

19.0 Intelligent Transportation Systems (ITS) Infrastructure

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

The ITS system includes various devices, such as Variable Message Signs (VMS), Closed Circuit Television (CCTV), Ramp Meter Stations (RMS), Microwave Vehicle Radar Detection (MVRD), Travel Time Indicators (TTI), Automatic Traffic Recorders (ATR), Doppler Radar, Road Weather Information Systems (RWIS) and an emissions collector. In addition, the ITS system includes the various components that make up the communication system, such as conduit, fiber optic cable, and Ethernet Switches.

The 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. All ITS devices shall be replaced with new devices per Appendix A. Older equipment maybe be reset in order to maintain operability during construction phasing, All ITS devices shall be new in final configuration. All ITS devices shall remain operational through the project with no outages.

All Final Network and Device communications shall be designed using Ethernet, field-hardened [CiscoCiena](#) Switches using CWDM.

All design and construction shall comply with the relevant requirements and standards listed in Book 3. Use the most current version of each listed standard as of the final issue date of this RFP, unless modified by Addendum or Change Order. In addition, use the references listed in the Reference Documents as supplementary information.

The ITS elements shall have the flexibility to accommodate Project changes that produce benefits or savings to CDOT or the Contractor without impairing the essential functions and characteristics of the Project, such as durability, desired appearance and maintainability.

19.0.1 List of Abbreviations

AC	Alternating Current
ARE	Additional Requested Element
ATR	Automatic Traffic Recorder
AVI	Automatic Vehicle Identification
CDOT	Colorado Department of Transportation
CWDM	Course Wavelength Division Multiplexing
CCTV	Closed Circuit Television
CTMC	Colorado Transportation Management Center
CTMS	Colorado Transportation Management Software
DTD	Division of Transportation Development
IP	Internet Protocol
ITS	Intelligent Transportation System
LED	Light Emitting Diode
MVRD	Microwave Vehicle Radar Detection
NEC	National Electric Code

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NTCIP	National Transportation Communications for ITS Protocol
POE	Power over Ethernet
RMS	Ramp Meter Station
ROW	Right-of-Way
RWIS	Road Weather Information System
SMFO	Single-Mode Fiber Optic
TTI	Travel Time Indicator
UPS	Uninterrupted Power Supply
VMS	Variable Message Sign

19.0.2 List of References

Author	Title
CDOT	2011 <i>Standard Specifications for Road and Bridge Construction</i>
CDOT	<i>M & S Standards – June 27, 2011</i>
CDOT	<i>CDOT Sign Design Manual – May 21, 2010</i>
RTD	Design Guidelines and Criteria
AASHTO	<i>A Policy on Geometric Design of Highways and Streets</i>
AASHTO	<i>Roadside Design Guide</i>
ASTM	American Society for Testing and Materials
EIA	Electronic Industries Alliance
FHWA	<i>Manual on Uniform Traffic Control Devices (Current Edition)</i>
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ITU	International Telecommunications Union
NFPA	<i>National Electric Code (Current Edition)</i>
RUS	Rural Utilities Service
Telcordia	Telcordia Technologies
TIA	Telecommunications Industry Association

19.1 Design Requirements

The Contractor shall design the ITS infrastructure components in accordance with the requirements in the following Sections. No part or attachment of any equipment shall be substituted or applied contrary to the manufacturer’s recommendations and standard practices. The Contractor shall submit, for approval to CDOT, all ITS devices and materials prior to installation by submitting product sheets. Infrastructure locations need to meet the requirements of CDOT.

19.1.1 Electrical Power

The Contractor shall provide alternating current (AC) power service to every ITS device and cabinet along with a metered service. This includes all existing devices or cabinets that are relocated by the Contractor. The Contractor shall obtain (from the power service provider[s]) approval of the power service design and coordinate and meet all requirements as specified by the power service provider for the complete and operational power service to all required locations. All power connections to devices shall include a quick-disconnect.

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The Contractor shall be responsible for the coordination of power source work to be performed by Xcel Energy. The Contractor shall contact the Xcel Energy Builder's Call Line at 1-800-628-2121 to request, and process to completion, the required coordination 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 cost charges from the power service provider, and all necessary materials, including meter, labor, and coordination required to maintain existing or establish new metered power sources shall be included in the Work. Contractor shall be responsible for coordinating all power source billings to the corresponding CDOT regional owner.

