Automated Vehicle Location (AVL), Maintenance Decision Support System (MDSS) - Integrated Mobile Observations (IMO) System

DEFINITIONS

For the purposes of these Specifications, the definitions below are applicable:

a) **"Availability"** means the ratio of time that the system is available and fully operational compared to total time in a particular time period. For the purposes of the project, availability must be computed to not include scheduled and CTDOT-approved preventive and routine maintenance activities.

b) **"AVL/ Global Positioning System ("GPS") System"** means all servers, software, and web services necessary to provide a password-protected web portal that allows authorized users to access and map real-time data from CTDOT vehicles, including location sensor data (vehicle locations and speeds), camera images, on-vehicle weather sensor data, vehicle sensor data, and equipment sensor data. The AVL/GPS System must allow authorized users to search, filter, export, and generate reports based on AVL/GPS System data.

c) **"Cameras"** means cameras installed on CTDOT vehicles to provide images of road conditions. The initial installation would include a single, interior-mounted, forward-facing, camera to provide both management and the public with an indication of weather and roadway conditions and trends.

d) **"Communications Equipment"** means all communications equipment installed in CTDOT vehicles necessary to allow the vehicle systems to communicate to central servers via the cellular network. Each vehicle would be equipped with a cellular modem and covert antennas that would transmit both outgoing and incoming data and messages.

e) **"Data quality" -** means the fitness of data for all purposes that require such data.

f) **"Department Representative"** means the project manager for the Department, or his/her designated representative(s),

g) **"Equipment Sensors"** means sensors installed on CTDOT vehicles to collect information on vehicle equipment, such as spreader settings and plow positions. Current CTDOT vehicles vary considerably in age and technology so a variety of solutions may be necessary.

h) **Intelligent Transportation Systems ("ITS")** means an advanced application which, without embodying intelligence as such, aims to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. Additionally, ITS includes the application of sensing, analysis, control and communications technologies to ground transportation in order to improve safety, mobility and efficiency.

i) **"In-Vehicle Display"** refers to a field-hardened, rugged touch-screen display mounted on the interior of CTDOT vehicles to provide the driver with an easy to read screen that can be used to present any useful information such as weather forecasts, treatment suggestions from the MDSS, and weather radar images. The display shall allow the driver to report on conditions, incidents, and to log activities via the touchscreen. **"Location Sensors"** means the GPS devices which collect location and direction data. Dual interior mounted covert antennas are being considered for the GPS.

j) **Maintenance Decision Support System ("MDSS")** means all servers, software, and web services necessary to provide a password-protected web portal that allows authorized users to access and map MDSS data, such as weather forecast information, pavement conditions information, and route-specific treatment recommendations. The MDSS System must allow authorized users to search, filter, export, and generate reports based on MDSS System data.

k) **On-Board Unit ("OBU") with Data Storage** means a field-hardened, interior-mounted computing unit that will integrate the data from various sensors and data inputs and store data locally until they can be transmitted via cellular connection to vendor-hosted central servers.

When connectivity to the cell network is lost, data will be stored on the vehicle temporarily until cell connectivity can be reestablished.

l) **"On-Vehicle Weather Sensors"** means weather sensors installed on CTDOT vehicles to collect information on weather and road conditions, including, but not limited to, air temperature, road temperature and relative humidity.

m) **"Other In-Vehicle Equipment"** means all other in-vehicle equipment, power harnesses, ancillaries, brackets, mountings, and components necessary to safely install sensors, cameras, displays, and data units in CTDOT vehicles in such a way as minimizes disruption and inconvenience to the driver.

n) **"Real-time data"** means sensor data, weather information, and other roadway condition information gathered in the field and reported in a timely manner. In order to be considered real-time data, the timeliness for the availability of this data will be ten (10) minutes or less from the time that the data is collected in the field.

o) **"Road Weather Management"** is comprised of weather sensors in the field, a communication system for data transfer, and central systems to collect field data from numerous weather sensors. These stations measure atmospheric, pavement and/or water level conditions. Central RWIS hardware and software are used to process observations from ESS to develop forecasts, and display or disseminate road weather information in a format that can be easily interpreted by a manager. Road weather information systems data are used by road operators and maintainers to support decision making.

p) **"Timeliness"** means the degree to which data values or a set of values are provided at the time required or specified. For the purposes of the project, real-time data timeliness must be measured as being reported to central systems within ten (10) minutes of data collection.

q) **"Vehicle Sensors"** means sensors installed on CTDOT vehicles to collect information about vehicle status, including, but not limited to, speed, odometer, and accelerometer.

r) **Weather Management Trucks ("WMT")** means CTDOT-owned and operated vehicles used for winter maintenance operations, such as snow plows.

1. <u>GENERAL</u>

A.   Introduction

This section describes the technical requirements pertaining to the procurement, installation, integration, testing, and ongoing support for the provision of Automated Vehicle Location (AVL), Maintenance Decision Support System (MDSS) - Integrated Mobile Observations (IMO) systems and services to the Connecticut Department of Transportation. The work as described is also referred to in the documents as "the Work" or "the Project."

B.   Deliverables

Refer to Exhibit D, Project Schedule and Key Milestones

C.   Maintenance, Technical Support, and Licensing

    I.   Contractor shall be responsible for providing technical support, software licensing, and system maintenance for the duration of the contract period. This must include 24/7 technical support for the AVL and MDSS websites and central systems. This must include regular preventive maintenance of all IMO vehicle equipment. This must include repair and replacement of faulty IMO vehicle equipment. This must include provision and maintenance of all required spare equipment on site at CTDOT designated facilities.

    II.   The Contractor shall host, configure, and maintain all IMO project software, servers, and websites in accordance with Connecticut state data standards, data storage, and data security policies and regulations. This must include hosting and maintaining the AVL server, AVL website, MDSS server, and MDSS website. The Contractor shall integrate all data inputs into the AVL and MDSS systems and provide all system configurations necessary to generate pavement treatment recommendations and verify system performance. The Contractor shall maintain all required data storage and respond in a timely manner to all CTDOT data requests.

    III.   The Contractor shall provide and maintain all required real-time data feeds, including the AVL data feed and the MDSS data feed. The Contractor shall provide documentation of the Real-time data feeds.

    IV.   The Contractor shall propose performance measures and reporting to demonstrate the IMO system effectiveness in achieving CTDOT's goals of more cost efficient weather management operation, more proactive roadway systems management with improved safety with decreased crashes, improved mobility and travel information, and decreased economic impacts.

2. <u>EQUIPMENT REQUIREMENTS</u>

A. General Equipment Requirements

I. The Contractor shall ensure that all work, software, services, and equipment supplied by the Contractor as part of the Contract must be consistent with relevant State of Connecticut data retention requirements. CTDOT reserves the right to review the Contractor's proposed IT policies, practices, and products to ensure consistency with the State's policies and standards are maintained throughout the duration of the Contract.

II. All materials, equipment, and systems supplied under this Contract must be new and in good condition. All materials must be of recent manufacture and the latest make and model offered by the manufacturer, unless otherwise specified and agreed to by CTDOT.

III. All equipment must be of such design and construction as to comply with the requirements hereinafter stated and any parts or attachments necessary to form a complete, functioning system must be furnished, whether specifically mentioned herein or not.

IV. The equipment supplied must be Commercial Off The Shelf ("COTS") equipment currently in use by other agencies/groups for IMO or Snow Plow Automatic Vehicle Location (AVL) applications.

V. All equipment supplied under this Contract must be interoperable with the equipment to which it is to be connected, without the need for modification.

VI. All equipment must be uniform within the vehicle classification groups (for various makes and models of WMT) and must be operational across all vehicle types.

VII. All modifications to equipment supplied under this Contract must require written approval from CTDOT, prior to modification by the Contractor.

VIII. All connections between sensors and equipment must be hard-wire ruggedized connections.

IX. All outdoor cable connections must be sealed and made weather tight using manufacturer recommended methods and materials.

X. All equipment installed in or on vehicles must be solid state with no moving parts such as fans and all communication hardware must be fully integrated into the equipment housing. All in-vehicle equipment must be enclosed by a ruggedized case.

XI. All electronics must be field-hardened and suitable for use in extreme temperature conditions and exposure to vibration.

XII. Equipment must utilize National Transportation Communications for Intelligent Transportation System Protocol ("NTCIP") standards where possible, including NTCIP 1204 (Environmental Sensor Station Interface Standard).

XIII. All equipment installed in or on vehicles must run off the vehicle's power system.

XIV. Major system components installed in the vehicle, such as the cellular modem and OBU must be able to detect and report previous power loss if equipment is disconnected then reconnected. (This reports if someone was to disable the system during their shift whether inadvertent or intentional.)

XV. All equipment installed in or on vehicles must be properly grounded and have built in protection from electrical power surges.

XVI. Upon vehicle ignition, the vehicle will automatically establish a connection to the central system. No operator interface will be necessary to begin transmitting position and sensor data. All information on vehicle status must be stored and accessible on through an online database

XVII. All equipment installed in or on vehicles must be able to remain powered on for a brief, configurable period following ignition shut-off, in order to ensure transmission of all data and the orderly shutdown of IMO systems.

XVIII. All equipment installed in or on vehicles must feature a power management feature or "sleep mode" and/or "Charge guard". This is to ensure that the vehicle battery is not discharged, after the vehicle is turned off. The current draw (Amps) of the equipment installed in or on vehicles must be minimal and allow for vehicles to sit unused for up to 2 months without discharging battery.

XIX. All equipment installed in or on vehicles must meet as a minimum Society of Automotive Engineers SAE J1455 environmental specifications and provide +/- 25g shock rating.

XX. All equipment installed in or on vehicles must be suitable for operating temperatures in the range from -40 F to 140 F and operating humidity up to 90%.

XXI. All equipment installed in or on vehicles must support over-the-air firmware updates. The system must be capable of being updated without the need to physically connect to each unit to manually update them.

XXII. All equipment installed in or on vehicles must be synchronized to the universal time clock and time stamp all data collected.

XXIII. All equipment installed in or on vehicles shall not interfere with Original Equipment Manufacturer ("OEM") electronics.

XXIV. All equipment installed in or on vehicles must allow for transferal to replacement vehicles with minimal reprogramming and downtime. Electronic equipment (e.g.,

OBU, cell modem, etc.) must be installed on a single back board in a central location. If removable storage media is used, it must have easy access to replace or reprogram if necessary.

XXV.   The system architecture for the equipment installed on or in vehicles must be designed to allow for future scalability, expansion, and modification.

XXVI.   Warranty – All equipment installed in or on vehicles by the Contractor must have a manufacturer warranty of at least one year commencing from the time of written acceptance of installation by CTDOT. The warranty period must not commence prior to issuance of written acceptance of installation, regardless of any beneficial use derived by CTDOT prior to issuance of written acceptance. All warranties must be given to CTDOT, and any warranties that exceed the contract period must be turned over to CTDOT at the expiration of the contract.

XXVII. Installation of all equipment on or in vehicles must be done at CTDOT-designated facilities. For purposes of bidding, the Contractor shall assume that all installation activities shall occur at the CTDOT Brooke Street Garage, located at 660 Brooke Street in Rocky Hill, CT.

XXVIII. Following the initial installation, all equipment repairs for equipment installed on or in vehicles will be done at the designated repair facility. Refer to Attachment 3 for a map of repair facility locations in Connecticut.

B. On-Vehicle Weather Sensor Requirement

I.   Description: Weather sensors include air temperature, road temperature and relative humidity. For vehicles with existing on-vehicle weather sensors, the Contractor shall be responsible for integrating these sensors into their IMO system. For vehicles that are not equipped with on-vehicle weather sensors, the Contractor shall install and integrate these sensors on the vehicles as part of the IMO project. The sensors must collect information on weather and road conditions. This data must then be seamlessly integrated with other data collected by the OBU and transmitted to vendor-hosted servers via a cellular connection.

II.   The On-Vehicle Weather Sensor must be a PreCise Air & Road Conditions ("ARC") TS-01 (No substitutions will be accepted).

III.   The On-Vehicle Air and Road Conditions display must be PreCise ARC System Model WCM-02 (No substitutions will be accepted).

IV.   The Contractor shall install on-vehicle weather sensors, display and cabling on each of the specified WMT to collect at minimum, the following:

        (a) Air temperature
        (b) Road temperature
        (c) Relative humidity

V.   The Contractor shall submit an installation plan to CTDOT for each WMT make and model for review and approval prior to installation of any sensors cables, and display. The plan must be in accordance with all manufacturers' requirements. The plan must include a wiring schematic and proposed locations for the TS-01 and WCM-02. Once a final installation plan is accepted and approved by CTDOT, installation of the equipment may proceed.

VI.   As described in the vehicle inventory, several of the specified WMT have already been equipped with the ARC WCM-02. For these WMT, the Contractor shall verify the functionality and operation of the existing units and provide and install all cabling and accessories necessary to integrate the On-Vehicle Weather Sensor with other vehicle equipment. The Contractor shall be responsible for replacing any sensors determined to be defective/faulty.

VII.   All on-vehicle weather sensors must be capable of sending sensor data in its original format for data integrity.

VIII.   All on-vehicle weather sensors must be integrated to provide data directly to the OBU, where the sensor data will be stored until it can be transmitted to the Contractor's central systems.

IX.   The on-vehicle weather sensor TS-01 must meet the following:

   (a) Air Temp: ±0.5°C (±1.0°F) typical
   (b) Relative Humidity: ±6% typical
   (c) Road Temp: ±1.0°C (±2.0°F) typical
   (d) Emissivity: calibrated to 0.95
   (e) Field of View: 10°
   (f) Operating Temp: -40°C to 85°C (-40°F to 185°F)
   (g) Radio Communications: IEEE 802.15.4 (2.4GHz DSSS)
   (h) Range: 10m (33ft) typical

X.   The WCM-02 on-vehicle weather sensor must display temperatures using a sunlight readable full color display. Backlight for the temperature display must be user selectable and auto-dimming.

XI.   The on-vehicle weather sensor must display temperature units in °C or °F, user selectable. The on-vehicle weather sensor must be configured to use °F.

XII.   The on-vehicle weather sensor must have an update frequency of 1 to 60 seconds, user selectable. The update frequency selected for use by the Contractor is subject to prior approval of CTDOT.

XIII.   The on-vehicle weather sensor must use 12 volt "V"-24V vehicle direct current "DC" power.

XIV.   The on-vehicle weather sensor must support RS-232, Society of Automotive Engineers "SAE" J-1708 and Controlled Area Network ("CAN").

XV. The on-vehicle weather sensor must be mounted using hardware and all necessary cabling and ancillaries as shown in the approved installation plan.

XVI. Cabling and wiring supplied and installed by the Contractor shall include:

(a) DC power, connected to the ignition side, along with an in-line fuse rated for three or five amps.
(b) Wiring harness between the WCM-02 (mounted inside the vehicle) and the TS-01 (mounted externally) the required length for connection. The wiring harness will be of sufficient length, PN 6M-5-PSG 6M/S90/S618
(c) RS-232 connector (9-pin D-connector or approved equal), for transmission of weather sensor data collected by the WCM-02 to the On-Board Unit (OBU)

C. On-Board Unit (OBU) with Data Storage Requirements

I. Description: Each WMT vehicle must be equipped with an OBU with data storage. This OBU must include a central processing unit ("CPU") and will integrate the various sensor and data inputs and transmit them via cellular connection to vendor-hosted central servers. When connectivity to the cell network is lost, data must be stored on the vehicle temporarily until cell connectivity can be reestablished.

