Special Specification 6433
Roadway Weather Information System

1. DESCRIPTION

Furnish and install Roadway Weather Information Systems (RWIS) to monitor weather conditions at the locations as shown on the project plans. The RWIS will include bridge deck pavement sensors, pavement sensors, pavement temperature probes, and complete weather station to monitor wind information, air temperature humidity, and other items defined in this Item. The system will be specifically designed for monitoring and displaying pavement surface conditions, pavement temperature, freeze point temperature, and subsurface temperature. Non-Intrusive sensors will be installed at the RWIS sites to monitor roadway surface status conditions including dry, wet, chemical wet, ice watch and ice warning.

Atmospheric or meteorological conditions monitored may include any of the following: air temperature, relative humidity, barometric pressure, accumulated precipitation, and wind or speed direction. The information from the RWIS sites will be transmitted back to the Transportation Management Center (TMC) via the Department's intelligent transportation system (ITS) network, where the data will be presented to the operations staff. The Departments Lonestar™ software will poll the RWIS to ask for data on a preset time interval specified by TxDOT to transfer and refresh with current conditions. Data from the RWIS must comply with standard National Transportation Communications for Intelligent Transportation System Protocol (NTCIP).

The RWIS will include all hardware, software, and licenses to operate as follows:

- non-intrusive surface sensors will measure bridge deck and or roadway pavement surface temperature along with surface wetness and communicate the data to the Remote Processing Unit (RPU),
- roadway atmospheric sensors will measure their respective weather parameters and communicate the data from each sensor to the RPU,
- atmospheric weather sensors will measure their respective weather parameters and communicate the data from each sensor to the RPU,
- RPU will acquire data from all connected sensors. The RPU will process and temporarily store the output from the pavement sensors and atmospheric sensors,
- RWIS server will poll the RPU of each local RWIS system on a scheduled basis. The RPU will respond to the poll and transfer all its data to the RWIS server,
- all data transfers between the RWIS server and local RWIS will be compliant with the most current Federal standard NTCIP Environmental Sensor Station (ESS) protocols, and
- RWIS user displays will include all sensor and forecast data in a Windows based Graphical User Interface or browser-based data display format.

2. MATERIALS

2.1. **RWIS Remote Processing Unit (RPU).**

Furnish and install a controller mounted RPU at locations as shown in the project plans.

The RPU must gather, process, and store data from all connected atmospheric sensors, pavement sensors and camera. The data must be transmitted to Lonestar™ upon polled request via NTCIP ESS protocols. The RPU must utilize a modular design consisting of a main data processing unit and secondary communication units that are used to power and connect sensors at the RWIS site. The main data

processing unit must utilize a Reduced Instruction Set Computing (RISC) type processor and run a Linux based operating system capable of multi-tasking operations to optimize data acquisition from all connected devices. The RPU must include in-built Global Positioning System (GPS) for real-time clock synchronization and location definition.

The RPU shall support standardized communication protocols for sensors from various manufactures that are NTCIP compliant.

The RPU must include a minimum of two 10/100 Ethernet ports, 6 serial ports configurable for RS-232, RS-485 two wire, or RS-485 four wire, capable of operating at full or half duplex from 300 to 115,200 bits per second. All circuitry of the RPU, the voltage inputs, the sensor inputs, and the communications ports must be designed and tested to provide transient voltage and surge protection.

The contractor will install 110 VAC service to the RPU power disconnects. Primary power should be installed to the RPU and fused for 20 amperes, with voltage surge protection. The RPU will operate in a range of 100-130 VAC at 50-60 Hz and will use not more than approximately 50 W of continuous power (excluding options). Battery backup must be provided to power the RPU for a minimum of 8 hr. in the event of loss of AC service.

The RPU must have the capability of being modified to utilize solar power or other power sources in place of conventional commercial electric power. Solar powered RPU sites must operate a minimum of 72 hr. without sunlight or solar charging of the batteries. Autonomy will be calculated based on the type and quantity of sensors as indicated by the plans or as directed and specifications."