19.1.2 Location and Protection of ITS Elements

The Contractor shall locate all ITS infrastructure elements within the public Right-of-Way (ROW) such that routine maintenance will not require a lane closure, affect traffic operations, or require complex traffic control. ITS elements shall not be located in the highway median. All devices shall be placed outside of the clear zone, on approved breakaway devices, or placed behind guardrail for the protection of the travelling public and the infrastructure.

All existing underground utilities shall be identified, and all ITS infrastructure elements shall be designed to avoid outages. The Contractor shall be responsible for all repairs to facilities damaged during construction. The Contractor shall be responsible for maintaining and keeping operational all existing ITS devices during construction. Fiber optic backbone cutover shall only be conducted over a weekend, all fiber backbone cutovers shall be done overnight. All current live fibers shall be respliced in one work shift. Contractor shall notify CDOT ITS two (2) weeks before fiber backbone cut over.

The Contractor shall ensure that all equipment, devices, interconnect wiring, communications devices, communications lines, power supplies, antennas, operator controls, and power service are protected to eliminate damage by external and internal sources, including power surges, lightning, induced voltages, and static discharge. A grounding system and protection devices that are suitable for the specific installation and equipment shall be designed.

19.1.3 Communications System

The ITS communications system is used to transmit data to and from all existing and proposed ITS devices. All Final Network and Device communications shall be designed using Ethernet, field-hardened [CiscoCiena](#) Switches using CWDM.

19.1.3.1 Design Requirements

The Contractor shall design a fiber optic communication system to replace the existing fiber optic communication. The system shall be capable of transporting data and video signals between field devices and support the following functional requirements, at a minimum:

- Provide CDOT and Denver continuous fiber optic communications backbone along I-25 and an independent fiber backbone along US 6 joining together in the interchange.
- Communications backbone shall be located within the Right-of-Way (ROW) line.
- Communications backbone shall provide physically diverse redundancy using a primary and secondary ring configuration. In areas without physical redundancy, the backbone shall be collapsed.

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- All fiber allocations, splicing diagrams, and network drawings shall be prepared by the Contractor and submitted to CDOT and Denver for Acceptance. CDOT and Denver will provide the Contractor with the existing splicing diagrams.
- Splicing of CDOT fiber optic cable shall be performed only in cable manholes. Splicing shall be consolidated to limit the number of splicing locations.
- Splicing of Denver fiber Optic cable shall be performed in pull boxes.

Physical redundancy shall be achieved by utilizing the existing fiber optic backbone that extends along I-25 from the north to the south and along US 6 from the east (I-25) west.

19.1.3.2 Material Requirements

The communications system shall be designed based on the following material requirements, at a minimum:

- The communications system shall include a backbone of a 144-strand SMFO cable for US 6 continuing onto NB I-25 and a 96-strand SMFO cable for US 6 continuing onto SB I-25. These two cables currently join in the SW quadrant and shall remain interconnect at all times at a location preapproved by CDOT ITS.
- The ITS system for Denver shall include one 72-strand (48SM/24MM) Hybrid Fiber Optic cable backbone and one 12 strand (6SM/6MM) Hybrid Fiber Optic cable lateral. The fiber optic cable as approved by Denver- ITS, its splices shall be housed in a splice closure (i.e. Express). All cut and unconnected fibers shall be coiled neatly in a splice closure inside pullbox.
- The ITS system shall include 12-strand SMFO cable laterals from the CDOT backbone to all field devices. Splice points shall remain concentrated to one point per area and in a concrete manhole, as approved by CDOT ITS.
- The ITS system shall include bend insensitive fiber optic cable shall be used for all patch cables and shall be fully compatible with all fiber optic laterals.
- Contractor shall purchase and install all the ITS devices and their communications cabinets along the corridor.

Refer to the Modified Standard Specification listed in Section 19.4 below for additional requirements.

19.1.4 Variable Message Signs (VMS)

The VMS are large dynamic displays that are used for a wide range of purposes, including providing driver information regarding weather advisories, travel times, amber alerts, and construction and incident notifications. No median mounted VMS will be allowed.