II. The Contractor shall install an OBU with data storage in each of the designated WMTs.

III. The OBU with data storage must be installed in accordance with a CTDOT-approved installation plan. Installation must be in the interior of the vehicle and designed for ease of access and maintenance.

IV. The OBU with data storage must have sufficient ports to interface with all required IMO equipment. At a minimum, the OBU with data storage must have sufficient number and types of ports to be able to interface with all proposed vehicle sensors and equipment, along with at least one (1) spare Universal Serial Bus ("USB") Ports, and one (1) spare Ethernet port.

V. The OBU with data storage must support a minimum 256 gigabyte ("GB") of memory in a solid state industrial grade drive, intended for automotive installations. The Contractor shall demonstrate that the minimum data storage capacity is sufficient for storage of system data over extended periods of loss of communications connectivity greater than or equal to at least 48 hours of observation data.

VI. The OBU with Data Storage must provide Store and Forward capabilities capable of storing over 256 GB of information while out of cellular communications coverage and automatically forwarding the same when back in coverage. The OBU must store all sensor data until communications with the central server can be re-established and all data has been successfully transmitted and stored on the central server. Data must not be deleted or overwritten on the OBU until data has been verified as being successfully transmitted to the central server.

VII.   The OBU with data storage must transmit from all integrated sensors simultaneously with the timestamp.

VIII.   The OBU with data storage must be able to interface to on-board discrete sensor inputs and 3rd party data logging systems simultaneously.

IX.   The OBU with data storage must communicate with on-board equipment sensors installed on the vehicle to report their present status and changes to their status in real-time. The sensors, such as proximity switches, infrared, magnetic read switches, micro limit switches or equivalent must be able to communicate their present status to the equipment with necessary cabling connected to onboard equipment when required.

X.   The OBU with data storage must be programmable in common full programming language, to accept input from sensors provided by the Contractor, or third party.

XI.   The OBU with data storage must utilize a Linux or windows-based operating system to allow Visual Performance Manager ("VPN") software.

XII.   The OBU with Data Storage will be capable of carrying additional VPN software at the Department's discretion.

XIII.   Troubleshooting – The OBU with Data Storage must have self-diagnostic capabilities to facilitate troubleshooting and maintenance activities.

XIV.   Remote Configuration – The OBU with Data Storage must have remote configuration capabilities. Remote configuration must be web browser based, and capable of configuring the unit to:

(a) Set distance and time reporting intervals
(b) Set destinations for data communications
(c) Detect Sensor status changes and expansion of devices

XV.   The OBU with Data Storage must allow for future enhancements that can allow for easy configuration, expansion and scalability. (Examples include: additional sensors, control units, and hardware.)

D. In-Vehicle Display Requirements

I.   Description: The cab of each WMT must be equipped with a touch-screen display. The display must provide the driver with an easy to read screen that can be used to present useful information such as weather forecasts, treatment suggestions from the MDSS, and weather radar images. The display must also be capable of being used as a data input device to allow the driver to report on road conditions, incidents, and to log activities.

II.   The Contractor shall install an in-vehicle display in each of the specified WMT, consisting of a ruggedized touch screen securely mounted in the vehicle.

III.   The in-vehicle display must be installed in accordance with a CTDOT-approved installation plan.

IV.   The in-vehicle display must be mounted so that it can be easily viewed by the driver, and must not obstruct the vehicle dashboard displays. Mounting of the in-vehicle display must meet all meet all state, local, and federal motor vehicle regulations, laws, and standards.

V.   The in-vehicle display must be connected to the OBU with data storage.

VI.   The in-vehicle display must be connected to power in the vehicle and will not require special battery charging or replacement.

VII.   The display screen must be sized a minimum of 6 x 8 inches.

VIII.   The in-vehicle display must include a data input method, such as a keyboard, touchpad, or touch screen. Any operator controls for the display screen must be capable of only being allowed to function when the vehicle is stopped.

IX.   The in-vehicle display must allow operators to receive voice messages and text messages from a central system. The in-vehicle display must not allow operators to create or send text messages using the in-vehicle display.

X.   The in-vehicle display must include display colors easy to read at varying light levels.

XI.   The in-vehicle display must include indications of power status, cellular connectivity status, and GPS status.

XII.   The in-vehicle display must be automatically adjusted to provide optimal visibility during changing light conditions.

E. Location Sensor Requirements

I.   Description: Location sensors include the GPS device which collects location and direction data. This GPS device may be integrated in the communications equipment (e.g., cellular modem). Dual interior mounted covert antennas must be installed for the GPS. Location data shall be seamlessly integrated with other data collected by the OBU and transmitted to vendor-hosted servers via a cellular connection.

II.   The Contractor shall install a location sensor, consisting of a GPS receiver and covert antennas in each of the specified WMT. This location sensor (GPS receiver) may be integrated into the communications equipment (e.g., cellular modem).

III.   Location sensors must be installed in accordance with a CTDOT-approved installation plan.

IV.   Location sensors must report latitude, longitude, speed, time, direction of travel, and whether the receiver has a GPS position lock.

V.   The GPS receivers must be parallel tracking receivers, capable of simultaneously tracking at least four (4) GPS satellites in the best available geometry, while also tracking at least the four (4) next best and/or upcoming (rising) satellites.

VI.   The GPS receivers must be Wide Area Augmentation System (WAAS)-capable, providing position accuracy within ten (10) feet (or three (3) meters) 95 percent of the time

VII.   The GPS receivers must have a cold start solution time of two (2) minutes or less and a re-acquisition time of fifteen (15) seconds or less.

VIII.   GPS output interval must be programmable as determined by CTDOT with collection intervals at least once every second. The ability to remotely configure collection intervals on GPS units must be available.

IX.   The GPS antennas must be dual covert antennas mounted in the interior of the vehicle.

F. Equipment Sensor Requirements

I.   Description: Equipment sensors provide information on WMT equipment used for winter maintenance operations and may include spreader/auger/liquid settings, loaders, and plow position. They measure the rate of dry or liquid salt or brine application and the position of the plow blade. Exterior installations of these sensors are exposed to extreme conditions and tend to be unreliable. For this reason, integration is preferred to utilize the spreader and plow control units located in the cab of the vehicle, if the vehicle is equipped with electronic units rather than hydraulic units. Current CTDOT vehicles vary considerably in age and technology so a variety of solutions may be necessary. This data must then be seamlessly integrated with other data collected by the OBU and transmitted to vendor-hosted servers via a cellular connection. The Contractor shall review the WMT inventory and recommend best practices for integrating equipment sensor data.

II.   The Contractor shall integrate Equipment Sensor data, as available, on designated WMT to collect data from the spreader controller, loader, or other supplemental equipment for the following data:

      (a) Plow Sensor (front plow, wing, underbody, tow plow)
      (b) Pavement Temperature and Ambient Sensor
      (c) Auger Feedback Sensor
      (d) Gate Sensor
      (e) Hydraulic Flow Meter Sensor
      (f) Material Flow Meter Sensor (to monitor if material is dispensing from WMT and to verify spreader controller).

III.   Equipment Sensors must be installed in accordance with a CTDOT-approved installation plan.

IV.   All Equipment Sensors must be capable of sending sensor data in its original format.

V.   All Equipment Sensors must be integrated to provide data directly to the OBU, where the sensor data will be stored until it can be transmitted to the Contractor's central systems.

VI.   For all salt spreader controls, the data should be collected, stored and reported whenever a change to any of the following fields occurs: solid material type (e.g., salt/sand), solid material spread rate, solid material spread width, gate setting, blast on/off, pause on/off, liquid material spread rate, pre-wet on/off, and error status – depending on the functionality available for each particular spreader controller.

G. Camera Requirements

I.   Description: The Contractor shall provide and install a single, forward facing, camera mounting bracket, ceiling mounted camera in each WMT to provide both management and eventually the general public with images of weather and roadway conditions. Camera images must be transmitted to vendor-hosted servers via cellular connection. The frequency of transmittal of camera images must be configurable to provide CTDOT with flexibility to maximize the efficiency of the communications links.

II.   The Contractor shall install a camera in each of the specified WMT. The camera must be a high definition "HD" camera with tamper resistant, waterproof fixed dome ceiling mount camera.

III.   Cameras must be installed in accordance with a CTDOT-approved installation plan.

IV.   Cameras must be securely mounted to the interior cab of the WMT using a ceiling-mounted camera mounting bracket (see Attachment 7 for additional camera mounting bracket information) and forward-facing.

V.   Cameras must be integrated to provide video and camera images directly to the OBU, where the video and camera images will be transmitted to the Contractor's central systems. No camera video must be permanently recorded.

VI.   The Camera must provide maximum resolution of 1,920 x 1,080 pixels (Full HD 1080p) up to 30 frames per second with a maximum 16:9 aspect ratio.

VII.   The Camera must utilize a 1/3 type high sensitivity metal-oxide-semiconductor ("MOS") image sensor.

VIII.   The Camera must use electronic lighting control technology to automatically adjust the lighting control and shutter speed.

IX.   The Camera must feature a wide dynamic range ("WDR") to independently adjust the intensity to produce balanced lighting intensity across the camera image.

X.   The Camera must produce a color image with a minimum illumination of 0.1 lux and a monochrome image with 0.08 lux at F2.3, maximum shutter of 1/30s and high gain mode.

XI.   The Camera must equip with M12 connector which can withstand the vehicular vibration and compatible with railway applications since these cameras comply with ECE-R10.

XII.   The Camera must utilize 3D-Multi process Noise Reduction ("3D-MNR") and Frequency Divided Filter (FDF) to remove visual noises in low light conditions.

XIII.   The Camera must be rated to IP66 and National Electrical Manufacturers Association ("NEMA") 4X standard against water and dust ingress.

XIV.   The Camera must be rated to IK10 vandal resistance.

XV.   The Camera must have 2x and 4x digital zoom function.

XVI.   The Camera must have High light compensation (HLC) function.

XVII.   The Camera must have lens distortion compensation to compensate the barrel distortion.

XVIII. The Camera must have a dehumidification unit to keep the camera dry inside.

XIX.   The Camera must conform to the Open Network Video Interface Forum ("ONVIF") standard.

XX.   The Camera must meet the following:

(a) Image Sensor   1/3 type MOS image sensor
(b) Scanning Mode   Progressive
(c) Scanning Area
     5.28 mm (H) x 2.97 mm (V) {7/32 inches(H) x 1/8 inches(V)}
(d) Minimum Illumination
       i.   Color   0.1 lux (F2.3, Maximum shutter: Max. 1/30s, Gain: On(High)
       ii.   B/W   0.08 lux (F2.3, Maximum shutter : Max. 1/30s, Gain : On(High)
(e) Day & Night   Electrical
(f) Dynamic Range   122 dB typ. (dynamic : ON, Light Control Mode : indoor)

XXI.   The Camera lens must meet the following:

(a) Focal Length   2.8 mm (1/8 inches)
(b) Angular Field of View
       i.   16:9 aspect ratio   H: 108°, V: 60°
       ii.   4:3 aspect ratio   H: 89, V: 66°

XXII.   The Camera Adjusting Angle must be:

(a) Horizontal   -20° (Left) ~ +20° (Right)
(b) Vertical   -20° (Right under) ~ +90° (Right beside)

XXIII.   The Camera video must meet the following:
(a) Compression Format   H.264, JPEG
(b) Image Resolution
      i.   16:9 aspect ratio (2 mega pixel mode)
            1,920 x 1,080 / 1,280 x 720 / 640 x 360 / 320 x 180 / 160 x 90 (30fps)
      ii.   4:3 aspect ratio (3 mega pixel mode)
            2,048 x 1,536 / 1,280 x 960 / 800 x 600 / 640 x 480 / 400 x 300 / 320 x 240 / 160 x 120 (30fps)
      iii.   4:3 aspect ratio (1.3 mega pixel mode)
            1,600 x 1,200 / 1,280 x 960 / 800 x 600 / 640 x 480 / 400 x 300 / 320 x 240 / 160x120 (30fps)
(c) H.264
      i.   Transmission Mode   Constant bitrate, VBR, Frame rate priority, Best effort, Advanced VBR
      ii.   Frame Rate   1 / 3 / 5 / 7.5 / 10 / 12 / 15 / 20 / 30 / 60 fps
      iii.   Bit Rate/Client   64 / 128 / 256 / 384 / 512 / 768 / 1,024 / 1,536 / 2,048 / 3,072 / 4,096 / 6,144 / 8,192 / 10,240 / 12,288 / 14,336 / 16,384 / 20,480 / 24,576 / 30,720 / 40.960kbps
      iv.   Image Quality   Low / Normal / Fine
      v.   Transmission type   Unicast, Multicast
(d) JPEG
      i.   Image quality   10 steps
      ii.   Transmission type   Pull, Push

XXIV.   The Camera Operation must meet the following requirements:

(a) On(High) / On(Normal) / Off automatically set Off on 60fps mode.
(b) ON / OFF (Only at dynamic : ON)
(c) Adaptive Black Stretch   ON / OFF (Only when dynamic is OFF)
(d) Fog compensation   ON / OFF (Only when dynamic/ Adaptive black stretch Off)
(e) AGC   ON (LOW, MID, HIGH) / OFF
(f) Electronic Sensitivity Up   Max. 1/10,000 s, max. 1/4,000 s, max. 1/2,000 s, max. 1/1000 s,
          max. 1/500 s, max. 1/250 s, max. 1/120 s, max. 1/100 s,
          max. 2/120 s, max. 2/100 s, max. 3/120 s, max. 3/100 s,
          max. 1/30 s, max. 2/30 s, max. 4/30 s, max. 6/30 s, max. 10/30 s,
          max. 16/30 s
(g) Day & Night   Off / Auto
(h) Digital Noise Reduction   High / Low
(i) VIQS   Up to 8 zones

(j) Camera Title (OSD)   Up to 20 characters
(k) Digital Zoom   1x, 2x, 4x
(l) Lens Distortion Compensation   256 steps

XXV.   The Camera network requirements must be:

(a) Network Interface   10Base-T / 100Base-TX, RJ-45 connector
(b) IP   IPv6, IPv4
(c) Supported Protocols
     i.   IPv6   TCP/IP, UDP/IP, HTTP, HTTPS, FTP, SMTP, DNS, NTP, SNMP, DHCPv6, RTP, MLD, ICMP, ARP

     ii.   IPv4   TCP/IP, UDP/IP, HTTP, HTTPS, RTSP, RTP, RTP/RTCP, FTP, SMTP, DHCP, DNS, DDNS, NTP, SNMP, UPnP, IGMP, ICMP, ARP

(d) Web Viewer
     i.   Supported OS - Microsoft Windows 10 / 8.1, / 8 / 7
     ii.   Supported Browser - Microsoft Internet Explorer 11 / 10 / 9 / 8
                              Safari, Google Chrome, Mozilla Firefox
     iii.   GUI Language- English

XXVI.   The Camera interface requirements must be:

(a) External I/O Terminals   ALARM IN 1/DAY/NIGHT IN, ALARM IN 2/ALARM OUT,
                                   ALARM IN 3/AUX OUT

(b) SD memory card slot   1 slot, SD/SDHC/SDXC

XXVII.   The Camera electrical requirements must be:

(a) Power Source   PoE (Class 2)

(b) Power Consumption   Approx. 4.3W(PoE)

XXVIII.   The Camera Safety/EMC requirements must be:

(a) Safety   UL (UL60950-1),

(b) EMC   FCC (Part15 Class A), ICES003 Class A, EN55022 Class B, EN55024

XXIX.   The Camera mechanical requirements must be:

(a) Dimensions (D x H)Approx. 109 mm x 70 mm (ø4-9/32 x 2-3/4 inches) (Including the base bracket)

      (b) Weight   Approx. 0.41 kg (0.9 lbs.)