RPU must have at least 512MB DDR3 and 2GB of NAND flash memory. The communication must be internal based Ethernet to ensure more reliable and faster communication. The RPU hardware and software must meet the following technical specifications:

The RPU will gather data from all connected sensors and remote pavement sensors, and process, store and transmit this data to the RWIS server upon polled request. The RPU will be capable of collecting data from the following sensors:

- wired precipitation type sensor,
- wired air temperature/relative humidity sensor,
- wired road surface /subsurface sensors,
- wired subsurface sensor,
- non-intrusive pavement condition sensors,
- non-intrusive pavement temperature sensors,
- rain sensor,
- wind speed/direction sensor,
- barometric pressure sensor, and
- wired pan-tilt-zoom camera.

The RPU must include an Ingress Protection (IP66), National Electrical Manufacturers Association (NEMA) 4X rated lockable stainless steel American Iron and Steel Institute (AISI) 316 powder coated enclosure that is resistant to weather, sunshine, de-icing chemicals, corrosion and damage from falling debris (ice, small rocks and tree branches) and vandalism. The enclosure must be capable of being mounted on poles with an outer diameter range of 6 in. to 24 in. The enclosure must house all RPU electronics, power supplies, and communication equipment and not exceed dimensions of 24 in. height by 20 in. width by 8.25 in. depth.

RPU communication with the server will utilize the most current published Federal Standard NTCIP-ESS protocol, with some manufacturer-specific objects. The server will poll the RPU via one of the following communications modes; Ethernet, PMPP leased line, PMPP spread spectrum radio, or PMPP serial fiber

optic. The RPU will incorporate "watch-dog" circuitry and monitor its own operation and reset itself if the RPU software enters an indeterminate state. The RPU will also have the capability to be reset by a "user administrator" from the server.

The RPU will have the capability of being modified to utilize solar power or other power sources in place of conventional commercial electric power. Solar powered RPU sites will operate a minimum of 72 hr. without sunlight or solar charging of the batteries.

2.2. **RPU Mounting Requirements.**

The RPU panel will be enclosed inside a RWIS specific communication cabinet, traffic signal controller cabinet or communications building as shown on the plans or as directed.

2.3. **Precipitation Type Sensor**

The precipitation sensor must utilize optical, Near-infrared technology to detect precipitation with beam interruptions by precipitation particles. The precipitation occurrence sensor must sense the onset and cessation of precipitation in the form of rain, snow, sleet, and freezing rain and shall indicate when precipitation is occurring. The sensor must provide all precipitation classification, measurements of intensity or water accumulation, as well as visibility. The sensor must operate within a minimum temperature range of -40°F to 140°F at 0 to 100 % relative humidity and meet an IP66 rating. The sensor must operate to specifications at cable lengths up to 100 ft. from the RPU.

The sensor must operate within a power range of 12 to 30 VDC and use no more than 5 W of power. The sensor must include RS-232, RS-485 data communication, and 4 to 20 Milliampere outputs; and be capable of operating to specifications at cable lengths up to 100 ft. from the RPU.

Communication and power cable connecting the sensor to the RPU must be shielded, with ultraviolet (UV) stable jacket rated for outdoor use. The Contractor is responsible for providing the correct length cable based on the planned installation.

2.4. **Air Temperature/Relative Humidity Sensor**

The Air Temperature/Relative Humidity Sensor will have an air temperature-sensing element that measure temperatures within a minimum range of -40°F to 140°F with an accuracy within 1 ° of actual temperature. The relative humidity sensing element will be of the "capacitance type" and have a measuring range of 10 to 100 % RH within 1 % of actual humidity levels. The sensor must be protected by UV stabilized white thermoplastic solar/wind-radiation shield and meet IP66 rating.