19.1.4.1 Design Requirements

The Contractor shall design a complete VMS system at the approximate locations listed below:

1. Northbound I-25 approximate mile marker:
 - 209 (in advance of US 6)
2. VMS shall have a cantilever with a vertical clearance of 18'-18.5' above the roadway and per current CDOT specifications.

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19.1.4.2 Material Requirements

The new VMS signs shall be designed based on the following material requirements, at a minimum:

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

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.1.5 Closed Circuit Television (CCTV)

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

19.1.5.1 Design Requirements

1. The Contractor shall design a CCTV system that provides full surveillance coverage along the project limits of the new CDOT fiber optic backbone, with no obstructions. The coverage shall include the entire roadway surface, including all mainline lanes, ramp lanes, and interchanges, with no obstructions. Full coverage is defined by the camera not being at maximum-zoomed extent to view the intended area. Roadway surface, including all mainline lanes, ramp lanes, and interchanges. The Contractor shall provide a complete CCTV system to Denver-ITS (Denver will install at the approximate SWC pole near north traffic signal intersection).
2. The Contractor shall prepare a coverage plan to be submitted for Approval to CDOT during preliminary design to demonstrate proper CCTV coverage.
3. Each CCTV camera pole shall have a lowering device to lower the camera for maintenance purposes and be accessible by CDOT without performing lane closures, affecting traffic operations, or requiring complex traffic control or a bucket truck.

19.1.5.2 Material Requirements

All CCTV cameras within the Project limits shall meet the following minimum requirements:

1. Ethernet-based
2. All-in-one color surveillance dome camera unit
3. Pan, 220 degree tilt, zoom operation
4. 30X optical zoom
5. Minimum illumination no less than 0.5 lux

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6. H.264 video stream
7. Compatible with Camera Cameleon ITS client

The CCTV camera shall also include a weatherproof dome housing, lowering device, mount adapter, camera transformer, attachment hardware and all other hardware, cables, and test equipment necessary for a complete installation.

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

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements

19.1.6 Ramp Meter Stations (RMS)

The RMS help control the number of vehicles entering US 6 when the highway experiences congestion. There are currently 2 RMS proposed within the US 6 corridor:

1. Eastbound US 6 on-ramp at the Federal Boulevard interchange (proposed)
2. Westbound US 6 on-ramp at the Federal Boulevard interchange (existing)

19.1.6.1 Design Requirements

The Contractor shall replace all existing RMS detection with MVRD for mainline detection and wireless in-pavement sensors for on-ramp detection. If the Contractor impacts any of the existing RMS along the corridor, the Contractor shall design and reconstruct a new fully functioning RMS in accordance with the latest CDOT guidelines on ramp metering stations and the CDOT ITS Standard Details included in the Reference Documents.

19.1.6.2 Material Requirements

All RMS shall utilize the following components:

1. MVRD to collect mainline data for each lane, and associated loop emulation cards
2. Wireless in-pavement sensors to provide on-ramp detection
3. Where impacted, install new 334 controller cabinets and controllers on new fiberglass porch-style foundations
4. Pull boxes, conduit, communications, signal equipment, advance flashers, wiring, and all other items necessary to provide a complete and functioning RMS

Saw cut loops are not allowed in new pavement areas for RMS.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.1.7 Microwave Vehicle Radar Detection (MVRD)

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

19.1.7.1 Design Requirements

The Contractor shall prepare a design to relocate the existing MVRDs to the original locations. Each location shall be accessible by CDOT bucket trucks to provide device maintenance and

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other functions without performing lane closures, affecting traffic operations, or requiring complex traffic control and cannot be placed in the median.

19.1.7.2 Material Requirements

The MVRD units shall detect all individual lanes of travel, including the general purpose and managed lanes in both directions. Data collection shall include volume, occupancy, speed, and classification.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.1.8 Travel Time Indicators (TTI)

TTI sites are comprised of Sirit 5204 readers and antennas that detect toll tag transponders in vehicles. While MVRD units give volume, occupancy, and speed data at a given point, the TTI are used to track vehicle travel times across segments spanning from one TTI location to the next.

19.1.8.1 Design Requirements

The Contractor shall prepare a design to install new TTIs at the existing TTI locations that will read only the general purpose lanes for both directions at US 6/Federal and I-25/US 6.

Each location shall be accessible by Department bucket trucks to provide device maintenance and other functions without performing lane closures, affecting traffic operations, or requiring complex traffic control and cannot be placed in the median.