      (c) Construction material

        i.   Main body   Aluminum die cast
       ii.   Dome section   Polycarbonate resin

      (d) Finish

        i.   Main body   Light gray
       ii.   Dome section   Clear

      (e) Camera mounting bracket. Submittal required for approval for multiple WMT make/models

XXX.   The Camera environmental requirements must be:

      (a) Vandal Resistance   IEC 62262 IK10
      (b) Ingress Resistance   IP66, IEC60529 measuring standard compatible, Type 4X (UL50), NEMA 4X compliant
      (c) Railway Application   EN50155-T3, EN50121, EN45545, EN50498 ECE-RE (WV-SFV130M)
      (d) Operating Temperature   -40 °C ~ +60 °C (-40 °F ~ 140 °F)
      (e) Operating Humidity 10 % ~ 90 % (without condensation)

H. Vehicle Sensor Requirements

I.   Description: Vehicle sensors provide information on vehicle performance and may include the vehicle speedometer, odometer. If integration of this sensor data is necessary for proper IMO system functioning or performance, integration of this sensor data is considered as part of this IMO project. These sensors may help confirm the location of the vehicles, their speeds, and the conditions of the roadway including roughness and slippage due to ice or snow both sideways and in line with the pavement. The speedometer and odometer must be the stock versions installed on the vehicle during manufacturing. Any accelerometer, if needed, must be installed with the other equipment and networked via the OBU. There is currently a wide variation in ages and technologies among CTDOT fleet and a variety of different methods of accessing these sensors may require Contractor integration.   This data must be seamlessly integrated with other data collected by the OBU and transmitted to vendor-hosted servers via a cellular connection.

II.   Based on the make and model of the WMT, the Contractor may propose to integrate information from vehicle sensors, such as engine hours and odometer values. If engine hours and odometer values are unavailable from the vehicle's on-board computer, the Contractor's IMO solution must be able to calculate virtual Odometer and Engine Hours based on the reporting of the vehicle and GPS distance. The Contractor's IMO solution must provide user-configurable odometer and hour meter synching to the

vehicle's actual odometer and hour meter. Onboard odometer and hour meter takes precedence over any virtual data.

I. Communications Equipment Requirements

I. Description: Each WMT vehicle must be equipped with communication equipment necessary to allow the vehicle systems to communicate to central servers via the cellular network. The CTDOT IMO system must use only cellular communication to transmit data, photos, and driver communication to the operations centers. Each vehicle must be equipped with a cellular modem and covert antennas that must receive/transmit both outgoing and incoming data and messages.

II. The Contractor shall install all communications equipment, including a rugged multi-function cellular router with 3 generation "G"/4G GPS data modem, and procure all cellular services, necessary to meet the communications requirements between the instrumented WMT and the Contractor's central systems. The cell modem must be 4G Lon-Term Evolution "LTE" capable with fallback capabilities. Refer to Section 3 for additional communications requirements.

III. Communications Equipment must be installed in accordance with a CTDOT-approved installation plan.

IV. Communications Equipment must be connected to the OBU, allowing for communication to and from the OBU and the Contractor's central systems.

V. Communications Equipment must be capable of using and changing carriers by changing carrier connection card or module without changing or replacing unit or other equipment.

VI. Communications Equipment must be capable of migrating to next generation communication technologies with change of connection card or module without changing or replacing unit or other equipment.

VII. Communications Equipment must be a rugged, multi-function cellular router suitable for the temperature and vibration environment with 3G/4G GPS (Modem).

VIII. Communications Equipment must include a cellular router with Gobi 4G LTE technology that must include capability to support changing networks.

IX. Communications Equipment must include a heavy-duty enclosure and connectors designed for shock and high vibration environments.

X. Communications Equipment must include Enterprise-class routing, VPN and firewall capabilities.

XI. Communications Equipment must include dual SIM for carrier redundancy.

XII. Communications Equipment must include full on-board train certifications including AAR S-9401 and EN50155.

XIII. Communications Equipment must include a remote manager that provides mass configuration, device management, and troubleshooting tools.

    (a) Communications Equipment interfaces must include hardened connectors, including M12 for Ethernet and serial, as well as TNC connectors for antenna connections

XIV. Modem requirements:

    (a) Cellular

       i. LTE Advanced CAT 6:700(B12,B13,B29)/800(B20,B26)/850(B5)/900(B8)/AWS(B4)/1800(B3)/1900(B2,B25)/2100(B1)/2300(B30)/2500(B41)/2600(B7)
         3G HSPA+: 850/900/AWS/1800/1900/2100 MHz
         Transfer rate (max): 300 Mbps down, 150 Mbps up
         Approvals: PTCRB, AT&T, Verizon

       ii. Connector
         (2) 50 Ω TNC (Center pin: female)
       iii. Sim Slots
         (2) Mini-SIM (2FF)

       iv. Sim Security
         SIM slot cover plate

    (b) WI-FI

       i. Standard
         802.11 ac/a/b/g/n 2.4/5 GHz

       ii. Modes
         Access point, Client and support for multiple SSID

       iii. Transmit Power
         16 – 22 dBm, +/- 2 dB

       iv. Receive Sensitivity
         71 – 93 dBm, +/- 2dB

       v. Security
         Open or shared key authentication; WEP (64- and 128-bit) encryption; WPA/WPA2 with RADIUS (WPA Enterprise and pre-shared keys)

       vi. Connectors

(2) 50 Ω RP-TNC (Center pin: male)

(c)   GPS

    i.   Channels
          50

    ii.   bSensitivity
          -163 dB

    iii.   Protocol
          NMEA 0183 V2.3 sentence output; +3.3 VDC active antenna drive; NMEA
          stream to local serial port or over TCP/IP

    iv.   Navigation
          Galileo ready

    v.   Augmentation
          SBAS

    vi.   Connector
          50 Ω RP-TNC (Center pin: male)

    vii. g.   Cold Start
          < 27 seconds TTFF (90%)
  viii. Horizontal Accuracy
          < 2.5 meters (90%)
    ix.   Velocity Accuracy
          0.1m/s
    x.   Additional Features
          Send GPS via UDP/IP, TCP/IP (up to two destinations) or serial; Customize
          and/or send data using Python; GPS status query; Time source capable.

(d)   Wired Interfaces

    i.   Serial
          1 port 5-lin A-coded M12 female; DCE
          Standard RS 232
          Signal support TXD, RXD, RTS, CTS, GND
          Flow Control Software (XON/XOFF), Hardware supported
    ii.   Ethernet
          4 ports (4) 10/100 Mbps (auto-sensing)
          Connector - Option of 4-pin D-coded M12 female or 8-pin A-coded M12
  female
    iii.   I/O
          Digital I/O Input: 4 - 28 VDC; Output: 28 VDC 50 mA max
          Connector - 4-pin A-coded M12 Male (2 pins are used for I/O; the other 2
          pins are used for DC Power)

(e)   Management
  i.   Remote Management (cloud based); SNMP v1/v2c/v3 (user installed/managed)
  ii.   Local Management Web Interface (HTTP/HTTPS); CLI (Telnet, SSH, Short Message Service ("SMS"), Serial port)
  iii.   Management/Troubleshooting tools FTP, SFTP, SCP, Protocol Analyzer with PCAP for Wireshark, Event Logging with Syslog and SMTP, NTP/SNTP
  iv.   Memory minimum 128 MB NAND Flash/64 MB DDR2 SDRAM

(f)   Power
  i.   Input 9-36 VDC
  ii.   Consumption 15W max, 8.5W typical
  iii.   Connector 4-pin A-coded M12 male (2 pins are used for power; the other 2 pins are used for I/O)
  iv.   DC Power Cord 4-pin A-coded M12 female to bare wire

(g)   Physical
  i.   Dimensions (L X W X H) approx. 11.5 in x 6.65 in x 2.05 in
  ii.   Weight approximate 5.7 lbs.
  iii.   Status LEDS Power, LAN, Wi-Fi, Serial, WWAN (Link, Act, SIM), Signal Strength
  iv.   Material/Rating Aluminum Alloy/ IP54
  v.   Mounting (4) mounting slots on the unit's flange

(h)   Environmental
  i.   Operating temperature -40° C to +70° C; (Reduced cellular performance may occur above +60° C)
  ii.   Storage Temperature -40° C to +85° C
  iii.   Relative Humidity 0% to 95% (non-condensing) @ 25°
  iv.   Ethernet Isolation 2 kV RMS
  v.   Serial Port Protection (EDS) 10 kV
  vi.   Conformal Coating

(i)   Approvals
  i.   Cellular PTCRB, NAPRD.03, GCF-CC, R&TTE, EN 301 511
  ii.   CDWA/EV-DO CDG TIA/EIA-690, CDG TIA/EIA-98-E
  iii.   Safety CUL 60950, CSA 22.2 No. 60950, EN60950
  iv.   Emissions/Immunity CE, FCC Part 15 Class B, AS/NZS CISPR 22, EN55024, EN55022 Class B
  v.   Industry EN50155 (all variants); AAR S-9401 (select variants)

XV.   Enterprise software requirements:

(a) Protocols HTTP, HTTPS, FTP, SFTP, SSL, SMTP, SNMP (v1/v2c/v3), SSH, Telnet and CLI for web management; remote management via Digi Remote

Manager; SMS management, protocol analyzer, ability to capture PCAP for use with Wireshark; DynDNS, Dynamic DNS client compatible with BIND9/No-IP/DynDNS

(b) Security/VPN IP filtering, Stateful inspection firewall with scripting, address and port translation; VPN: IPSec with IKEv1, IKEv2, NAT Traversal; SSL, SSLv2, FIPS 197, Open VPN client and server; PPTP, L2TP; (5) VPN Tunnels (upgradable to a maximum of 200); Cryptology: SHA-1, MD5, RSA; Encryption: DES, 3DES and AES up to 256-bit (CBC mode for IPsec); Authentication: RADIUS, TACACS+, SCEP for X.509 certificates; Content Filtering (via 3rd party); MAC Address Filtering; VLAN support

(c) Routing/Failover IP pass-through; NAT, NAPT with IP Port Forwarding; Ethernet Bridging; GRE; Multicast Routing; Routing Protocols: PPP, PPPoE, RIP (v1, v2) OSPF, SRI, BGP, iGMP routing (multicast); RSTP (Rapid Spanning Tree Protocol); IP Failover: VRRP, VRRP+TM; Automatic failover/ failback to second GSM network/Standby APN

(d) Other Protocols DHCP; Dynamic DNS client compatible with BIND9/No-IP/DynDNS; QoS via TOS/DSCP/WRED; Modbus UDP/TCP to serial; X.25 including XOT, SNA/IP, TPAD and PAD; Protocol switch; Modbus bridging for connecting diverse field assets.

XVI. Antenna requirements:
 (a) Antenna must be a low profile wideband MIMO cellular and GPS antenna
 (b) Electrical
 i. Frequency Range (MHz) Elements 1 & 2 698-960 / 1710-3800, Element 3 1562-1612MHz
 ii. Peak Gain Isotropic ɪ Element 1 & 2: 698-960MHz 1.5dBi
  Elements 1 & 2: 1710-2170MHz 4.5dBi, Elements 1 & 2: 2500-3800MHz
5dBi
 iii. Pattern Omni-directional
 iv. Nominal Impedance 50Ω
 v. Max Input Power (W) 20
 vi. Shall support MiMo & diversity across 2G, 3G and 4G
 vii. 2 x 2 Cellular /LTE MiMo
 (c) GPS/GNSS Data
 i. Frequency Range (MHz) 1562-1612MHz
 ii. LNA Gain (dB) 26
 iii. Polarization Right Hand Circular
 iv. Operating Voltage 3-5 VDC (Fed via Coax)
 v. Current typical <20MA
 (d) Mechanical
 i. Dimensions (H X L X W) approx. 1.92" x 5.90" 1.77"
 ii. Operating Temperature (-30° / 158°F)
 iii. Material UV Stable ABS Plastic
 iv. Black color
 v. Typical weight 0.74 lbs.

(e) Mounting in accordance with manufacturer's recommendations. Mounting shall be in a location where a good ground plane can be established.
(f) Cable
    i.   Elements 1 & 2: Cell/LTE RG174 Termination 2x SMA plugs
    ii.   Element 3 GPS/GNSS RG174 Termination SMA plug

J. Other In-Vehicle Equipment Requirements

I.   Description: The Contractor shall be responsible for providing and installing all Other In-Vehicle Equipment necessary for integrated operation of sensors, cameras, data units, displays, and communications equipment. This includes all wiring, power harnesses, ancillaries, components, processors, power supplies, antennas, brackets, mountings, and hardware items.

II.   All Other In-Vehicle Equipment must be installed in accordance with a CTDOT-approved installation plan.

K. General Installation

I.   The Contractor shall procure, install, integrate, configure, and test all IMO equipment to be installed on CTDOT vehicles, including on-board weather sensors, equipment sensors, vehicle sensors, location sensors (GPS), cameras, OBU with data storage, in-vehicle displays, cellular communications equipment, and any other required on-board equipment necessary for the proper operation and performance of the IMO project. The Contractor shall be responsible for all wiring, cabling, connectors, mountings, brackets, and ancillaries required. The Contractor shall provide all required equipment spares, to be maintained on CTDOT premises for the duration of the contract period. CTDOT shall make vehicles available to the Contractor at a designated CTDOT facility for equipment installation.

II.   The Contractor shall procure, configure, install, test, and manage all communications necessary to facilitate two-way cellular communications between instrumented CTDOT vehicles and the Contractor's central systems. The Contractor shall procure unlimited data plans for 4G LTE network coverage for each vehicle installation. The Contractor shall provide all necessary hardware items, SIM cards, processors, antennas, etc. The Contractor shall be responsible for all coordination with the cellular service provider, including all technical support and service claims. The Contactor shall be responsible for managing data plans and activating/deactivating them as necessary. The Contractor is responsible for managing invoices from the cellular service provider and invoicing them to CTDOT for reimbursement as per the payment schedule.

III.   The Contractor shall conduct and participate in Communications Testing, which will consist of testing all installed cellular modems are properly configured and fully operational. Refer to section 9 testing for further Communications Testing requirements.

3. COMMUNICATIONS REQUIREMENTS

A. General Communications Requirements

I. The Contractor shall be responsible for procuring, configuring, and providing all communications necessary to facilitate two-way cellular communications between instrumented CTDOT WMT and the Contractor's central systems.

II. The Contractor shall procure unlimited data plans for 4G LTE network coverage for each WMT installation. The cellular data plan must allow for data transmittal to the Contractor's central systems to be at least 60 seconds within real time conditions for WMTs.

III. The Contractor shall transmit data using the Transmission Control Protocol/Internet Protocol ("TCP/IP") protocol.

IV. All services used will be Request for Comments ("RFC") compliant.

V. The Contractor's communications equipment must be able to operate on multiple major cellular carriers, in different parts of the state, with the simple replacement of the communications module.

VI. Cellular Coverage - The Contractor shall select a major cellular carrier with coverage of a minimum cellular signal strength of -90 dBm for at least 90% of the CTDOT roadway network across the state.

VII. Cellular Network Reliability – The Contractor shall select a major cellular carrier who maintains on-site backup power generators for all its cell tower locations.

VIII. Priority Cellular Network – The Contractor shall coordinate with major cellular carrier for all data plans provided under this contract to receive any available priority status for emergency services and first responders offered by the major cellular carrier.