System dew point temperature will be calculated by the system from the air temperature and relative humidity. Both atmospheric sensing elements will be mounted on the RWIS tower at the standard meteorological height of approximately 6 ft. above ground level.

The sensor must operate within a power range of 7 to 30 VDC and use no more than 5 watts of power. The sensor must include RS-485 two-wire serial data communication, 0 to 10 v, and resistance level outputs; and be capable of operating to specifications on cable lengths up to 100 ft. from the RPU.

Communication and power cable connecting the combined sensor to the RPU must be shielded, with UV stable jacket rated for outdoor use. The Contractor is responsible for providing the correct length cable based on the planned installation.

The sensor must include all mounting hardware necessary to complete the installation.

2.5. **In-Pavement Sensor**

Furnish and install intrusive pavement sensors as shown on the project plans or as directed. The intrusive sensor supplied will be a single solid-state electronic device that is installed in the roadway or bridge deck pavement at the locations as shown on the plans or as directed. Exact sensor placement will be as determined by the engineer with guidance from the equipment supplier.

The sensor will be constructed of materials that have thermal characteristics similar to common pavement materials. The top of the sensor will be installed with epoxy sealer, so the top is flush with the surrounding roadway surface. The sensor will be thermally non-intrusive, providing stable operation over a temperature range from -40°F to 140°F. Weather conditions, traffic, or ice control chemicals will not degrade its performance. The sensor will be supplied with 300 ft. of attached molded cable that is waterproofed and sealed as an integral part of the assembly. Each sensor will be capable of operating at extended cable lengths up to 5000 ft. from the RPU by splicing to direct burial sensor extension cable. The sensor will electronically sample the following pavement parameters:

- surface temperature at the sensor head and
- pavement surface conductivity.

In addition, the pavement sensors will supply data for the RWIS to determine the following pavement surface conditions when sufficient water is present on the pavement, and atmospheric data from precipitation and air temperature sensors is available:

- dry is absence of moisture on the surface sensor,
- trace moisture is when pavement moisture is above freezing (no precipitation),
- wet is when precipitation has occurred and there is a continuous film of moisture on the pavement sensor,
- chemically wet is continuous film of water and ice mixture at or below freezing (32°F) with enough chemical to keep the mixture from freezing, and precipitation is not occurring,
- ice warning is continuous film of ice and water mixture at or below freezing (32°F) with insufficient chemical to keep the mixture from freezing (active precipitation), and
- ice watch is thin or spotty film of moisture at or below freezing (32°F), and precipitation is not occurring.

After bid opening and prior to contract execution, the successful Contractor will supply actual field test documentation that substantiates pavement sensor performance.

2.6. Subsurface Temperature Probe

Furnish and install the subsurface temperature probes in the roadway near a surface sensor at a depth of 18 in. The probe will measure the ground temperature below the roadway pavement surface. The temperature-sensing element of the probe will operate over a temperature range of -40°F to 140°F.

The probe will be supplied with 300 ft. of attached cable, which is waterproofed and sealed as an integral part of the assembly. Each sensor will be capable of operating at extended cable lengths up to 5000 ft. from the RPU.

The wired sub-surface sensor must be installed per manufacturer's recommendations to detect temperature at a depth of 18 in. Exact placement of the sensor must be as determined by the field engineer with guidance from the manufacturer. All cabling for the sensor, where it is not embedded in the road, must be installed in conduit at a minimum depth of 36 in. Installation must be done in a manner to eliminate all cable splicing. The sensor must be configured and calibrated to function as designed with the RPU.

2.7. Non-Intrusive Pavement Condition Sensors

The non-intrusive pavement condition sensor must utilize Class 1 laser technology to accurately measure presence of water, ice, slush, snow, and frost on the road surface. The sensor must also measure the level

of grip or friction coefficient of the roadway. The sensor must be capable of accurate measurements within a minimum range or 7 ft. to 50 ft. The sensor must operate in a minimum temperature range of -40°F to 140°F at 0 to 100 % relative humidity.