19.1.8.2 Material Requirements

The TTI units must be Sirit 5204 multi-protocol readers and antennae and be able to read both Title 21 and ISO 18000-6C transponder tags. All existing TTI units along the project limits shall be replaced with new multi-protocol units.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.1.9 DTD Automatic Traffic Recorders (DTD ATR)

The CDOT Division of Transportation Development (DTD) automatic traffic recorder stations continuously collect vehicle volume and functional classification data using in-pavement loops, conduit and ground mounted cabinets. Currently, there are DTD ATR stations at the following mile markers:

1. I-25 near 6th Ave at MM 208.5
2. US 6 at Federal at MM 283.3

19.1.9.1 Design Requirements

The Contractor shall design replacement DTD ATR counting stations for those locations that are impacted by the Project. Each new DTD ATR must collect data for all lanes of travel, including the general purpose lanes and managed lanes in both directions. Communications to the DTD ATR stations shall be provided via the existing telephone line.

19.1.10 Automatic Traffic Recorders (ATR)

The ATR stations are counting stations that continuously collect vehicle volume and functional classification data. The data collected is transmitted to CDOT Region 6 for processing and analysis. ATR stations utilize the same equipment as the RMS. Currently, there are ATR Stations at the following mile markers:

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1. US 6 MM 284.4(EB and WB at I-25)
2. I-25 MM 209.2 (NB at US 6) and I-25 MM 209.5 (NB and SB at 8th Ave)

19.1.10.1 Design Requirements

The Contractor shall design replacement ATR stations for those locations that are impacted by the Project.

19.1.10.2 Material Requirements

The ATR stations shall utilize the following components:

1. MVRD to collect mainline data for each lane, and associated loop emulation cards
2. Ground Mounted 334 cabinets with 112/114 loop emulation cards for the MVRD.

Saw cut loops are not allowed in new pavement areas for the ATR. Existing ATR controllers and cabinets may be salvaged and reused.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.1.11 Doppler Radar

These are self-contained, solar-powered units that collect point travel data and transmit it wirelessly to the device manufacturer SpeedInfo and to CDOT. These devices are owned by SpeedInfo,

19.1.11.1 Design Requirements

Because the SpeedInfo Doppler radar units are self-contained (including wireless communications), all existing units that need to be relocated shall be installed per the manufacturer's recommendations. Locations shall be in a similar area as the original installations.

19.1.11.2 Material Requirements

The existing self-contained SpeedInfo DVSS-100 Doppler radar units shall be salvaged and reset in the same vicinity as the current devices. No additional units shall be provided as part of the Project.

19.1.12 Road Weather Information System (RWIS)

Road Weather Information Systems (RWIS) are used for traveler information systems and highway maintenance operations by providing on-Site weather information.

19.1.12.1 Design Requirements

The Contractor shall design RWIS station at a suitable location along US 6 at I-25 to replace the existing RWIS in the SW quadrant.

19.1.12.2 Material Requirements

The RWIS shall include the following material requirements:

1. Fold-over tower
2. Weather monitoring system (wind sensor, temp sensor, humidity sensor, etc)
3. Concrete pad and chain link fence

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Refer to the Modified Standard Specification listed in Section 19.4 for the specific requirements for each component.

19.1.13 Pull Boxes and Manholes

19.1.13.1 Design Requirements

The Contractor's design shall utilize fiberglass reinforced, polymer concrete pull boxes and pre-cast concrete manholes with a cast iron frame ring and cover. Pull boxes shall be 24 inches x 36 inches for intermediate locations and manholes shall be used for splice locations. 100 feet of fiber optic cable shall be coiled inside each manhole, and 50 feet of fiber optic cable shall be coiled inside each pull box. Pull box and manhole spacing shall not exceed 1,000 feet.

19.1.13.2 Material Requirements

All CDOT pull boxes shall be constructed of fiberglass reinforced, polymer concrete and have a detachable cover with a skid-resistant surface and have the words "CDOT COMM", cast into the surface. Painting of words shall not be allowed. All pull boxes shall be verified by a third-party nationally recognized Independent Testing Laboratory as meeting all test provisions of

ANSI/SCTE 77 2007 Specification for Underground Enclosure Integrity, Tier 22 rating. Pull boxes shall be UL listed. Certification documents shall be submitted with material submittals.