IX. Two-way Communications – The Contractor shall provide capability to send messages and images to the vehicle as well as receive data and images from the vehicle.

X. Individual vs. Group/Fleet messaging – The Contractor shall provide messaging capabilities for communicating to one WMT, all WMTs, or CTDOT-configurable groups of WMTs, without use or additional cost of "text messaging".

XI. CTDOT Carrier Selection – CTDOT reserves the right, at any point during the contract period, to procure cellular data plans at a reduced cost using state contracting mechanisms. If CTDOT exercises this right, the Contractor shall be responsible for integrating and managing cellular data plans provided by CTDOT.

B. Communications Monitoring

I. The Contractor shall provide a method to automatically monitor the operational status of all the Contractor-provided communications components in real-time.

II.   The Contractor shall provide alerts in real-time to configurable designated support staff (both Contractor and CTDOT support staff) when communications faults or failures are detected.

III.   The Contractor shall collect and provide network information including system availability/uptime, latency, and bandwidth.

IV.   The Contractor shall provide reports of the operational status of the communications system.

V.   The Contractor shall record and store all maintenance reports of the communication system.

VI.   As part of its invoicing, the Contractor shall submit monthly cellular data plan charges, with allowable markup, for all cellular data plans in service that month. The Contractor shall not be reimbursed for any cellular data plan charges associated with vehicles that are out of service, or awaiting repairs.

4. AVL/GPS SYSTEM REQUIREMENTS

A. General Requirements

I.   The Contractor shall provide an AVL/GPS System that includes all servers, software, and web services necessary to provide a password-protected web portal that allows authorized users to access and map real-time data from CTDOT vehicles, including location sensor data (vehicle locations and speeds), camera images, on-vehicle weather sensor data, vehicle sensor data, and equipment sensor data. The AVL/GPS System also shall allow authorized users to search, filter, export, and generate reports based on AVL/GPS System data

II.   The AVL/GPS System must be a proven solution that has been successfully deployed for a minimum of two (2) public agency roadway clients in North America with WMT fleets of at least 200 vehicles of similar scope and complexity in the past five (5) years.

III.   The AVL/GPS System must be a web-hosted solution accessible from any web browser (including at minimum: Internet Explorer, Chrome, Firefox, and Safari) with the appropriate User Name and Login credentials.

IV.   The AVL/GPS System must provide unlimited user names and unlimited access. It is expected that potentially 300 CTDOT staff statewide will require user names and passwords.

V.   The AVL/GPS System must allow multiple users to be able to access the information simultaneously from multiple locations.

VI. The AVL/GPS System must be designed to accommodate 600 simultaneous users of the website with no noticeable impact on website performance.

VII. The AVL/GPS System must assign user privileges based on usernames and passwords. The AVL/GPS System must allow modification of the number of vehicles to be monitored, sensors to be monitored, and monitor characteristics. User access levels must be configurable for type of user (i.e. administrator, management, various office/agency level), as defined by CTDOT.

VIII. Database – The AVL/GPS System must access, store, and archive system data in a relational database specific to CTDOT. Database should be designed to preserve the integrity of collected data, include a dictionary and relationship diagram for translation, and facilitate access and integration into other systems and applications.

IX. Database Operation – The AVL/GPS System must have a database with the ability to be in continuous operation 24 hours per day, 365 days per year, and must be capable of handling year-end changes and daylight savings changes with no impact to the system.

X. Database Backup/Recovery – The AVL/GPS System must provide for automatic recovery after any type of network failure. The AVL/GPS System must allow a means of automatic data archival and backup without system interruption.

XI. Availability – The Contractor shall ensure system availability meets or exceeds 99.9%. Out-of-service time must include reboots and system maintenance, excluding planned and CTDOT-approved preventative and routine maintenance. Allowance will be made for up to 40 hours of scheduled routine and preventative system maintenance per year during non-Winter months.

XII. The AVL/GPS System's website user interface must utilize point and click features as much as possible to increase ease of use and limit input user error.

XIII. Real-Time Data Feed - The system must include a web services Application Programming Interface ("API") to allow read only secured access for raw data retrieval for use in other relational database applications (such as GIS mapping or other customer uses). Real-time data must be published to the data feed a minimum of once every 2 minutes. Refer to Section 6 "Real Time Data Feeds" for more real-time data feed requirements.

B. AVL/GPS System Website

I. This secure website must be hosted by the Contractor and must allow for authorized CTDOT personnel to monitor and access information describe herein.

II. The AVL/GPS System website must allow users to be able to view the position of their fleet vehicles at any point of time via a standard web browser on from a computer,

tablet, and/or smartphone. The primary display must be a map view of fleet vehicles with icons to indicate the status of vehicles and when it last reported.

III. The AVL/GPS System website must be responsive, automatically sizing itself to adjust to the device the user is using to view the website.

IV. Each vehicle on the map should have a unique identifier, such as license plate, as determined by color coded icon.

V. Color coded icons for at-a-glance status must be used.

VI. The AVL/GPS System must provide a minimum of the following mapping and reporting information:

    (a) Last known asset location map view – fleet wide view
    (b) Dispatch map (full screen "live" view)
    (c) Asset last location relative to home (a configurable address that may be specific to each WMT)
    (d) Asset Odometer readings, if available
    (e) Total engine hours, if available
    (f) Last time asset reported in
    (g) Last known location (individual asset map view)
    (h) Historical trip report (individual asset map view)
    (i) View Maintenance History/Update Maintenance Record
    (j) Ping Asset SMS
    (k) Distance measurement tool within the fleet-wide map view

VII. The AVL/GPS System must also provide the following mapping and reporting information:

    (a) Vehicle Identifier: This must be an identifier that is unique to the organization from which the data is being collected.
    (b) Time (required): This should be a complete description of the date and time of the report to within 1 second of accuracy. It can be in the form of a string (e.g., "12/20/2013 3:43 AM EST" or "1-20-2005 9:43 UTC") or numeric (such as a Unix timestamp, which is a count of seconds since a certain point in history). The form of string representations of the date & time is flexible, but should include at least the year, month, day, hour, minute, second and time zone of the observation (Eastern Standard Time).
    (c) Location (required): Location information should be provided in the form of a GPS latitude and longitude associated with the vehicle's location at the time of the report. Three or more decimals of accuracy are required.
    (d) Lane Identifier (required): This should be an identifier that can be used to uniquely determine the lane or lanes that a report applies to.
    (e) Maintenance Data:

        i.   Road Temperature (required)
        ii.   Air Temperature (required)

	iii.	Dew Point (required)
	iv.	Camera Feed (required): Programmed to collect a time stamped forward camera image when option is installed.
	v.	Plow Position (optional)
	vi.	Scraper/Underbody Position (optional)
	vii.	Wing Position (optional)
	viii.	Material Applied (optional)
	ix.	Material Form (optional)
	x.	Application Rate (optional)
	xi.	Application Rate Units (optional)

VIII. The map display must be such that vehicle position and status automatically update on screen without any input form the end-user, additionally, end-users must be able to view the status of monitored on-board vehicle equipment.

IX. The map display must allow the user to hover over a vehicle icon and be able to access the most recent camera image from that vehicle. The camera images update frequency should be user configurable to coincide with polling of GPS location data from the vehicles. At a minimum the camera images should be capable of being updated at least once every two (2) minutes.

X. The system must allow viewing of a vehicle in motion leaving tracks or "breadcrumbs" as it travels with arrow indicators for direction and showing all operations (GPS & telematic data) as they occur including exact street location. Users must be able to view the above mentioned data for their entire fleet or select a specific vehicle(s) for a login session using a filter tool.

XI. Users must be able to toggle back and forth between mapping interface and other features without having to close screens.

XII. The AVL/GPS System must have the capability to enter an address or select a landmark to display at a minimum the 5 closest vehicles to that location including vehicle ID & distance to the specified location.

XIII. The AVL/GPS System must have the capability to create, edit, and delete landmarks and/or geofences to be displayed on the map. In addition the landmark/geofence must be identified in the reports.

XIV. The AVL/GPS System must have an easy 'intuitive' navigation sequence (i.e. navigator bar and/or tabs for easy access to various functional screens). Tools must include but not be limited to:

 (a) Map navigational tools (zoom in/out, center, pan, etc.);
 (b) Automatic Vehicle Location Tool;
 (c) Breadcrumbs;
 (d) Filter Tool;
 (e) Historical Data; and
 (f) Reports.

XV.   Users must have options to select from different map views of the map in order to accommodate varying business requirements, desktop equipment performance, and Internet connectivity.

XVI.   The AVL/GPS System must include a playback feature allowing users to review historical data for selected vehicle(s), date(s) and timeframe. This data must be outputted via map-based (graphical) and/or text based report. When reviewing the data graphically, the playback feature must have pause, fast forward, and rewind capabilities for ease of use.

XVII.   Playback history must include the ability to leave tracks or "breadcrumbs" depicting progress and direction along a roadway. This function must enable the user to view data that has been collected from the vehicle (GPS and telematic data).

XVIII. The AVL/GPS System must provide fully licensed maps as part of its website solution.

XIX.   Reports must be available for users by interactively selecting an area using the map interface.

XX.   If available, the Contractor must provide any available Android, iOS, or Windows apps version of the website to CTDOT at no additional charge.

C. AVL/GPS System Reports

I.   Users shall have immediate access to all saved historical data and reports throughout the contract period.

II.   Data Exports – Reports must be exportable to Microsoft Excel, Microsoft Word, .csv format, and other relational databases.

III.   Vehicle Usage Report - The system must provide Daily, Weekly, Monthly and Custom usage reports to accurately display vehicle utilization as well as hourly usage reports to reflect how many minutes in each hour a vehicle was in use.

IV.   Vehicle Mileage Report – The system must provide a vehicle mileage report with user selectable date ranges showing miles traveled per day and first start/last stop times for each day in the selected date range.

V.   Vehicle Hours Report – The system must provide an engine hour report with user selectable date ranges showing engine hour usage per day and first start/last stop times for each day in the selected date range.

VI.   Vehicle Speed Applying Treatment Report – The system must provide a report of individual vehicle speeds while applying treatment in the selected date range.

VII.   Custom Reports – The system must provide a custom input usage report with user selectable date ranges showing usage of monitored auxiliary equipment such as

underbody blades, temperature sensors, and additional components. Report must be able to show all activity or be run on a single auxiliary equipment input such as plow position.

VIII.   Material Usage Report - System must provide material usage reports to accurately track the amount of granular material, pre-wet and/or direct liquid that was applied to a predefined section of roadway, or "zone". (For spreader integrated equipment only).

IX.   The Contractor shall be able to provide data from all salt spreader controllers into one report. Users shall be able to select all, multiple, or individual vehicles and date(s) and timeframe for each report. Report must output at a minimum vehicle ID, date/time, vehicle spreading time/distance, deadheading time/distance, vehicle total travel time/distance, dry material usage (pounds / lane mile), liquid material usage, avg. application rate.

X.   The system must be able to generate summary reports based on the user's input parameters. Each user shall have the ability to configure the parameters included in a report

XI.   Reports must be configurable to select a single WMT, all WMTs, or a CTDOT-configurable group of vehicles (e.g., all WMTs in a specific garage).

XII.   It must be possible to generate additional user defined reports. These include, but are not limited to:

(a) Zone/Route report
(b) Fleet Start/Stop Report
(c) Individual Vehicle Mileage Report
(d) Daily/Weekly/Monthly Asset Usage Report
(e) Custom Asset Usage Report
(f) Custom Input Usage Report (6 discreet inputs)
(g) Asset Distance Report
(h) Exception Reports

XIII.   In addition to standard reports, the system must be capable of generating exception reports for parameters such as:

(a) Stop times
(b) Speed
(c) Idle time
(d) Zones
(e) Input based exceptions (i.e. Panic buttons, PTO times, etc.)
(f) Data logging exceptions (i.e. mileage, odometer value, etc.)
(g) Exception reports

XIV.   Exception reports must be configurable by each user and the capability to generate an exception report from a combination of 2 or more parameters must be possible. For example, it must be possible for a user to create an exception report for WMTs that are applying material and traveling above a requested speed.

XV.   All exception reports must have the capability of generating an alert. Alerts must be displayed on the website and be capable of being sent automatically to CTDOT-configurable user groups via email and or text message (as defined by the user).

XVI.   The system must provide an easy to use reporting tool to provide vehicle and material information such as date, time started, time completed, total miles traveled, total miles spread, total dead head miles, material usage (Ton), application rate, Liquid usage (gal), liquid application rate, and totals of the above information per snow event/storm.

D. AVL/GPS System Data Archiving

I.   The AVL/GPS System must include a short and long-term data storage capability. The process of saving data must not interfere with the normal operation of the AVL/GPS System.

II.   Short-Term Archive - The short-term archive must consist of the latest seven (7) days of data. Data in the short-term archive must include all raw GPS data. The oldest stored data must be routinely overwritten (scrubbed) by new incoming data, such that the integrity of incoming data is preserved. Data within the short-term archive must be viewable by selecting the date and time of interest from the display interface.

III.   Long-Term Archive - The long-term archive must consist of data sets specifically saved by the user. The long-term archive must include all summary reports. Data from the short-term archive must not be overwritten until summary reports have been generated. Once saved to the long-term archive, the AVL/GPS System must not delete (scrub) data within the long-term archive. All long-term archive data must be retained in accordance with Connecticut State data retention policies and procedures. The user shall have the capability to select the date, time, and filename for the long-term archive. The AVL/GPS System must provide a capability for the user to review data from the long-term archive. This review must not interfere with the operation of the real-time system. This requirement may be met by having a separate System available to view data from the long-term archive.

E. AVL/GPS System Security

I.   The Contractor must utilize industry best practices to ensure that security of the AVL/GPS system, and immediately address any known system vulnerabilities to CONNDOT.

II.   Hosted systems must be housed in physically secure facilities.

III.   Means must be provided to prevent the unauthorized use or misuse of the AVL/GPS System. This particularly applies to those functions that can be used to reconfigure or change the operating status of the AVL/GPS System.

IV.   Security must be provided (e.g., password protection) to ensure that the AVL/GPS System cannot be accidentally disabled from any display device or network system.

5. MDSS REQUIREMENTS

A. General Requirements

I. Description: The MDSS server must receive real-time mobile observation data from equipped CTDOT vehicles. The MDSS server must also receive information from CTDOT's RWIS sites, the National Weather Service, and other weather information service providers. These data inputs must be used to generate weather forecasts, pavement condition information, and real-time, route-specific treatment recommendations. These treatment recommendations will be available for CTDOT management staff to review via the MDSS website. It will be at the discretion of supervisors to use or modify MDSS treatment recommendations. Performance measures must be used to determine the effectiveness of MDSS recommendations in terms of material use, operating costs, and safety impacts. Data must be stored on the service provider's servers in accordance with CTDOT policy requirements. A real-time data feed must also be provided, showing calculated road condition information for all snow plow routes configured in the MDSS. The output from the MDSS could be presented on the public website, showing road conditions by a limited set of categories on a map of statewide roads. Detailed raw data must be stored for an appropriate amount of time based on the storage needed. Summary reports must be available indefinitely and eventually archived at the end of the contract period. This secure website must be hosted by the Contractor and must allow for authorized CTDOT personnel to monitor and access MDSS information using any of the following Internet browsers: Internet Explorer(Version 11), Mozilla FireFox (latest version), Google Chrome (latest version), and Safari (latest version).

II. The Contractor may propose alternative system configurations that meet or exceed the overall functional and performance capabilities of the system. If the Contractor proposes an alternative system configuration to the design as specified, the Contractor shall provide a justification for the alternative system configuration and must demonstrate, to the satisfaction of the Department Representative, that the alternative system configuration meets or exceeds the functional and performance requirements of the system.

