall be Approved by CDOT prior to installation. The central computer operating system shall be the latest version of Microsoft Windows Business OS and minimum true 64-bit operating system or approved equivalent and shall be approved by CDOT prior to installation.

Internet Service

The system shall be supplied with the necessary internet connection hardware to provide communications between the RPU spray system controller and central computer over standard communication lines. The internet router shall be industrial grade, intended for harsh environments, capable of operating in a temperature range from -40° F to 149° F, and a humidity range from 0 percent RH to 100 percent RH. The system shall be compatible with existing CDOT servers. The RPU shall be able to support communications with the central computer utilizing an I.P. addressable DSL connection or other suitable service. Communications between the RPU and central computer shall be verified via user name and password method. The Contractor shall supply all DSL equipment or other suitable service.

System Requirements

General

- Ambient Environment. The System shall be able to withstand temperatures in the range of –40° F to 149° F with no permanent loss of function or component failure. The non-invasive sensors and nozzles shall withstand temperatures up to 185° F.
- Operating Environment. The System shall accurately apply liquid anti-icing/de-icing chemicals to a pavement surface in the temperature range of –22° F to 41° F.
- Chemical Environment. The System shall be able to safely store and apply the commonly encountered liquid anti-icing/de-icing chemicals. Those liquid chemicals include but are not limited to: Calcium Chloride, Magnesium Chloride, Potassium Acetate, Sodium Chloride, Calcium Magnesium Acetate, and Calcium Magnesium Acetate/Potassium Acetate blend. The entire permanent anti-icing/de-icing spray system components shall consist of materials that are resistant to corrosion from whatever chemical is selected by CDOT for use in the system.
- Communications and Software. The System communication software delivered shall meet standard communication protocol specifications (NTCIP). The System shall communicate functions such as automatic system operation and display, the system software programs in the controller, tank level, pressure and fluid flow control along with manual operation of the system. The system data collection software shall run as a background service on the central computer. The central computer need not be logged on to CDOT's network to continue to log data from the anti-icing/de-icing system.
- Operating System: Latest Microsoft Windows Business OS and minimum true 64-bit operating system or approved equivalent. CDOT shall approve operating system prior to the time of installation.
- Software/Firmware: Client software shall not require OS administrative privilege to operate. Software/Firmware manufacturer shall support bug fixes and maintenance upgrades for a minimum of one year after system Acceptance.

- Software Licensing: Contractor shall provide a minimum of 6 remote access licenses and one license for the software on the central computer or a web based system.
- Users. The system shall permit a minimum of 3 simultaneous users with user-configurable and changeable web access.
- Security. All communication to and from the RPU shall be verified by user name and password. The system shall provide two levels of password security, one with administrative configuration abilities, and the other user as read-only access. All passwords shall be stored in an encrypted format with no clear text. User accounts names and passwords shall be user definable and changeable. The system shall support a minimum of two user accounts within the RPU.
- Regulatory Requirements. The System shall comply with all applicable national, state, and local construction and safety codes.
- The System provided shall be capable of two-way communication using any or all of the following methods:

    - Computer Network. The System provided shall be capable of networking with wide area networks. The System provided shall utilize a current state of the art Windows Server approved by CDOT. The server provided shall network with standard computers via network router and frame relay, etc.
    - Onsite Hook-up. The System provided shall provide the capability for local on-site connection of a portable computer to the RPU spray controller using and RS-232C and/or RS-485 serial interface protocol. Additionally, the RPU shall also have an Ethernet interface for local on-site connections to the RPU.

Control Options

The System provided shall provide for the control of the liquid chemical application with full automation. The system provided shall be capable of the following control modes:

- Fully Automated. The System operation shall be automatic utilizing user defined parameters and the pavement and weather conditions indicated by the non-invasive pavement sensors.
- Manual Override. The System provided shall allow for manual override of the automated mode locally, at the site, or remotely.
- Fully Manual. The System provided shall respond only to a user generated command. Manual control options shall include the override ability by networked computers and/or manual on-site locking pushbutton.