The sensor must be powered from a 9 to 30 V direct current (VDC) source and use no more than 4 W of power. The sensor must provide RS-232 and RS-485 serial data communication interfaces and be capable of operating to specifications at cable lengths up to 300 ft. from the RPU for RS-232 and 495 ft. from the RPU for RS-485.

If the RWIS is greater than 25 ft. from the white edge line of the roadway being measured, then the non-intrusive pavement condition sensor must include a steel pole with breakaway assembly as per TxDOT Standard and underground conduit to install the sensor at an appropriate height to detect conditions of the closest lane of travel.

Communication and power cable connecting the sensor to the RPU must be shielded, with UV stable jacket rated for outdoor use. The Contractor is responsible for providing the correct length cable based on the planned installation.

The sensor must include all mounting hardware necessary to complete the installation.

The quantity of non-intrusive pavement condition sensors and desired sensor detection location must be provided on the Plans or as directed by the project engineer.

2.8. **Non-Intrusive Pavement Temperature Sensors**

The non-intrusive pavement temperature sensor must use infrared technology to accurately measure road surface temperature. The sensor must be capable of accurate measurements within a minimum range of 7 ft. to 50 ft. The sensor must operate in a minimal temperature range of -40°F to 140°F at 0 to 100 % relative humidity. The sensor must operate within a power range of 9 to 30 VDC and use no more than 0.05 W of power. The sensor must provide RS-232 and RS-485 serial data communication interfaces and be capable of operating to specifications at cable lengths up to 300 ft. from the RPU.

If the RWIS is greater than 25 ft. from the white edge line of the roadway being measured, then the non-intrusive pavement condition sensor must include a steel pole with breakaway assembly as per TxDOT Standard and underground conduit to install the sensor at an appropriate height to detect conditions of the closest lane of travel.

Communication and power cable connecting the sensor to the RPU must be shielded, with UV stable jacket rated for outdoor use. The Contractor is responsible for providing the correct length cable based on the planned installation.

The Contractor is responsible for providing the correct length cable based on the planned installation.

The sensor must include all mounting hardware necessary to complete the installation.

2.9. **Wind Speed Sensors**

Wind Monitor. The Wind Monitor sensor will be installed at the standard meteorological height of approximately 30 ft. above ground level. The sensor must be mounted such that birds are not able to perch or nest on the sensor. The sensor may be a combination wind speed and direction sensor of lightweight corrosion-resistant construction. The sensor must be based on three transducer ultrasonic technology and not have any moving parts.

The sensor will have an operating range of 0 to 200 ft/sec, with a survival operation limit of 279 ft/sec. Accuracy will be $\pm$1 ft/sec. Wind speed resolution must be 1.0 ft/sec. Wind direction accuracy must be $\pm$ 2

%. Wind direction resolution must be 1°. The sensor must operate within a minimum temperature range of -40°F to 140°F and the sensor must meet IP66 and IP67 ratings.

The sensor must operate within a power range of 9 to 40 VDC and use no more than 30 W of power. The sensor must include both 0 to 5000 millivolt analog and RS-232/RS-485 digital outputs; and be capable of operating to specifications on cable lengths up to 100 ft. from the RPU.

Communication and power cable connecting the sensor to the RPU must be shielded, with UV stable jacket rated for outdoor use. The Contractor is responsible for providing the correct length cable based on the planned installation.

The sensor must include all mounting hardware necessary to complete the installation.

2.10. **Pan-Tilt-Zoom Camera**

The pan-tilt-zoom camera must be furnished by the Department and installed per manufacturer recommendations on the RWIS approximately 3 ft. below the top of the structure or on top of the structure or as directed by the engineer and configured for a minimum of two preset positions as determined by the engineer. The installation of the pan-tilt-zoom camera must be paid for using item 6010-6011 CCTV FIELD EQUIP (DIGITAL) (INSTL ONLY).