III. The Contractor shall provide an MDSS that includes all servers, software, and web services necessary to provide a password-protected web portal that allows authorized users to access and map weather forecast information, pavement condition information, and route-specific treatment recommendations. The MDSS must allow authorized users to search, filter, export, and generate reports based on MDSS data.

IV. The MDSS must detect, diagnose, forecast, and display surface transportation weather phenomena, road condition information, and winter maintenance treatment recommendations (described herein) for supporting winter road maintenance operations (e.g., snow plowing, deicing, anti-icing, etc.).

V. The MDSS must integrate environmental (weather), road condition and transportation operational data in a manner that allows it to provide predictions of pavement conditions (e.g., pavement temperature, precipitation accumulation, anti-icing chemical effectiveness, etc.) associated with winter road maintenance.

VI. Using the pavement condition and environmental prediction information, the MDSS must provide decision support guidance to winter road maintenance practitioners and the guidance must include information related to treatment options (e.g., plow, deice, anti-ice, etc.), timing of application, location of application, and amount of application) based on current and predicted weather conditions.

VII. The MDSS shall notify users when data updates (e.g., new forecasts) are available and the updates shall be loaded when the user selects to do so.

VIII. The MDSS must be a web-hosted solution accessible from any web browser (including at minimum: Internet Explorer, Chrome, Firefox, and Safari) with the appropriate User Name and Login credentials.

IX. All MDSS equipment and software must be compliant with NTCIP standard 1204.

X. The MDSS must provide unlimited user names and unlimited access. It is expected that potentially 300 CTDOT staff statewide will require user names and passwords.

XI. The MDSS must allow multiple users to be able to access the information simultaneously from multiple locations.

XII. The MDSS must be designed to accommodate 600 simultaneous users of the website with no noticeable impact on website performance.

XIII. The MDSS must include the capability to routinely monitor the system status.

XIV. The MDSS must be fault tolerant with high reliability.

XV. The MDSS must be designed in accordance with standard commercial practices for software development.

XVI. The MDSS must be designed to make reasonable allowance for expansion of computing power.

XVII. The MDSS software must be designed to ensure that it can run on commercial-off-the-shelf hardware commonly available.

XVIII. The MDSS must be designed to ensure that it can incorporate weather and road data from disparate sources (e.g., National Weather Service (NWS), Department AVL/GPS, Department Connected Vehicle projects, mesonetworks, RWIS, AWOS, etc.).

XIX. The MDSS (including all servers and displays) must be synchronized using a time standard. The MDSS must use Local Time (LT) for all displays.

XX. The MDSS displays must be implemented in English with English units as the default setting.

XXI. The MDSS must assign user privileges based on usernames and passwords. The MDSS System must allow modification of the number of vehicles to be monitored, sensors to be monitored, and monitor characteristics. User access levels must be configurable for type of user (i.e. administrator, management, various office/agency level), as defined by CTDOT.

XXII. Database – The MDSS must access, store, and archive system data in a relational database specific to CTDOT. Database should be designed to preserve the integrity of collected data, include a dictionary and relationship diagram for translation, and facilitate access and integration into other systems and applications.

XXIII. Database Operation – The MDSS must have a database with the ability to be in continuous operation 24 hours per day, 365 days per year, and must be capable of handling year-end changes and daylight savings changes with no impact to the system.

XXIV. Database Backup/Recovery – The MDSS must provide for automatic recovery after any type of network failure. The MDSS must allow a means of automatic data archival and backup without system interruption.

XXV. Availability – The Contractor shall ensure MDSS system availability meets or exceeds 99.9%. Out-of-service time will include reboots and system maintenance, excluding planned and CTDOT-approved preventative and routine maintenance. Allowance will be made for up to 40 hours of scheduled routine and preventative system maintenance per year during non-Winter months.

XXVI. The MDSS website user interface must utilize point and click features as much as possible to increase ease of use and limit input user error.

XXVII. Real-Time Data Feed - The system must include a web services Application Programming Interface (API) to allow read only secured access for raw data retrieval for use in other relational database applications (such as GIS mapping or other customer uses). Refer to Section 6 "Real Time-Data Feeds" for more real-time data feed requirements.

B. MDSS Operation

I. The Contractor shall demonstrate an understanding of Connecticut weather and climatology, as well as a thorough knowledge of winter weather patterns and the variations within the State. Refer to Attachment 4 for CTDOT's Weather Zones Maps.

II. The Contractor shall demonstrate an understanding of CTDOT's winter maintenance practices. Refer to Attachment 5 for CTDOT's Snow and Ice Guidelines.

III. The weather forecasting system shall include integrated MDSS functionality to support appropriate road maintenance actions that result in optimal road surface results with

efficient use of resources for specific weather conditions. Treatment recommendations must be provided for each hour of the forecast when indicated by the current and future pavement and weather forecast parameters.

IV.   The system must support the FHWA Pavement Recommendation Rules of Practice regime as the default treatment recommendations for specific weather situations. It must also allow users to incorporate their own customized treatment plan recommendations to reflect individual best practices in chemical application, timing, type and rate as well as plowing actions. Users must also be able to select the appropriate route cycle times or times for their routes. Treatment recommendations must be provided for the next 48 hours to indicate required actions prior to, during, and after a storm.

V.   All forecasts provided by the Contractor shall become the property of CTDOT. CTDOT may, at its discretion, share the forecast with other agencies as appropriate. A unique forecast shall be provided for each localized area/route.

VI.   Maintenance Decision Support tools including road treatment recommendations will be required November 1st through April 30th, unless otherwise instructed by CTDOT.

VII.   Long-term Forecast will be provided once daily and will cover a period of 1 to 10 days. The long-term forecast will be provided year round.

VIII.   Forecasting parameters must be selectable enabling each one to be turned on or off.

IX.   Forecasts must be displayed hourly for 48 hours and daily for 10 days.

X.   Users must be able to select customizable alerts for specific weather data or sensor data. Limits must be selectable for each alert. Users will have the option of getting alerts via text, phone, or email. Alerts can be sent to an individual user or to a CTDOT-configurable group of users.

C. MDSS Coverage Area

I.   The MDSS must be designed to operate (via configurable files) in any user-defined region (e.g., state, city, county, etc.) that has input data necessary to support its operations.

II.   The MDSS must generate weather forecasts for zones or regions around the State as identified by the user (e.g., forecast zones, maintenance zones, etc.).

III.   The MDSS shall provide weather and road condition products (via configurable files) for road routes (maintenance routes) identified by the user.

D. Weather Forecast Products

I.   Weather forecast products refer to weather elements above the ground. Weather forecast products must be provided out to at least 48 hours. Weather forecast products

must have a temporal resolution of at least one hour. Weather forecast products must be updated no less than every three hours; that is, a new 48-hour forecast will be provided every three hours.

II.   The following weather forecast products must be provided 2 meters above ground level (AGL), unless otherwise noted:

    (a) Surface air temperature
    (b) Surface dew point
    (c) Surface relative humidity
    (d) Surface wind speed & direction
    (e) Surface wind gust
    (f) Precipitation type
    (g) Precipitation rate
    (h) Snowfall accumulation (e.g., 3-hr total, 6-hr total, and total accumulation during the forecast period)
    (i) NWS watches, warnings and advisories

III.   The weather forecast products must be geo-referenced to the Department's domain using map overlays that include roads, road designators, political boundaries, etc.

IV.   Surface Air Temperature Forecast Product - The output (content) of the Surface Air Temperature Forecast Product on the display must have the following characteristics:

    (a) The surface air temperature must be provided in degrees Fahrenheit
    (b) Time series information (text and graphical formats) of the surface air temperature must be provided.
    (c) Reference lines (configurable) associated with frequent thresholds (e.g., freezing) must be provided.

V.   Surface Dew Point Temperature Forecast Product - The output (content) of the Surface Dew Point Temperature Forecast Product on the display must have the following characteristics:

    (a) The surface dew point temperature must be provided in degrees Fahrenheit
    (b) Time series information (text and graphical formats) of the surface dew point temperature must be provided.

VI.   Surface Wind Speed & Direction Forecast Product - The output (content) of the Surface Wind Speed & Direction Forecast Product on the display must have the following characteristics:

    (a) The wind speed must be provided in statute miles per hour by default
    (b) The wind direction must be provided in degrees with respect to true north.
    (c) Time series information (text and graphical formats) of the wind speed and direction

VII. Surface Wind Gust Forecast Product - The output (content) of the Surface Wind Gust Forecast Product on the display must have the following characteristics:

(a) The wind gust speed msut be provided in statute miles per hour.
(b) Time series information (text and graphical formats) of the wind gust speed must be provided.

VIII. Conditional Probability of Precipitation Type Forecast Product - The conditional probability of precipitation type is a product that describes the probability that a particular precipitation type (e.g., rain, snow, freezing rain, etc.) will occur if there is any precipitation at all.
The Precipitation Type Forecast Product must include the conditional probability of precipitation type. That is, the user must be able to view the probability of each type of precipitation as well as the predominant type. The precipitation type must be provided for at least the following:

(a) Rain
(b) Snow
(c) Ice
(d) Mixed (rain, snow, ice)
(e) The predominant precipitation type (the type that the model selects as the most likely kind that will occur) shall be identified.
(f) Time series information (text and graphical formats) of the predominant precipitation type must be provided.

IX. Precipitation Rate Forecast Product - The output (content) of the Precipitation Rate Forecast Product on the display must have the following characteristics:

(a) The liquid equivalent precipitation rate must be provided in inches per hour (to a precision of a hundredth of an inch).
(b) The snowfall precipitation rate must be provided in inches per hour (to a precision of a tenth of an inch).
(c) Time series information (text and graphical formats) of the precipitation rate must be provided.

X. Snowfall Accumulation Forecast Product - The Snowfall Accumulation Product must indicate the amount of snow that is expected to reach the surface (ground) over a specified period. Melting of precipitation due to warm surface conditions is not considered in this product. The output (content) of the Snowfall Accumulation Forecast Product on the display must have the following characteristics:

(a) The snowfall accumulation must be provided in inches (to a precision of a tenth of an inch).
(b) Time series information (text and graphical formats) of the snowfall accumulation must be provided.
(c) Snowfall accumulation must be provided at user-defined temporal increments out to 48 hours (e.g., 3-hour, 6-hour, 12-hour accumulation, etc.).

E. Weather Observation Products

    I.   Weather observation products must be provided by the MDSS. The weather observations products must be geo-referenced to the DOT domain using map overlays that include roads, road designators, political boundaries, etc.

   II.   Weather observation products must include, but not be limited to, observations from the following sources: NWS, DOT, FAA, and other sources as available.

 III.   Weather observation products must include the following parameters, where available:

         (a) Air temperature (degrees F)
         (b) Relative humidity (percent)
         (c) Dew point (degrees F)
         (d) Wind speed & wind direction (miles per hour & degrees with respect to true north)
         (e) Radar Imagery

 IV.   The weather observation products must update as new data arrive. The output (content) of the weather observation products on the display must have the following characteristics:

         (a) The surface observation data must expire off the screen after a configurable number of minutes.
         (b) The expiration time must be independently configurable for each observation product.
         (c) Time series (text and graphical formats) must be provided.
         (d) Animation of the observations must be provided.

F. Radar Product

    I.   The radar product must be based on data provided by NOAA. Other radar data sources may be used if applicable (e.g., FAA Terminal Doppler Weather Radar, local media owned radars). The radar product must be based on the reflectivity (intensity) field. The radar product shall update as new data arrive.

   II.   The output (content) of the radar product on the display must have the following characteristics:

         (a) The radar reflectivity (intensity) field must be displayed (plus color legend).
         (b) Radar products must be provided for user-defined domains.

G. NWS Watch, Warnings and Advisories Product

    I.   The MDSS must provide NWS watch, warnings and advisories for the DOT domain.

   II.   The NWS watch, warnings and advisories must include, but not be limited to:

(a) Winter storm watches and warnings
(b) Flood watches and warnings
(c) Flash flood watches and warnings
(d) Severe thunderstorm watches and warnings
(e) Tornado watches and warnings
(f) High wind watches and warnings
(g) Special weather statement
(h) Freeze watches and warnings
(i) Winter weather advisories
(j) Dense fog advisories
(k) Snow advisories

III.   The NWS watch, warning and advisory product must be provided in text format. Graphical depictions of NWS watches and warnings may be provided, where applicable.

IV.   When an NWS watch, warning or advisory is in effect for an area (configurable) that covers the DOT domain, the display must provide an indicator (e.g., highlighted button).

H. Road Condition Observation Products

I.   Road condition observation products must be provided and shown on the display.

II.   Road condition observation products may include, but not be limited to, observations or measurements from the following sources:

(a) Road Weather Information Systems (RWIS)
(b) Mobile Road Weather Information Systems (MRWIS)
(c) GPS/AVL data and Connected Vehicle data from Department fleet

III.   Road condition observation products must include the following parameters, where available

(a) Road temperature (degrees F)
(b) Subsurface temperature (degrees F)
(c) Chemical concentration on road (percent by weight)
(d) Freeze point temperature (degrees F)
(e) Pavement condition as: Wet, Dry, or Chemically Wet
(f) Snow, frost, and ice depth (inches
(g) Blowing snow (yes/no)
(h) Visibility (miles or fractions of miles)

IV.   The road condition observation products must update as new data arrive. The output (content) of the road condition observation products on the display must have the following characteristics:

(a) The surface observation data must expire off the screen after a configurable number of minutes

(b) The expiration time must be independently configurable for each observation product.

(c) Viewing of the product must be user selectable.

(d) Time series (text or graphical formats) of the observations must be provided.

(e) Animations of the road condition products must be provided.

I. Road Condition Prediction Products

I.   The road condition prediction products shall be provided out to at least 48 hours.

II.   The road condition prediction products shall have a temporal resolution of at least one hour.

III. The road condition prediction products shall be updated every three hours; that is, a new 48-hour forecast shall be provided no less than every three hours.

IV.   The following road condition prediction products shall be provided:

(a) Road temperature
(b) Road chemical concentration
(c) Snow depth on road
(d) Blowing snow potential
(e) Pavement frost potential
(f) Pavement condition

J. Road Temperature Prediction Product

I.   The Road Temperature Prediction Product must be provided at predefined (configurable) locations associated with each CTDOT maintenance route. The Road Temperature Prediction Product shall be based on a thermal energy balance model and/or empirically based model.

II.   The output (content) of the Road Temperature Prediction Product on the display must have the following characteristics:

(a) The road temperature must be provided in degrees F
(b) The road temperature must be presented graphically at each forecast location within the chosen (configurable) maintenance routes.
(c) Time series information (text and graphical formats) must be provided.

K. Road Snow Depth Prediction Product

I.   The Road Snow Depth Prediction Product shall provide information that describes the amount of snow that is predicted to accumulate on a road surface without traffic and for specific winter maintenance treatments

II. Calculation of the Road Snow Depth Prediction Product shall take into account (at a minimum) the forecasted precipitation type and rate, and road temperature to estimate the amount of snow that will accumulate on the road surface.

III. The Snow Depth Prediction Product shall be provided at predefined (configurable) locations within each CTDOT maintenance route.

IV. Calculation of the Snow Depth Prediction Product shall take into account treatment options including the amount of snow expected to accumulate on the road when;

(a) no treatment is performed,
(b) the recommended treatment is performed, and
(c) a user-defined treatment is performed.