All Denver traffic communication pull boxes shall have the words —TRAFFIC COMM- physically impressed (not painted) on its top. The interconnect pull boxes or Pull Box (Special) shall have minimum inside dimensions of 30.5" long by 17.5" wide by 24" deep. The covers shall be attached to the pull box body by screw-in bolts and shall have two lift slots to aid in the removal of the lid. Pull boxes that are to be in traveled ways shall be outfitted with traffic bearing lids rated for HS 20-44 loads. The pull boxes shall have a special concrete footing extending 8 inches around the outside and 6 inches around the inside of the pull box bottom, as shown in the plans. Pull boxes installed in dirt or landscape areas shall have a 12 inch wide by 6 inch thick concrete collar placed around the top in lieu of the concrete footing, as shown in the plans. When the plans call for a fiber optic cable location marker to be installed at the pull box location, the concrete foundation support for the location marker shall be placed monolithically with the concrete collar.

Manholes shall consist of a pre-cast concrete, 4'x4'x4'-foot square vault with a base and cast iron frame ring and cover. The manhole shall be designed to provide a pre-cast conduit entrance depth of 3 feet. Each manhole, frame and cover shall conform to AASHTO HS20-44. Each manhole shall be equipped with a removable ladder that is engineered to support 300 pounds. The ladder support shall be permanently fixed to the manhole. The manhole cover shall have a skid-resistant surface and have the words "CDOT COMM", physically impressed (not painted) on its top. The cover shall be attached to the manhole body by screw-in bolts.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.1.14 Cabling and Conductors

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

19.1.14 Conduit

19.1.14.1 Design Requirements

The Contractor shall design new and separate conduit systems (including all hardware, fasteners, and accessories) for communication and power control systems. Longitudinal conduits for the communications network shall be installed within the ROW and as close to the ROW line as practical. ITS conduit shall be a minimum of 4-foot deep. The mainline communications run shall contain:

1. Three 2” conduits for the CDOT backbone
2. One 2” conduit for the CDOT Laterals
3. Two 3” conduit for the Denver backbone and laterals

All Fiber Optic cable splices shall be contained in a manhole not a pull box for CDOT.

All Fiber Optic cable splices shall be contained in a pull box for the City of Denver.

Lateral conduits shall not exceed the NEC fill ratio requirements. The following conduit colors shall be used so that the contents can be easily identified:

1. 2-inch CDOT fiber conduit – Orange
2. 2-inch CDOT spare/empty conduit – Grey
3. 2-inch CDOT power conduit – Red

19.1.14.2 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.

Refer to the Modified Standard Specification listed in Section 19.4 below for additional requirements.

19.2 Construction Requirements

19.2.1 Electrical Power

The Contractor shall make appropriate arrangements 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. Finally, The Contractor shall be responsible for all ongoing monthly electricity costs of all new ITS equipment installed under this Project until Final Acceptance. CDOT will be responsible for ongoing electricity costs of existing ITS equipment.

19.2.2 Location and Protection of ITS Elements

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

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

19.2.3 Communications System

The Contractor shall install the fiber optic system for communications to all ITS field devices. All Final Network and Device communications shall be constructed using Ethernet, field-hardened CiscoCiena Switches using CWDM. No ITS devices shall remain without Ethernet communications to their field Ethernet Switch. Contractor shall ensure that all Field Switches are connected to the main CTMC ~~Cisco 3600 Switch~~ Ciena 5150 Carrier Ethernet Service Aggregation Switch.

Prior to performing any work that may impact existing ITS communications systems, the Contractor shall coordinate with the owner of the affected system.

The Contractor shall be responsible for all splicing work necessary to provide the ITS equipment communications.

Fiber optic backbone conduit shall not be located in the travelled way.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.2.4 Variable Message Signs (VMS)

The Contractor shall be fully responsible for protecting the existing NB I-25 VMS sign from construction.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.2.5 Closed Circuit Television (CCTV)

The Contractor shall carry out all installation, field-testing, burn-in of the system, and connection of each device to the communication system using fiber optic laterals. Existing CCTV cameras in the corridor may not be reused and shall be salvaged and returned to CDOT, except for those CCTV cameras outside of the roadway widening limits.