The Contractor is responsible for using the appropriate communication protocol based on RPU to sensor connection to maximize communications reliability.

All sensor and camera cables connecting to the RPU must be secured to themselves and the structure every 3 ft. Cables should enter through the bottom of the RPU enclosure, be labeled by sensor type and location where applicable, and connect to the appropriate port on the RPU. All cabling must be installed in a neat and workmanlike manor.

3. CONSTRUCTION

Construction for the RWIS will be as follows:

Install the RWIS in accordance with the RWIS vendor's recommendations, plans and Standard Specifications and all federal, state, and local codes and requirements. The Contractor will be responsible for providing all traffic control and safety work zones for the installation of the roadway sensors in accordance with TxDOT traffic control requirements.

3.1. **RWIS System Commissioning.**

Upon completion of the RWIS system equipment installation, the system vendor must provide an on-site field engineer to start-up and test the entire system. This engineer will make all final sensor connections to the RPU; perform all final system checks, sensor alignments, software setup, and software configuration to provide a fully operational RWIS system.

3.2. **RWIS System Vendor.**

Furnish a detailed description (technical cut sheets) of the RWIS to be supplied by the Contractor and the experience of the vendor/manufacturer in supplying such RWIS to other like agencies.

Before any award, the Department may require the Contractor to demonstrate the proposed RWIS can provide interoperability and connectivity to the existing statewide RWIS system. The RWIS equipment vendor chosen by the Contractor must have at least 10 successful RWIS system installations in North America. As part of the equipment approval process, the Department may ask the Contractor to provide the names of at

least 5 agencies, with names, telephone numbers and contact person to verify said RWIS installations were successful.

3.3. **Warranty.**

Provide a limited, on-site warranty covering all equipment for a 24-mo. period from the RWIS commissioning date and one-year telephone technical support at no additional charge to the Department. The technical support must include access to a trained service representative who can respond within 24 hr. to questions related to all RWIS related equipment problems and maintenance issues.

3.4. **RWIS System Equipment Warranty.**

Furnish all RWIS system equipment for this project which will be state of the art and in current manufacture at the time of purchase. The vendor must factory warranty the RPU and sensors for a period not less than 36 mo. Batteries will be supported by their respective manufacturer's warranty.

3.5. **Training.**

Provide a minimum of 24 hr. of instruction to 10 designated personnel in the operation and maintenance procedures of equipment or systems installed. Provide the training during installation, testing, and integration. Provide the training through practical demonstrations, seminars, and other related technical procedures.

The training session will be conducted by the vendor representative. Furnish a training session agenda, a complete set of training material (manuals and schematics), and the names and qualifications of proposed instructors for approval 60 days before the training. The Department will determine the training location and provide the training facility. Provide 1 copy of the course material for each person. Provide training in the following areas of interest and as shown on the plans or as directed:

- the "Hands-on" operation for each type of equipment,
- explanation of all system commands, their function and usage,
- required preventative maintenance procedures,
- all equipment servicing procedures, and
- system "troubleshooting" or problem identification procedures.

4. MEASUREMENT

This Item will be measured by the complete RWIS installed and by each individual RWIS component installed. The cable must be considered subsidiary to each component installed.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit bid price for "Furnish and Install Roadway Weather Information System", "Precipitation Type Sensor", "Air Temperature/Relative Humidity Sensor", "Road Surface Sensor", "Subsurface Sensor", "Non-Intrusive Pavement Condition Sensor", "Non-Intrusive Pavement Temperature Sensor", "Rain Sensor", "Windspeed/Direction Sensor", "Barometric Pressure Sensor". This price is full compensation for furnishing, placing, testing all materials and equipment, software licensing, and all tools, labor, supplies, and incidentals. All incidental items including costs associated with arranging for the manufacturer's representative to be on-site will not be paid for separately but must be subsidiary to Furnish and Installation of Road Weather Information System.