V. The output (content) of the Snow Depth Product on the display must have the following characteristics:

(a) The snow/ice amount must be given in inches by default (to a tenth of an inch)
(b) The snow depth must be shown for various treatment options including: no treatment, recommended treatment, and user-defined treatment.
(c) The road snow depth must be presented graphically at each forecast location associated with the chosen (configurable) maintenance routes.
(d) Time series information (text and graphical formats) of the road contamination accumulation must shall be provided.

L. Blowing Snow Potential Product

I. The Blowing Snow Potential Product must provide information that describes the likelihood for blowing snow (e.g., low, medium, high). Calculation of the Blowing Snow Potential Product must take into account (at a minimum) recent snowfall characteristics, the forecasted precipitation type and rate, predicted wind speed, local topography, and predicted air temperature. The Blowing Snow Potential Product must be provided at predefined (configurable) locations within each CTDOT maintenance route.

II. The output (content) of the Blowing Snow Potential Product on the display must have the following characteristics:

(a) The likelihood value for blowing snow (e.g., low, medium, high or as a percentage)
(b) Likelihood values must be provided at hourly increments.
(c) Likelihood values must be provided at hourly increments.
(d) Time series information (text and graphical formats) must be provided

M. Pavement Frost Potential Product

III. The Pavement Frost Potential Product must provide information that describes the likelihood for frost on the pavement surface (road and/or bridges) (e.g., low, medium, high or as a percentage). Calculation of the Pavement Frost Potential Product must take

into account (at a minimum) predicted pavement temperature, predicted precipitation type and rate, predicted wind speed, predicted relative humidity (considerations of dew point/frost point), and predicted air temperature. The Pavement Frost Potential Product must be provided at predefined (configurable) locations within each CTDOT maintenance route.

IV. The output (content) of the Pavement Frost Potential Product on the display must have the following characteristics:

(a) The likelihood value for pavement frost (e.g., low, medium, high or as a percentage)
(b) Likelihood values must be provided at hourly increments
(c) Likelihood values must be provided for each road forecast segment (e.g., plow route).
(d) Time series information (text and graphical formats) must be provided.

N. Pavement Condition Prediction Product

I. The Pavement Condition Prediction Product must provide information on the predicted state of the pavement and include:

(a) Wet
(b) Dry
(c) Chemical wet
(d) Percent coverage of snow and
(e) Snow, frost, and ice depth (inches)

II. The output (content) of the Pavement Condition Prediction Product on the display must have the following characteristics:

(a) The pavement condition must be presented in text format indicating the pavement condition (e.g., wet, dry, chemical wet, etc.) for each road forecast location (e.g., plow routes).

(b) Time series information (text and graphical formats) must be provided.

III. Calculation of the Pavement Condition Prediction Product shall take into account the pavement condition when;

(a) no treatment is performed,
(b) the recommended treatment is performed, and
(c) a user-defined treatment is performed.

O. Forecast Confidence Product

I. A measure of confidence shall be provided for the following weather forecast and road condition prediction products:

(a) Snow accumulation
(b) Precipitation type
(c) Road temperature

II. The calculation of prediction confidence must take into account recent statistical performance of each parameter and other appropriate metrics.

III. The output (content) of the Prediction Confidence Product on the display must have the following characteristics:

(a) The prediction confidence must be given as a percentage, and must be able to be displayed graphically.
(b) Error statistics must be calculated that reflect recent skill.
(c) Time series information of the prediction confidence or error statistics must be provided for the above-mentioned products.

P. Generation of Treatment Recommendation Predictions

I. The MDSS must provide treatment recommendation predictions for winter road maintenance at user defined (configurable) locations (e.g., plow routes).

II. The MDSS must provide treatment recommendation predictions out to no less than 24 hours into the future.

III. The winter maintenance rules of practice used in the MDSS must be based on the CTDOT Snow & Ice Guidelines (see Attachment 5), and be configurable, as necessary, to reflect local CTDOT practices.

IV. Treatment recommendations must include the following for each user defined route:

(a) Recommended initial treatment start time
(b) Recommended subsequent treatment start time
(c) Recommended treatment type (e.g., chemical, abrasives, plow)
(d) Recommended chemical type based on available chemicals as identified by the Department
(e) Recommended material rate (e.g., amount per lane mile)
(f) Recommended pre-treatment type (solid or liquid), where applicable

V. The MDSS must have a capability to incorporate constraints (configurable) for each route so that irrelevant treatment recommendations are not provided. For example, the use of NaCl should not be recommended if the user does not use that chemical. Constraints may include:

(a) Available materials (e.g., NaCl, $MgCl_2$, $CaCl_2$, abrasives etc.)
(b) Application rate limits (based on truck spreading limits)
(c) Route cycle limits (minimum turnaround time to repeat treatments)

VI. Treatment recommendations must be calculated, to the greatest extent possible, using a combination of current observational data on the state of the roadway and predicted weather and road conditions.

VII. Treatment recommendation calculations should consider, to the greatest extent possible, factors that impact treatment effectiveness (e.g., chemical scatter, splatter, traffic impacts, spreader characteristics, etc.).

Q. System Alert Function

I. The System must provide a capability to alert the user when specific data thresholds (configurable) have been exceeded. Users shall be able to query the System and view the information related to an alert.

II. The System must indicate that an alert is active by one or more of the following methods:

(a) Highlighting an alert button
(b) Changing the color of an alert button
(c) Flashing an alert button
(d) Audible alert (finite series of beeps or tones)

III. The System must include a capability to send e-mail or text message notices to an individual user or a CTDOT-configurable group of users when specific alerts (configurable) are generated.

R. MDSS Display

I. The MDSS website display must have the following general capabilities:

(a) Ability to view plan-view graphics
(b) Ability to view time-series information
(c) Animation
(d) Time selection whereby the user can select the time period for data viewing
(e) Print function
(f) Alert function
(g) Ability to review historical data
(h) Ability to select viewing area
(i) Ability to select products for viewing
(j) Help function
(k) Ability to combine data on time series plots
(l) Ability to configure data ranges (scale) for each time series plot
(m) Ability to overlay and combine graphical products

II. The MDSS in-vehicle display must have the following general capabilities:

(a) Ability to view plan view graphics
(b) Ability to view local radar

    (c)   Ability to view route specific treatment recommendations
    (d)   Ability to view route specific weather and pavement forecast
    (e)   Ability for vehicle operators to report on road conditions

S. MDSS Map Overlays

I.   The System must make it straightforward (e.g., via configuration files) to incorporate new map data.

II.   Map overlays must be available for the following:

    (a)   Roads (State and local highways and secondary roads)
    (b)   Road designators (e.g., route numbers, etc.)
    (c)   Road Control section and mile marker identification.
    (d)   CTDOT Districts, CTDOT Maintenance Zones, and CTDOT Weather Zones
    (e)   Political boundaries (e.g., States, counties, etc.)
    (f)   Cities
    (g)   Weather and road condition observation sites

T. MDSS Data Archive

III.   The MDSS must include a short and long-term data storage capability. The process of saving data must not interfere with the normal operation of the MDSS.

IV.   Short-Term Archive - The short-term archive must consist of the latest forty-eight (48) hours of data. The oldest stored data must be routinely overwritten (scrubbed) by new incoming data, such that the integrity of incoming data is preserved. Data within the short-term archive must be viewable by selecting the date and time of interest from the display interface.

V.   Flagged Storm Data – The MDSS must be able to flag data in the short-term archive so that it will be permanently saved and not automatically overwritten. CTDOT shall be able to notify the Contractor that it would like data to be retained indefinitely for up to ten (10) separate storm events. This detailed storm data would be indefinitely retained, until CTDOT approves overwriting of this data.

VI.   Long-Term Archive - The long-term archive must consist of data sets specifically saved by the user. The long-term archive must include all summary reports. Data from the short-term archive must not be overwritten until summary reports have been generated. Once saved to the long-term archive, the MDSS must not delete (scrub) data within the long-term archive. All long-term archive data must be retained in accordance with Connecticut State data retention policies and procedures. The user must have the capability to select the date, time, and filename for the long-term archive. The MDSS must provide a capability for the user to review data from the long-term archive. This review must not interfere with the operation of the real-time system. This requirement may be met by having a separate system available to view data from the long-term archive.

VII.   The MDSS must have a capability to view (recent) historical weather and road condition prediction products together with actual observational data to give the user an indication of the performance of the weather and road condition predictions.

VIII.   Users shall have the ability to select any of the forecasts from the previous 24-hour period. For example, the user shall be able to select a forecast 6 hours previous and compare the predicted conditions to the actual conditions.

U. MDSS Security

I.   The Contractor shall utilize industry best practices to ensure that security of the MDSS, and immediately address any known system vulnerabilities.

II.   Hosted systems must be housed in physically secure facilities.

III.   Contractor shall prevent the unauthorized use or misuse of the MDSS. This particularly applies to those functions that can be used to reconfigure or change the operating status of the MDSS.

IV.   Security must be provided (e.g., password protection) to ensure that the MDSS cannot be accidentally disabled from any display device or network system.

6. REAL-TIME DATA FEEDS

A. Access to Data

I.   The Contractor shall provide a real-time API for the following two data feeds:

(a) Real-time AVL/GPS data, with sensors data with camera images
(b) Real-time MDSS data.

II.   The real-time AVL/GPS data feed must include all applicable WMT vehicle location information along with the most recent associated camera image. Authorized CTDOT users must be able to filter information for which WMT is published to the real-time data feed by any combination of the following filters:

(a) Only vehicles within a certain (configurable) distance of snow plow routes or other geo-fenced area
(b) Only vehicles traveling over a certain (configurable) speed
(c) Only vehicles meeting a certain (configurable) status condition (e.g., snow plow is down)
(d) Only a certain (configurable) subset of the WMT fleet

III.   The camera image must include a timestamp of when the camera image was taken.

IV.   The real-time MDSS data feed must include estimated pavement condition information for all configured CTDOT roadway segments.

V.   The Contractor shall support server to server communication for real-time data transfer.

VI.   The Contractor shall provide updated real-time data at a minimum frequency of once every two (2) minutes. Update frequency must be user configurable.

VII.   The Contractor shall allow CTDOT to temporarily store real-time data locally on CTDOT-owned and -maintained server hardware.

VIII.   The Contractor shall allow CTDOT to interface their ATMS (the CRESCENT system) and Traveler Information Systems, including, but not limited to, the CT Travel Smart website, with the real-time data feed.

B. Performance

I.   The Contractor shall supply real-time data with a maximum timeliness allowable of three (3) minutes. Timeliness must be defined as the time period between when the time data was measured in the field and the time that data is received at the CTDOT local hosting server.

II.   Real-time data services must have Availability of 99.9%. Allowance will be made for up to forty (40) hours of scheduled routine and preventative system maintenance per year during non-winter months.

III.   The Contractor shall employ automatic methods and tools to measure and monitor system performance and compliance with these system availability requirements throughout the term of the Contract.

C. Mapping Standard

I.   The Contractor shall provide real-time data at the link level using an industry standard mapping system, such as Traffic Message Channel (TMC) codes.

II.   The Contractor shall provide required data for each segment of the roadway system:

    (a) Segment definition must be based on logical breaks in facilities where one would expect the potential for differing traffic conditions such as an interchange, a lane drop or a major at grade intersection.
    (b) At a minimum, roadway segments must break at each interchange.
    (c) Segment definitions must at a minimum contain beginning and ending latitude, longitude, heading, common name or route number, and a unique identifier (such as the TMC code).

D. Data Sharing

I.   The Contractor shall provide full right to CTDOT and its officially designated representatives for internal CTDOT use of all real-time data.

II. The Contractor shall provide full right to CTDOT and its officially designated representatives to disseminate real-time data, processed real-time data, and any information and calculations derived from the real-time data to the general public.

E. Privacy

I. The Contractor shall ensure that all real-time data does not contain any Confidential Information

7. **CONTRACTOR SERVICES**

A. General

I. The Contractor shall be responsible for providing a fully functional turn-key solution, including provision, installation, and integration of all equipment; provision, configuration, management of all communications services, including cellular data plans; provision, configuration, and support for all software, websites, and real-time data feeds; and all required testing and documentation necessary for system acceptance. Following system acceptance, the Contractor shall be responsible for providing equipment and software maintenance, licensing, and support.

II. The Contractor shall install all equipment on WMTs provided as part of this Contract, including sensors, cameras, OBUs with data storage, and communications equipment. A detailed installation plan must be provided to CTDOT as part of the System Design documentation and approved before any installation may commence. The Contractor shall be responsible for providing all tools and equipment necessary to complete installation.

III. The Contractor shall provide regular preventive maintenance of all equipment installed on WMTs as part of this Contract. At minimum, annual maintenance and inspection of all equipment must be conducted prior to the start of the winter maintenance season (November 1st to April 30th). Preventive maintenance must be scheduled with CTDOT at least thirty (30) calendar days in advance. Documentation on preventative maintenance of hardware will be provided to CTDOT.

IV. The Contractor shall be responsible for the repair and replacement of faulty equipment throughout the duration of the Contract period. Equipment repairs must occur at designated repair facilities located throughout the State of Connecticut. Maintenance and Technical Support requirements are described below in Sections section B. "Technical Support"

V. The Contractor shall be responsible for the configuration and maintenance of cellular communications, including provision of unlimited data plans.

VI. The Contractor shall be responsible for the hosting and maintaining of all system software and websites, in accordance with Connecticut state data standards, data storage, and data security policies and regulations.

VII. The Contractor shall be responsible for the provision and maintenance of all real-time data feeds.

VIII. The Contractor shall be responsible for the provision and maintenance of all required data storage and must respond to all CTDOT data requests.

IX. The Contractor shall be responsible for integration of all data inputs into the MDSS and initial configuration.

X. All data collected as part of this Contract is the property of CTDOT and shall be turned over to CTDOT at the end of the contract.

B. Technical Support

I. The Contractor shall provide a suitable means of communication between the Contractor and CTDOT. This must include a twenty-four (24) hour telephone number for contacting Contractor personnel for urgent AVL/GPS and MDSS server issues, website issues, and Contractor-provided WMT equipment (e.g., OBU, weather sensors, cellular modem, GPS unit, antennas, camera, etc.). The Contractor shall also provide support via telephone and email for maintenance problems regarding the hardware, software, communications, services, and systems provided as part of this Contract.

II. For the purposes of technical support and maintenance on this project:

Regular Hours Work Period "Regular Hours"
The hours between 7:30 A.M. and 3:30 P.M, Monday through Friday are considered regular hours (the "Regular Hours Work Period"), excluding the following holidays, New Years' Day, Memorial Day, Independence Day, Labor Day, Thanksgiving and Christmas.

Off-Hours Work Period
All work outside the Regular Hours Repair Work Period is considered as off-hours work ("Off Hours Work"). The hourly rate for both Regular Hours Repair Period and Off-Hours Work will be based on one (1) person working for one (1) hour of work including, but not limited to, all travel, equipment, vehicles, tools, test equipment, etc.

III. The Contractor shall provide a single point of contact for technical support for the entire system, with the exception of non-contractor furnished sensors.

IV. For urgent AVL/GPS server system or AVL/GPS website issues, when CTDOT notifies the Contractor of a technical support issue, the Contractor shall acknowledge receipt of the notification within four (4) hours. From November 1 to April 30 each calendar year, the Contractor shall restore full AVL server systems and Website operations within twelve (12) hours from notification.

V. For urgent MDSS server system or MDSS website issues, when CTDOT notifies the Contractor of a technical support issue, the Contractor shall acknowledge receipt of the

notification within four (4) hours. From November 1 to April 30 of each calendar year, the Contractor shall restore full MDSS server systems and Website operations within twelve (12) hours from notification.