Detection and Remediation

The System provided shall detect problems and compensate for these problems and notify the user of the problems by the following methods:

- Self-Check. The System provided shall detect chemical leakage, low pressure or loss of fluid or pressure outside of design parameters during system operation within the entire spray system. Additionally, the System provided shall detect hardware failures in all other connecting systems and alert the system user of the problem.
- Remediation. The System delivered shall provide for a single push button reset of normal functions upon completed system repairs or inspections. The system shall automatically detect system defects and take action without operator intervention to prevent system damage or environmental damage.
- User Notification. The System shall automatically notify system user through the central computer of detected problems including location of abnormalities and actions taken. The notification system shall include user definable and configurable alarms and notifications.

Inventory Tracking and Control

The System shall automatically provide tracking of material used by the anti-icing/de-icing system. The system shall provide inventory control. The system shall detect and report liquid levels in the tank throughout the range from full tank to empty tank. The status of the tank level shall be reported to the user using the communications system. The system also shall have alarms for full tank, low level refilling required and low level-not sufficient chemical to operate the system. The system shall provide an alarm to the operator and an automatic shut-off to prevent system damage. All alarm levels shall be settable by the system user.

Operating Capabilities

The system shall have the following basic operating capabilities as a minimum:

- Automatic system tests or monitoring on a preprogrammed and/or timed basis. The system shall measure system pressure and quantity of liquid flow and prevent system operation if parameters exist outside of acceptable operating conditions.
- The system shall monitor and alarm for tank levels of low and or empty.
- Ability to activate a warning device before the spraying operation commences.
- The system shall be capable of going through a system evaluation before activating the spraying operation. This system evaluation shall check for system leaks, low chemical reservoir levels, and other system defects and shall not activate the system if any of these conditions exist. During system activation, the system shall evaluate if individual spray valves do not activate and shall document in the system log and alert the operator of these conditions.
- Autonomous operations based on various weather parameters in the non-invasive sensors.

The non-invasive pavement sensors shall include the following:

- The sensor shall work with any anti-icing/de-icing chemical, multiple chemicals, varying water depths, oils, dirt, and other remaining residuals on the road surface that can change the freezing point temperature. This includes any potential chemical applied on the surface by maintenance trucks.

Sensor technology shall allow the system to have total user flexibility in system operation.

The system provided shall allow for software logic programs that utilize all of the capabilities of the non-invasive sensor processor to properly interface with the anti-icing/de-icing spray system controller. The system provided shall have user settable thresholds for adjusting automatic operation of the system:

- System activation when road moisture is at or near freezing via user settable thresholds;
- System activation when freeze point temperature sensors detect when pavement surface moisture is near freezing via user settable thresholds;
- System activation when chemical dilution is occurring via user settable thresholds;
- System activation and accurate freeze point temperature measurements even when multiple chemicals are used via user settable thresholds;
- Accurate system activation without calibration of pavement sensors with changing chemicals;
- Immediate system activation when falling snow or freezing precipitation is detected and surface temperatures is below user settable threshold;
- The ability to include other weather parameters in the system logic such as low pavement temperature lockout according to different anti-icing/de-icing chemicals for minimum temperature, relative humidity, etc. or high wind lockout, via user settable thresholds.

The system shall have a minimum of 16 different spray programs available for activation of the various nozzles, separate timed sequences, or separate circuits. A circuit is defined as a pump, supply lines, valve units and controlling device. These programs shall be capable of operating a minimum of 240 valves. Programs shall be capable of spraying each nozzle through its controlled motor driven ball valve for a specific length of time, selectable from 1 to 10,000 milli-seconds. Programs shall be capable of changing the length of pauses between nozzle spraying, selectable from 1 to 10,000 seconds.

Manual override of system operations shall be available from any of the manual options. The system shall include the following manual operating capabilities:

- Manual pushbutton at the site;
- Activation from remote computer via internet connection;
- Computer activation from a state of the art Web or Windows based PC software Approved by CDOT.