The Contractor shall notify CDOT ITS upon installation of each CCTV camera and complete a CDOT data sheet. The Contractor shall be responsible for the integration of each new CCTV back to the CTMC. CDOT ITS shall be responsible for modifying the Camera Cameleon software to incorporate the new devices.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.2.6 Ramp Meter Stations (RMS)

The Contractor shall carry out all installation, field-testing, and burn-in of the system. The testing shall demonstrate that the detection systems operate per the manufacturer's specifications.

Each RMS system shall be connected to the communication system using fiber optic laterals. The Contractor shall notify CDOT ITS upon installation of each RMS system and complete a CDOT data sheet. The Contractor shall be responsible for the integration of each new RMS back to the CTMC.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.2.7 Microwave Vehicle Radar Detection (MVRD)

The Contractor shall carry out all installation, field-testing, and burn-in of the system per the manufacturer's recommendations and CDOT standards. Each device shall be connected to the communication system using fiber optic laterals. Existing MVRD units may be reused as long as they meet the appropriate material requirements outlined herein. Incompatible units shall be

salvaged and returned to CDOT ITS. The Contractor shall notify CDOT ITS upon installation of each MVRD device and complete a CDOT data sheet. The Contractor shall be responsible for the integration of each new MVRD to the CTMC. CDOT ITS shall be responsible for modifying the CTMS software to incorporate the devices.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.2.8 Travel Time Indicators (TTI)

The Contractor shall carry out all installation, field-testing, and burn-in of the system per the manufacturer's recommendations and CDOT standards. Each device shall be connected to the communication system using fiber optic laterals. Existing units shall be salvaged and returned to CDOT ITS. The Contractor shall notify CDOT ITS upon installation of each TTI device and complete a CDOT data sheet. The Contractor shall be responsible for the integration of each new TTI to the CTMC. CDOT ITS shall be responsible for modifying the CTMS software to incorporate the devices.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.2.9 DTD Automatic Traffic Recorders (DTD ATR)

The Contractor shall carry out all installation, field-testing, and burn-in of all DTD ATR counting stations that are replaced. All Work shall be inspected by the Traffic Data Collection Unit (TDC) during installation. The Contractor shall test and operate the loops under actual traffic conditions. A minimum of one week of actual data shall be collected. The volume and vehicle class shall be within ± 10 percent for the Site compared to historical data for the test period. There shall be no more than 1 percent sensor misses in any one lane for the test period. The Contractor shall submit all testing and operational data for Acceptance.

Refer to the Modified Standard Specification listed in Section 19.4 below for additional requirements.

19.2.10 Automatic Traffic Recorders (ATR)

The Contractor shall carry out all installation, field-testing, and burn-in of all ATR stations that are replaced. The testing shall demonstrate that the MVRD loop emulation detection system operates per the manufacturer's specifications.

Refer to the Modified Standard Specification listed in Section 19.4 for additional requirements.

19.2.11 Doppler Radar

The Contractor shall coordinate any relocation work with SpeedInfo (408-446-7660) if any of the existing Doppler radar units, currently installed along the corridor, need to be relocated to new locations. Any associated work, including new poles, shall be by the Contractor as part of the project.

19.2.12 Road Weather Information System (RWIS)

The Contractor shall install the heavy duty fold-over tower, base assembly, concrete footing, concrete pad, and chain link fencing based on the requirements outlined in the Modified Standard Specification listed in Section 19.4.

19.2.13 Pull Boxes and Manholes

The Contractor shall install all pull boxes and manholes based on the latest CDOT *Standard Specifications*. Each location shall be easily accessible for maintenance purposes. Pull boxes

and manholes shall not be placed in a known flood-prone area or drainage ditch. A fiber optic cable label shall be attached to each fiber optic cable located within a pull box or manhole. All fiber optic cable splices inside manholes shall be housed in a separate splice closure.

Refer to the Modified Standard Specification listed in Section 19.4, below, for additional requirements.

19.2.14 Salvaging of Materials

The Contractor shall salvage all existing ITS elements that are affected by the Project. Salvaged equipment shall be returned to CDOT ITS.

19.2.15 Cabling and Conductors

All cables shall be installed per the manufacturer requirements for each device or the requirements found in the Modified Standard Specifications in Section 19.4, below. The maximum conduit fill ratio for both new and existing conduits shall be in accordance with the NEC, latest version.