VI. For any service to the AVL and MDSS Server Systems and Website between May 1 and October 31 each calendar year, the Contractor shall acknowledge receipt of the notification within one (1) business day. From May 1 to October 31 each calendar year, the Contractor shall restore full AVL server systems and website operations within two (2) business days from notification.

VII. For all Contractor-provided WMT equipment maintenance issues, when CTDOT notifies the Contractor of a technical support issue, the Contractor shall acknowledge receipt of each issue notification within four (4) regular hours of the start of the next business day. From November 1 to April 30 each calendar year, the Contractor shall restore each WMT equipment within (2) business days from notification.

VIII. For any service to the Contractor-provided WMT equipment between May 1 and October 31 each calendar year, the Contractor shall acknowledge receipt of the notification within one (2) business days. From May 1 to October 31 each calendar year, the Contractor shall restore each WMT equipment within five (5) business days from notification.

IX. The Contractor shall notify CTDOT immediately of any faults or failures detected.

X. The Contractor shall notify CTDOT immediately of any unplanned system maintenance.

XI. The Contractor shall respond to any and all CTDOT data requests to comply with FOIA requirements within fourteen (14) days. The Contractor shall provide data at no additional charge to the Department.

C. Maintenance and Repairs

I. During the Maintenance, Technical Support, and Licensing period(s), the Contractor shall service and maintain all equipment provided by the Contractor as part of this project. Contractor shall be available to service and maintain all equipment on twenty-four (24) hours per day, seven (7) days per week basis.

II. Depending on operational needs and WMT and facility availability, CTDOT, at its sole discretion, may alter these repair times to provide the Contractor with additional repair time if WMT or repair facility is not immediately available.

III. For non-emergency maintenance repairs, the Contractor shall submit its proposed repair schedule to CTDOT Maintenance Supervisor for review and approval.

IV. The Contractor shall notify CTDOT immediately by telephone upon its arrival at the work location. The Contractor shall notify CTDOT immediately upon completion of the work operation and confirm with CTDOT's representative that the task has been

completed prior to leaving the site. This notifications procedure must be followed for each work site that the Contractor has been dispatched to.

V.   The Contractor shall maintain sufficient amount of replacement equipment packages on hand (spares) to provide a consistent level of service. For equipment installed on the vehicle exterior, at minimum, a quantity equal to 10% of the total equipment provided by type must be kept on hand as spares at all times during the Maintenance, Technical Support and Licensing period. For equipment installed on the vehicle interior, at minimum, a quantity equal to 5% of the total equipment provided by type must be kept on hand as spares at all times during the maintenance, technical support and licensing period. Spares must be located on CTDOT premises under separate lock and key. CTDOT shall provide the Contractor access to spares during Regular Hours.

VI.   CTDOT reserves the option of supplying to the Contractor spare parts or any component, part or assembly that the Contractor needs to replace faulty parts or equipment.

VII.   At the end of the Contract period, the Contractor shall turn all spares over to CTDOT.

D. Licensing

I.   The Contractor shall provide to the Department a fully licensed complete software solution for the duration of the Contract. The Contractor represents and warrants that the products and services that it provides pursuant to this agreement do not infringe the intellectual property rights of any third party, including any patent, trademark, trade dress, copyright or trade secret rights.

II.   Unless otherwise specified, the software and firmware must be the latest edition or version offered at the time of the Department's acceptance of design documentation.
III.   During the Maintenance, Technical Support, and Licensing period(s), the Contractor shall notify the Department of the availability of enhancements, releases, and newer versions of the AVL/GPS system and the MDSS, including all bug fixes, patches, and modifications.

IV.   When enhancements, releases, and newer versions become available, the Contractor shall provide the Department with reasonable supporting materials detailing the impacts and risks associated with implementing such enhancements, releases and newer versions. Based on the anticipated impacts and risks, the Contractor shall consult with the Department concerning the advisability of implementing such enhancements and newer versions. The Department shall then decide whether or not to request the implementation of the enhancement, release, or newer version. If The Department decides not to implement the enhancements or new versions, the Contractor shall continue to maintain and support the current version of the software for the duration of the contract period.

V.   Upon the Department's request, and within thirty (30) calendar days, the Contractor shall implement the enhancement, release, or the new version for the Department. In

doing so, the Contractor shall provide such enhancements, releases, and new versions to the Department at no charge.

VI. Following implementation of the enhancement, new release, or new version, the Contractor shall be responsible for verifying all required functionality is still provided by the system. Such testing shall be performed at no additional cost to the Department.

VII. Should the provision of such a new enhancement, release or version result in any loss of required functionality, at CTDOT's sole discretion, the Contractor shall be required to revert to the previous fully functional version at no additional cost to CTDOT.

VIII. The Contractor shall coordinate the scheduling of the provision and implementation of any new enhancement, release or version with CTDOT.

IX. The Contractor shall provide to CTDOT at no additional charge all updated system documentation in the form of new revised manuals or changed pages to current manuals (or updated "help screens") consistent with the original system documentation supplied, and reflecting changes embodied in the enhancement, in the new version, or in the improvement provided herein.

X. The Contractor shall provide to CTDOT at no additional charge any additional training and online help tools required for new add-on modules, enhancements, new versions, system patches, fixes, modifications, etc.

8. PROJECT MANAGEMENT REQUIREMENTS

A. General

I. The Contractor shall appoint a project manager who will be the primary point of contact with CTDOT for the duration of the contract period.

II. The Contractor shall be responsible for all project management activities, including the creation and maintenance of a Project Management Plan. As part of the Project Management Plan, the Contractor shall create and maintain a Master Schedule of Work and critical path schedule. The Contractor shall be responsible for attending progress meetings and submitting progress reports and meeting materials, and providing ongoing coordination with various CTDOT units and staff.

III. The Contractor shall carry out a Design Review Process, described in more detail in the Technical Specifications. During this Design Review Process, the Contractor shall be responsible for submitting detailed design documentation of the system design and configuration. As part of the design process, the Contractor shall meet with CTDOT to discuss system functionality, and recommend routes, centroids, and other locations for configuration in the MDSS in order to maximize the usefulness of the MDSS for both evaluation purposes and statewide reporting purposes. The Contractor shall develop Draft and Final System Design Documents. The detailed design documentation shall include all equipment cut sheets, vehicle-specific installation

plans, details on the system architecture and configuration, and a finalized traceability matrix. The Contractor shall not procure any equipment until it has received CTDOT's written approval of the Final System Design Document. As part of the Design Review Process, the Contractor shall participate in all design, review, coordination, and progress meetings.

IV.   The Project Manager or her/his designee shall participate in all scheduled project activities, attend scheduled meetings and promptly respond to new meeting requests, requests for information, technical support or other necessary communication activities.

V.   As part of the project initiation, the Contractor's Project Manager shall attend and conduct a project start-up meeting in person at CTDOT headquarters located at 2800 Berlin Turnpike in Newington, CT. At this project start-up meeting, the Contractor's Project Manager shall meet with CTDOT staff to fully understand project objectives and user requirements in customizing the applications, as well as to identify any gaps between the Contractor's proposed solution and user requirements. The Contractor's Project Manager shall also present its Project Management Plan to CTDOT for review and approval at this project start-up meeting.

VI.   The Contractor shall prepare and submit a Project Management Plan to CTDOT for approval. Refer to "Project Schedule and Key Milestones" for submission of deliverables timeline. Refer to Section 11 "Documentation Requirements".

VII.   The Contractor shall prepare and submit the Test Plan to CTDOT for approval. Refer to "Project Schedule and Key Milestones" for submission of deliverable timeline. Refer to Section 9. "Testing Requirements".

VIII.   The Contractor shall prepare and submit Training Plan to CTDOT for approval. Refer to "Project Schedule and Key Milestones" for submission of deliverables timeline. Refer to Section 10 "Training Requirements".

IX.   The Contractor shall submit User and Administrator's Manual to CTDOT for approval. Refer to "Project Schedule and Key Milestones" for submission of deliverables timeline. Refer to Section 11 "Documentation Requirements" for additional user and administrator's manual requirements.

X.   For each of the Contractor's submittals, the Contractor shall build into its schedule sufficient time to accommodate at least one round of enhancement revisions incorporating review comments and feedback from CTDOT. CTDOT shall endeavor to complete its reviews of Contractor submittals within fourteen (14) calendar days of CTDOT receipt of submittal. The Contractor shall ensure that each of its submittals is of sufficient quality to minimize the number of iterations and the potential impact to the project schedule. Substandard or incomplete documentation submissions will be rejected by CTDOT.

XI.   The Contractor shall perform all Testing, as per the approved Test Plan, including but not limited to accuracy testing, system availability testing and data quality testing. The

Contractor shall submit Test Results, signed by the Contractor and any test witnesses, for each test. The Contractor shall correct any communications, hardware and software deficiencies to the satisfaction of the Department to obtain the written approval of Test Results for each Test.

B. Progress Meetings

I. During the design, installation, and testing periods, the Contractor shall participate in regular progress meetings to be conducted via teleconference at least once every two (2) weeks, unless otherwise directed by CTDOT. Participation in all progress meetings by the Contractor shall be provided at no additional cost to CTDOT.

II. During the design, installation, and testing periods, the Contractor shall prepare and present progress reports, including an agenda for the Progress Meeting and an up-to-date project schedule that shall be submitted to CTDOT at least two (2) business days prior to each Progress Meeting. Progress reports must be submitted in a format approved by the Department.

III. The Contractor shall be represented in these Progress Meetings by at a minimum their Project Manager, as well as any additional Contractor staff necessary to properly address the current issues and project status.

IV. The Contractor shall submit meeting minutes and an updated Action Item List (AIL), if needed, within seven (7) calendar days of each Progress Meeting.

9. TESTING REQUIREMENTS

A. Test Plan

I. The Contractor shall provide a detailed Test Plan outlining the criteria for test initiation, test equipment, detailed test procedures and expected results, and procedures for dealing with test failures and retests, and the test schedule. The Test Plan must be sufficiently detailed to allow test observers to easily follow the testing procedure, witness the expected test results, and confirm test success or failure.

II. The Test Plan must describe and include test procedures for, at minimum, the Vehicle Prototype Test, Communications Testing, the Phase 1 Demonstration Test, the Phase 2 Demonstration Test, and System Availability Tests.

III. The Contractor shall have an ongoing Quality Assurance program.

IV. The Contractor may propose alternative testing for the CTDOT's review and consideration that will still provide CTDOT with the verification and validation of all technical requirements.

V. CTDOT shall have the right to independently evaluate all Test Results, and shall have the right to independently verify the Contractor's test results.

B. Vehicle Prototype Test

I. Description: The Contractor shall conduct and participate in a Vehicle Prototype Test, which shall consist of installing IMO equipment on four to five different makes and models of WMT in accordance with the Contractor's approved installation plans. The Vehicle Prototype Test will be overseen by CTDOT or their designated representative. Following installation, CTDOT staff will inspect the equipment installed in the WMT to identify any issues with equipment placement, materials, or installation methods. The Contractor shall then test the system to demonstrate equipment operation, features and functionality, and proper system configuration and integration. The Contractor shall then propose modifications to its installation plans to address these issues. Once CTDOT is satisfied that all installation issues have been addressed, CTDOT shall issue written approval of the Vehicle Prototype Test and the Contractor will be allowed to proceed to installation of equipment on the rest of the Phase 1 vehicles. Refer to Technical Specifications for additional requirements and details.

II. The Vehicle Prototype Test must consist of installing equipment on four to five different makes and models of WMT in accordance with CTDOT-approved installation plans.

III. The Contractor shall schedule the Vehicle Prototype Test at least 14 calendar days in advance. CTDOT and/or its designated representatives shall be invited to witness the Vehicle Prototype Test.

IV. Following installation, CTDOT staff will inspect the equipment installed in the vehicles to identify any issues with equipment placement, materials, or installation methods.

The Contractor shall then propose modifications to its installation plans to address these issues.

V. Upon resolution of installation issues, the Contractor shall test vehicle equipment to demonstrate: safe and stable operation of all equipment, all equipment required features and functionality, proper equipment integration, successful integration and transmittal of data from the vehicle to the central system (which must require communications testing as described below), and proper configuration and reporting of data in the AVL/GPS and MDSS servers.

VI. At minimum, the testing must include the following testing categories:

(a) Equipment power on/power off
(b) GPS signal testing
(c) GPS performance and accuracy testing
(d) Camera performance testing
(e) Weather sensor performance testing
(f) Equipment sensor performance testing
(g) Communications performance testing
(h) OBU performance and data retention testing
(i) In-vehicle display performance testing
(j) AVL/GPS website features and report testing
(k) MDSS website features and report testing
(l) Data integration and data quality testing
(m) Real-time data feed testing

VII. Once CTDOT is satisfied that all installation issues have been addressed, CTDOT shall issue written approval of the Vehicle Prototype Test and the Contractor will be allowed to proceed to installation of equipment on Phase 1 vehicles.

C. Communications Testing

I. As part of the Vehicle Prototype Test, the Phase 1 Demonstration Test, and the Phase 2 Demonstration Test, the Contractor shall conduct communications testing to ensure that all communications equipment, modems, data cards, etc. have been properly installed, configured, and are fully operational.

II. The Contractor shall test to confirm the actual data throughput and packet error rate for all cellular modems installed in WMTs.

III. The Contractor shall submit all communications test documentation to CTDOT for review and approval.

D. Phase 1 Implementation

I. Upon receipt of written approval of the Vehicle Prototype Test, the Contractor shall install IMO equipment on the remaining Phase 1 WMT vehicles. Upon completion of installation, the Contractor shall conduct and participate in Phase 1 Demonstration

Testing. For each WMT, the Contractor shall conduct a hardware test to ensure that all equipment has been properly installed, integrated, and configured and is operating properly. The Contractor shall demonstrate that all equipped WMT are transmitting data successfully, and that the data has been properly integrated into the AVL Server, AVL website, MDSS server, and MDSS website. The Contractor shall demonstrate that the real-time data feeds for the AVL server and MDSS server are available and performing as intended. The Contractor shall then participate in a 30-day operational test period to demonstrate the IMO system stability and reliability. Upon successful completion of this 30-day operational test period, CTDOT shall issue written acceptance of Phase 1, and the Contractor's Maintenance, Technical Support, and Licensing Period must commence.

E. Phase 1 Demonstration Test

I.   As part of Phase 1, the Contractor shall install equipment in approximately sixty-one (61) WMTs, consisting of sixteen (16) WMT at the Orange garage, fifteen (15) WMT at the Trumbull garage, and ten (10) WMT in each of the other three (3) remaining Districts.

II.   For each WMT, the Contractor shall conduct a hardware test, replicating the Vehicle Prototype Test, to ensure that all equipment has been properly installed and is operational. As part of the hardware test, the Contractor shall verify the accuracy of the GPS unit, the camera, the weather sensors, the in-vehicle display, the OBU, etc. CTDOT shall be invited to witness the hardware test and inspect the installation. The Contractor shall submit all test documentation for each WMT to CTDOT.

III.   Following CTDOT approval of all WMT installations in Phase 1, the Contractor shall demonstrate that all WMT are successfully transmitting data and are properly integrated into the AVL/GPS System and the MDSS within seven (7) calendar days of the CTDOT approval of the hardware tests.

IV.   Once all the WMT in Phase 1 have been instrumented and the Contractor has demonstrated that all vehicles have been integrated into the AVL/GPS System and the MDSS, a 30-day operational test period shall commence.