Commissioning, Testing, and Training

A qualified factory trained representative shall provide for the installation of the automatic anti-icing/de-icing system including the start-up, alignment, and testing of the entire system. The Contractor/manufacturer shall recommend and provide values for system defaults and reasons for their recommendation for CDOT evaluation, e.g. based on CDOT practices & weather conditions or previous CDOT installations. Potable water supplied by the Contractor shall be used to initially test the system for logic and leakage and to provide training. A minimum of two four-hour on-site training sessions shall be provided by a qualified factory representative, for up to 10 CDOT maintenance personnel, at the times scheduled by CDOT. This training shall cover the operation, commissioning, seasonal decommissioning and maintenance of the FAST. The installation test shall simulate the full range of functions the anti-

icing/de-icing system is intended to provide. After initial testing and training is complete, the system shall be purged of the potable water and filled with anti-icing/de-icing chemical supplied by CDOT and retested. At the end of the first operating season (Oct 1st to April 30th), the Contractor/Manufacturer shall provide a hands-on training for the seasonal decommissioning of the system. The Contractor/Manufacturer shall supply a Point of Contact(s) including Name, Phone # and E-mail address for prompt resolution of problems encountered during the first fully operational season. Response to field problems shall be less than four (4) hours.

Warranty

The system shall be warranted to meet the manufactures specifications and for defects in material and workmanship for a period of one year starting on the date of system Acceptance. Both material and labor shall be covered by this Warranty.

Acceptance

The system shall be evaluated for Acceptance during one winter season of operation (Oct 1st to April 30th). The system performance shall be evaluated based on observations by maintenance personnel. System information detailing icing conditions (e.g. moisture conditions and temperature) and operation times during the icing conditions may be used to supplement personnel observations. During this evaluation period, the Contractor shall be responsible for supplying and replacing any defective equipment or parts to the satisfaction of CDOT. If the system does not perform as required during the times of icing conditions, the system (logic/sensors/nozzles/hydraulic equipment) shall be adjusted, augmented or replaced, as required by CDOT, to ensure adequate performance.

Submittals

The Contractor shall submit the following for Review and Approval in accordance with Book 2, Section 3.

- Detailed design and installation shop drawings for the complete anti-icing/de-icing spray system with sufficient detail to allow Review of all power and communications for compliance with the specifications. The shop drawings shall include specific details and exact locations of all system components (nozzle layout, sensor layout, etc.) including proprietary equipment.
- Pump house equipment layouts drawings as described in the pump house criteria.
- Compliance traceability matrix for all components including computer and electronic device hardware and software that give evidence of the compliance of each component or function with the requirements in these specifications and the vendors specifications.
- Communications Infrastructure Plan showing routing of electronic communications between devices in the field, between devices and computers, between systems, and between the field computers/systems and remote users.
- Installation schedule that shall outline the steps the Contractor intends to make to complete the system within the Project schedule. The installation schedule shall be revised and resubmitted if there is a significant change to the schedule.
- Documentation of five years of proven field operation of the FAST programmable system controller software in automated liquid anti-icing/de-icing spray systems.
- Structural drawings and engineering design calculations for the pump house building prepared and sealed by a Colorado Licensed Professional Engineer.

- Electrical schematics and engineering design calculations and shop drawings for the system prepared and sealed by a Colorado Licensed Professional Engineer.
- Mechanical schematics and pipe support locations and engineering design calculations and shop drawings for the system prepared and sealed by a Colorado Licensed Professional Engineer.
- Shop drawings and product data for doors, louvers, frames and all accessories and hardware for the pump house.
- Design calculations and shop drawings for the pump house stair framing that have been prepared and sealed by a Colorado Licensed Professional Engineer in Colorado.
- Shop drawings for the non-invasive sensor mounting pole and foundation.
- Product data sheets and certificates of conformance with the Specifications, and Quality Assurance reports for the following system components:

    1. Spray nozzles and assemblies (curb and barrier designs);
    2. Non-Invasive Pavement sensors;
    3. Chemical pressure piping;
    4. Conduit for chemical pressure piping;
    5. Valves and valve controller;
    6. Pressurized accumulator tanks;
    7. System control cable;
    8. Sensor control cable;
    9. Conduit for sensor control cable and RPU slave unit power cable;
    10. Anti-icing/de-icing chemical;
    11. Anti-icing/de-icing chemical storage tanks;
    12. Pump and motor;
    13. RPU spray system controller;
    14. Network routers
    15. CDOT concrete, in accordance with Section 601 of the Standard Specifications, for cast-in-place building foundation;
    16. CDOT concrete, in accordance with Section 601 of the Standard Specifications, for precast building;
    17. Epoxy resin waterproofing for concrete surfaces;
    18. Deformed steel reinforcing bars, epoxy-coated;
    19. 7-wire steel post-tensioning strand for precast building;
    20. Silicone sealant and bond breaking tape for building joints;
    21. Floor grating for building;
    22. Handrail for building;
    23. Strainers;
    24. Electrical boxes;
    25. Valve boxes;
    26. Flush mount nozzle connection details (curb and bridge barrier);
    27. Doors, louvers, frames and accessories schedules.

Operations and Maintenance Manual

The Contractor shall furnish an Operations and Maintenance Manual, or O&M Manual, for the anti-icing/de-icing system. The O&M Manual shall include detailed operation and maintenance instructions for all systems and items of equipment provided for the Project. The O&M Manual shall be in the form of neatly formatted bound ring binders and electronic format in the form of USB drives in searchable PDF format. Prior to completion of the Work, and at least 90 Days prior to final payment, the Contractor shall furnish for CDOT's Review, 5 O&M Manual draft copies. At least 30 Days prior to final payment, the Contractor shall furnish for CDOT's use, 10 copies of the final O&M Manual and USB drive with the manual in a searchable PDF format. CDOT before a Final Acceptance of the Work, shall Approve the final O&M Manual.

The O&M Manual shall consist of product data sheets, brochures, bulletins, charts, schedules, Approved shop drawings corrected to As-Constructed conditions, assembly drawings, wiring diagrams, operation and maintenance information for equipment, and other information necessary for CDOT to establish an effective operating maintenance program.

Oversized sheets and shop drawings larger than 8.5 inches by 11 inches shall be neatly folded to that size with title block exposed along one edge, and bound or placed in pockets within the Manual. The O&M Manual shall include:

- Title page giving the name and location of the facility, bridge plan numbers, and Project Numbers;
- Performance curves for all pumps and equipment;
- Approved shop drawings of each component;
- Approved product data sheets and dimensioned drawings of each piece of equipment, and details of all replacement parts;
- Manufacturer's installation, operation, and maintenance instructions for each piece of equipment and complete listing of nameplate data;
- Complete wiring diagrams of all individual pieces of equipment and systems including one line diagrams, schematic or elementary diagrams, and interconnection diagrams;
- Complete piping and interconnection drawings;
- Complete parts list with parts assembly drawing preferably by exploded view, names and addresses of spare parts suppliers, recommended list of spare parts to be kept on hand by CDOT, and sample order forms for ordering spare parts. Lead time required for ordering spare parts shall be estimated;
- Instructions with easily understood schematics or diagrams for disassembling and assembling the equipment for overhaul or repair.

Delivery of O&M Manual satisfactory to CDOT is an essential part of Project delivery. Incomplete or inadequate manuals will be returned to the Contractor for correction and resubmission.

The Contractor shall not start construction or installation of any part of the anti-icing/de-icing system until the complete design and installation shop drawings and installation schedule have been received, Reviewed and Approved by CDOT.

Such Approval shall not relieve the Contractor of responsibility for results obtained by the use of these designs and drawings or any of the Contractor's other responsibilities under the contract.

Known manufacturers of anti-icing/de-icing systems include:

Boschung America LLC
https://boschungamerica.com/
930 Cass St.
New Castle, PA 16101
800-334-4225

EnviroTech Services, Inc.https://envirotechservices.com/
910 54th Avenue, Suite 230
Greeley, CO
Greeley, CO 80634
800-369-3878
970-346-3900