19.2.16 Conduit

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

Refer to the Modified Standard Specifications listed in Section 19.4, below, for detailed construction requirements for all conduit installations.

19.2.17 Integration and Testing

Integration and testing shall be conducted for all components that meet any of the following criteria:

1. A new device and/or cabinet supporting the device has been installed.
2. A device and/or cabinet supporting the device has been relocated.
3. The communications path between the devices and the local cabinet has been disturbed and/or relocated.
4. A new communication path to a device has been established

The Contractor shall be responsible for the installation and integration of all ITS devices. This includes all VMSs, CCTVs, RMSs, MVRDs, TTIs, ATRs, RWISs and Fiber Optic Cable. The integration of each ITS device to the CTMC shall be done by the Contractor. All modifications to the CTMS or Camera software on the CDOT end will be performed by CDOT ITS.

For all devices connected to the fiber optic communication network, integration shall include field site integration and subsystem integration.

CDOT has testing procedures for certain devices as outlined in the Modified Standard Specification listed in Section 19.4, below. For all other elements, the Contractor shall develop a test plan for conducting system and subsystem testing and submit it to CDOT for Approval. No testing shall be performed until CDOT has approved the test plan. CDOT may adjust the proposed testing schedule by up to 14 Days, at no cost to CDOT, to accommodate availability of personnel. A CDOT staff member or an authorized CDOT representative will witness and sign off on all tests.

At a minimum, the test plan shall include the following tests:

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1. The fiber optic cable testing shall be performed based on the requirements found in the Modified Standard Specification listed in Section 19.4, below.
2. A local field operations test shall be performed for all devices such as for each VMS, CCTV, RMS, MVRD, TTI, ATR, and RWIS to demonstrate that all hardware, cables, and connections furnished and installed by the Contractor operate correctly and that all functions are in accordance with the requirements described herein. Verify the power supply voltages and the functionality of the cabinet fans and heaters. Provide CDOT a 5-Day pretest notification and test completion notification. In addition, the Contractor shall prepare a Device Data Sheet for each installed device and submit to CDOT.
3. A subsystem communication throughput test over the communication path between each field device and the communications hub. The testing shall occur after all communication installation for a particular site has been completed, the communication paths between the device and the communications hub have been functional for at least one (1) week, and all fiber optic tests have been successfully passed. Notify CDOT at least two (2) weeks prior to beginning testing.

No existing communication line or device shall be off line for more than (1) weekend.

Documentation indicating successful passing of each test shall be submitted to CDOT for Approval prior to Final Acceptance.

19.3 Deliverables

At a minimum, the Contractor shall submit the following to CDOT ITS for review, Approval and/or Acceptance:

Deliverable	Review, Acceptance, or Approval	Schedule
CCTV coverage plan	Acceptance	4 weeks prior to first design plan submittal
ITS plan sheets and details	Acceptance	4 weeks Prior to Released for Construction
Network diagrams	Acceptance	4 weeks Concurrent with design plan submittals
Supporting reports and design calculations	Acceptance	Concurrent with design plan submittals
ITS infrastructure product sheets	Approval	4 weeks Prior to ordering
Splicing details	Acceptance	4 weeks prior to splicing
Integration and testing plan	Approval	5 weeks prior to testing and integration
Testing results	Acceptance	Following test period of each component within 2 weeks
CDOT device data sheets	Acceptance	4 weeks prior to device integration

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As-builts upon construction showing devices and fiber locations for integration into CDOT's fiber inventory system, for acceptance.

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

19.4 Project Special Provisions

Appendix A to this Section 19 includes the Modified Standard Specifications that shall be applicable to the Project.

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

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

All references to "Engineer" that are incorporated into this Section refer to the Contractor's Engineer, unless the context requires otherwise. Non-capitalized terms, such as "work" that are defined in Book 1, Exhibit A, shall have the meanings defined therein unless the context requires otherwise. References to "approve, approval or approved" shall mean "Approve, Approval or Approved" as defined in Book 1, Exhibit A, when the approval is by CDOT or a division of CDOT. If the interpretation(s) pursuant to this paragraph are not clear, CDOT shall decide, in its sole discretion, how these terms shall be interpreted.

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

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

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

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

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

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

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

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

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

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