V.   During the 30-day period, CTDOT shall operate the system under normal operating conditions to ensure that all requirements are met and to measure the system reliability and availability.

VI.   During the 30-day period, the Contractor shall measure and report system performance and failures, and report the same to CTDOT on a weekly basis. System failures may result in the suspension or restart of the 30-day period.

VII.   During the 30-day period, the Contractor shall record any changes to system configuration or operation, shall report these changes to CTDOT, and shall update system documentation as necessary.

VIII.   Failures during the 30-day period must be defined as follows:

(a) Type I Failures: A Type I failure is a malfunction resulting from conditions beyond the control of the Contractor, or failures that are minor in nature and can be corrected within twenty-four (24) hours.

(b) Type II Failures: A Type II failure is a malfunction that involves conditions within the control of the Contractor including: a failure related to the system design, installation, or configuration; or a failure that takes longer than twenty-four (24) hours to correct; or a Type I failure that re-occurs following initial Contractor correction.

IX. For Type I failures:

 (a) Unless otherwise approved by CTDOT, the 30-day period must be suspended for the time necessary to make the corrections.

 (b) Time suspension must begin when the failure is first reported, and it must extend only as long as required to correct the failure.

 (c) Once the Contractor has demonstrated that the failure has been corrected, CTDOT will authorize the Contractor to proceed and the 30-day time period will resume, continuing from the time prior to the suspension.

 (d) If a subsequent Type I failure occurs similar in nature to a previous Type I failure, the Contractor shall provide evidence that the failures were distinct and unrelated or the subsequent failure will be reclassified as Type II.

X. For Type II failures:

 (a) Unless otherwise approved by CTDOT, the 30-day period must be suspended for the time necessary to make the corrections.

 (b) Time suspension must begin when the failure is first noticed, and it shall extend only as long as required to correct the failure.

 (c) Once the Contractor has demonstrated that the failure has been corrected, CTDOT will authorize the Contractor to proceed and the thirty (30) day period will begin again.

XI. During the 30-day period, all failures must be documented and reported to the Department. A Failure Review Team ("FRT") shall be established to review all failures. The FRT shall be comprised of one (1) member from CTDOT, one (1) member from the Contractor, and potentially, one (1) member of CTDOT's outside consultant team. This team will initially attempt to settle any disputes through mutual agreement. In the event that a dispute cannot be settled by the FRT, the dispute resolution provisions of the Contract shall apply.

XII. Upon commencement of the 30 day period, the Contractor shall have sixty (60) total calendar days to complete the 30-day operational test period, including all testing suspension periods and restart periods. Failure by the Contractor to complete the 30-day operational test period within sixty (60) total calendar days, excluding delays beyond the Contractor's control, may be considered a breach of contract and contract resolution terms shall apply.

F. Phase 2 Implementation

I.   Description: Following successful completion of Phase 1, the Contractor shall be authorized to install IMO equipment on Phase 2 WMT vehicles. Upon completion of installation, the Contractor shall conduct and participate in Phase 2 Demonstration Testing. For each WMT, the Contractor shall conduct a hardware test to ensure that all equipment has been properly installed, integrated, and configured and is operating properly. The Contractor shall demonstrate that all equipped WMT are transmitting data successfully, and that the data has been properly integrated into the AVL Server, AVL website, MDSS server, and MDSS website. The Contractor shall demonstrate that the real-time data feeds for the AVL server and MDSS server are available and performing as intended, including the data for both Phase 1 and Phase 2 WMT. The Contractor shall then participate in a 30-day operational test period to demonstrate the IMO system stability and reliability. Upon successful completion of this 30-day operational test period, CTDOT shall issue written acceptance of Phase 2. The Contractor's Maintenance, Technical Support, and Licensing Period must then continue, including both Phase 1 and Phase 2 WMT.

G. Phase 2 Demonstration Test

I.   Following successful completion of Phase 1, the Contractor shall receive written authorization from CTDOT to commence Phase 2. For Phase 2, the Contractor shall install equipment on all remaining WMTs (approximately 90 additional WMTs for a total of 151 WMTs) under this Contract.

II.   The Contractor shall then replicate the Phase 1 Demonstration Test for all Phase 2 WMTs and their integration into the AVL/GPS System and the MDSS.

III.   A 30-day operational testing period will also be conducted for the Phase 2. The 30-day operational testing period for Phase 2 shall follow the same requirements as the 30-day operational testing period for Phase 1.

H. System Availability Testing

I.   The Contractor shall use automatic methods to collect information on system availability for the AVL/GPS System, the MDSS, and the real-time data feeds in order to calculate system availability as defined in these Technical Specifications.

II.   The Contractor shall perform ongoing system availability testing and provide CTDOT with monthly, quarterly, and annual results.

I. Quality Assurance Program

I.   The Quality Assurance Program requirements apply to all activities affecting the quality of items, including, designing, purchasing, storing, handling, fabricating, inspecting, assembling, installing, testing, and shipping.

II. The Contractor shall submit a Quality Assurance Plan as part of the Project Management Plan that integrates Quality Assurance in all phases of this Project. The Contractor shall maintain the Quality Assurance Plan throughout the Contract.

III. As a minimum, the Contractor's plan must include Quality Assurance objectives, criteria, organization responsibilities, and the following specific elements:

    (a) Establish and maintain written procedures defining the Quality Assurance Program. Procedures must encompass all phases of the system to include where applicable, but not be limited to, within the Contractor's organization: receiving, inspection, production and process control, testing, discrepancy control, measuring and test equipment calibration and certification, drawing control, configuration control, Quality Assurance records, shipping inspection, and other quality specifications to meet the requirements of the Contract.

    (b) The Quality Assurance Plan must provide procedures for evaluation of engineering and related design activities in order to ensure complete compliance with Contract requirements for proposing, approving, and effecting changes to the baseline requirements.

IV. The Contractor shall maintain all records to provide evidence of quality and accountability. The Contractor shall maintain complete records, and make the records available to the Department at any time during performance of the Work to demonstrate compliance with the Quality Assurance Plan.

V. The Contractor shall include in the records results of inspections and audits, tests, process controls, certification of processes and personnel, discrepant material (including records of disposition), and other quality requirements defined in the Contract.

    (a) Establish and maintain written procedures defining the Quality Assurance system. Procedures shall encompass all phases of the system to include where applicable, but not be limited to, within the Contractor's organization: receiving inspection, production and process control, testing, discrepancy control, measuring and test equipment calibration and certification, drawing control, configuration control, Quality Assurance records, shipping inspection, and other quality specifications to meet the requirements of the Contract.

    (b) The Quality Assurance Plan shall provide procedures for evaluation of engineering and related design activities in order to ensure complete compliance with Contract requirements for proposing, approving, and effecting changes to the baseline requirements.

VI. The Contractor shall establish, maintain and implement procedures to ensure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations and defects in material and equipment, are promptly identified and corrected. In case of conditions adverse to quality, measures shall be taken to ensure that the cause of the

condition is determined and corrective action is immediately taken to preclude repetition of such conditions. Corrective action and related information must be documented and made available to the Department upon request. Corrective action must extend to performance of all suppliers and include as a minimum:

> (a) Analysis of data and examination of discrepant products to determine extent and causes.
> (b) Introduction of required improvements and corrections, initial review of the adequacy of such measures, and monitoring of the effectiveness of corrective action taken.

VII.   The Contractor shall obtain from each subsystem supplier a written certification that the method being used for installation and connection of equipment by the Contractor is satisfactory to the subsystem supplier, and make the certification available to the Department upon request.

VIII.   If the Department has reasonable evidence that defective Work has been performed by the Contractor, or that defective materials have been used, the Department may desire to make an examination of Work partly or fully completed. The Contractor shall furnish or arrange for the appliances and labor for making such investigation and inspection as may be required by the Department.

10. **TRAINING REQUIREMENTS**

A. Training Plan

I.   Description: The Contractor shall provide training services in accordance with its approved training plan. Training must include preparation of all training materials. The Contractor shall provide training sessions for up to 650 WMT drivers/operators demonstrating the use of in-vehicle equipment. The Contractor shall provide up to twenty (20) driver/operator training classes with up to thirty-five (35) attendees at each class. The Contractor shall also provide training sessions for up to 150 CTDOT users/administrators demonstrating the use of software and website features, monitoring and reporting tools, and retrieval and exporting of system data. The Contractor shall provide up to ten (10) users/administrators training classes with up to fifteen (15) attendees in each class. Following successful completion of the initial training, the Contractor shall also provide annual refresher training for the duration of the Contract prior to the Winter maintenance season for up to 100 CTDOT WMT vehicle drivers, and fifty (50) CTDOT users/administrators.

II.   The Contractor shall submit a Training Plan to the Department for review and approval. Refer to Project Schedule and Key Milestones for deliverable timeline.

III. The Training Plan must describe proposed training sessions, including information on presenters, materials to be presented, training objectives, and training facility requirements.

IV.   The Training Plan will summarize the any online help tools and/or user tutorials, including sample screen shots and information on accessing these items online.

V.   The Contractor shall coordinate with CTDOT to schedule the training sessions.

B. System Training

I.   The Contractor shall conduct training of CTDOT staff demonstrating the use of the in-vehicle equipment. The Contractor shall assume training for up to 650 WMT vehicle drivers/operators.

II.   The Contractor shall conduct training of CTDOT staff demonstrating the use of the software and websites, and accessing the online help tool and tutorials, for Department-designated personnel. The Contractor shall assume training for up to 150 CTDOT users/administrators.

III.   Training must be carried out at CTDOT premises, as per CTDOT's discretion.

IV.   The minimum training provided must introduce all features of the in-vehicle equipment, all features of the website and software tools including accessing the data, data analysis, report preparation, and retrieving/exporting of data.

V.   The demonstration must also include an overview and examples of the various reports that can be created using the software tools.

VI.   The Contractor shall provide all necessary training materials and allow CTDOT to make unlimited quantities of training materials for future internal use.

VII.   The Contractor shall provide annual refresher training prior to the winter maintenance season for up to 100 CTDOT WMT vehicle drivers, and fifty (50) CTDOT users/administrators.

C. Online Help Tools and User Tutorials

I.   The Contractor shall provide online help tools and tutorials for the websites and software.

II.   The online tutorials must provide step-by-step instructions on all functionality provided by the websites and software

III.   The online help tools must provide general information about the websites and software and Frequently Asked Questions (FAQs).

11. DOCUMENTATION REQUIREMENTS

A. General

I. The Contractor shall provide detailed documentation that describes the system design, configuration, testing, training, as-built conditions, operation and maintenance, and user manuals. Refer to "Project Schedule and Key Milestones" for deliverable timeline.

II. The System Documentation must include the following:

    (a) Project Management Plan
    (b) Master Schedule of Work
    (c) System Design Document
    (d) Requirements Traceability Matrix
    (e) Test Plan
    (f) Test Results
    (g) Training Plan
    (h) User and Administrator's Manual

III. All documentation must be in English, must utilize US (English) measurements, and must be submitted directly to Department electronically in one of the following formats:
    (a) MS Office formats (DOC, XLS, PPT, VSD)
    (b) Adobe PDF (searchable)

IV. Scanned documents consisting of signatures, etc. may be approved for submittal.

V. Any and all communications or submissions to CTDOT must be via email. System Design submissions must be made in hard copies in addition to the electronic submission.

VI. The Contractor must include the necessary time and resources to modify the documentation to incorporate comments from CTDOT. The Contractor shall then include additional time for CTDOT to review the revised documentation.

VII. CTDOT will complete a review of deliverable submittals within fourteen (14) calendar days of receiving the submission.

B. Project Management Plan

I. The Contractor shall provide a project management plan in accordance with the description supplied as part of the Contractor's proposal, detailing the Contractor's approach to completing this Project within the specified period of time. The Project Management Plan shall describe at minimum:
    (a) The overall project management approach to the project.
    (b) Identification of roles and contact information for key members of project team.
    (c) A description of major assumptions and risks;
    (d) Project progress reporting and meetings;
    (e) A detailed Master Schedule of Work (see Section 11.3);
    (f) A Quality Assurance Plan (see Section 9.7); and

(g) A description of any other major project management tasks and activities.

C. Master Schedule of Work

I. The Contractor shall provide a Master Schedule of Work which shall enable the envisioned overall implementation sequence as described in the RFP.

II. The Master Schedule of Work must identify all project implementation activities including delivery and installation of equipment and systems, training programs, and test procedures.

III. The Master Schedule of Work must identify planned delivery of documentation as described in these specifications.

IV. The Contractor shall include in the Master Schedule of Work the necessary time and resources to modify documentation to incorporate comments from Department.

V. The Contractor shall include in the Master Schedule of Work the time for CTDOT to review the revised documentation.

VI. The Master Schedule of Work must be implemented in PERT, GANTT or equivalent form to show Department and any third party responsibilities and activities, and their associated dependencies. The Master Schedule of Work shall be submitted to the Department as a .PDF file.

D. System Design Document

I. The Contractor shall provide detailed documentation that describes in-vehicle equipment system architecture, data and product sheets for all in-vehicle equipment, installation plans (wiring diagrams, mounting locations, etc.) for each of the various makes and models of WMT, communications information, user guides and sample reports for the AVL/GPS System, user guides and sample reports for the MDSS, information on the real-time data feeds, and information on the system hosting facilities for the AVL/GPS system and MDSS.

II. The software descriptions msut include functional description, Graphical User Interface (GUI) descriptions with mock-ups, database design documentation, interface descriptions, configuration details, reporting functions, query functions, and standard reports.

III. The communications documentation must include details on communications equipment and hardware, cellular data service provider selection and coverage, communications protocols, data capacity calculations, path redundancy and resiliency provisions, data backup and system recovery provisions, network configuration details, etc.

E. Requirements Traceability Matrix

I. The Contractor shall provide a requirements traceability matrix that can be used to verify that the design addresses all system requirements in accordance with standard Systems Engineering practices.

F. Test Plan

I. The Contractor shall provide a Test Plan outlining the criteria for test initiation, test equipment, detailed test procedures and expected results, and procedures for dealing with test failures and retests, and the test schedule. For more information on the Test Plan, refer to Section 9, The Test Plan must reflect the final design of the system.

G. Test Results

I. As part of every test, the Contractor shall submit Test Results. The Test Results must include, but not be limited to, the following:

(a) Detailed description of test environment.
(b) Test results recorded on approved test report forms. For commercial off-the-shelf products, this includes stamped quality testing documents from before it leaves the factory environment.
(c) The Requirements Traceability Matrix listing linking each requirement proposed to be demonstrated in the test to applicable test results.
(d) Any additional submittals required by the System Design specification.
(e) Documentation of all system equipment and configuration changes required to meet System Requirements following test failures.
(f) Test logs.

H. Training Plan

I. The Contractor shall provide a Training Plan describing the System Demonstration Workshop and the training tools provided. For more information on the Training Plan, refer to Section 10. The Training Plan must reflect the final design of the system.

I. User and Administrator's Manual

I. The Contractor shall provide a User and Administrator's Manual for the AVL/GPS System and for the MDSS.

II. The User and Administrator's Manual for each system must describe at minimum:

(a) Features and functionality.
(b) Data analysis and reporting tools.
(c) Frequently asked questions and troubleshooting.
(d) Inventory of vehicles outfitted, and the equipment installed in each vehicle

(e) User manual for in-vehicle systems (e.g., the touch screen display or any other operator-controlled equipment in the WMTs)

(f) Description of any recommended preventive and recurring maintenance requirements for the equipment installed on WMTs (calibration tests, filter replacements, camera cleaning, etc.)