Special Specification 6147
Road Weather Information System

1. DESCRIPTION

Furnish and install Roadway Weather Information Systems (RWIS) to monitor weather conditions at the location(s) 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. Passive in-pavement sensors will be installed at the RWIS site(s) to monitor roadway surface status conditions including dry, wet, chemical wet, ice watch and ice warning.

Atmospheric/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 initially via vendor supplied software. This software is to be installed on an existing Department server (called the RWIS server in this Specification) running Windows XP, 2000, 2003 or NT and shall provide an Application Programming Interface (API) to allow for integration into the TMC software. Until such time that the data is integrated into the Department's software, the vendor shall supply a separate interface for the data.

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

- Passive in-pavement surface sensors will measure bridge deck and 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 to the RPU.
- Atmospheric weather sensors will measure their respective weather parameters and communicate the data from each to the RPU.
- The RPU will acquire data from all connected sensors. The RPU will process and temporarily store the output from the pavement sensors and atmospheric sensors.
- The 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 of 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 ESS protocols.
- The 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 contractor will install 110 VAC service to the RPU power disconnects. Primary power should be installed to the RPU and fused for 15 amps, 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 shall be provided to power the RPU for a minimum of 1 hr. in the event of loss of AC service.

The RPU hardware and software shall 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:

- 3 Passive pavement sensors,
- 1 Subsurface temperature sensor,
- 1 Air temperature sensor,
- 1 Rain sensor,
- 1 Wind speed/direction sensor,
- 1 Tipping bucket rain gauge,
- 1 Barometric pressure sensor, and
- 1 Relative humidity sensor.

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, PPP dial-up over telephone, PMPP leased line, PMPP VHF/UHF 2-way radio, 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 communication cabinet, traffic signal controller cabinet or communications building as shown on the plans.

2.3. **RPU to Network Server Data Communications.**

Note: The following are common NTCIP terms:

Application Layer Terms:

- STMF AP-STMF Simple Transportation Management Framework
- SNMP AP-SNMP Simple Network Management Protocol
- STMP AP-STMP Simple Transportation Management Protocol
- Simple Transportation Management Framework (STMF) Level I is SNMP
- Simple Transportation Management Framework (STMF) Level II is SNMP+ STMP + 13 Dynamic Objects

Transport Terms:

- NULL TP-NULL
- TCP/IP TP-TCPIP
- Sub Network Profile Terms:
- PMPP SP-PMPP Point to Multipoint Protocol
- SLIP SP-SLIP Serial Line Internet Protocol
- PPP SP-PPP Point to Point Protocol
- Ethernet SP-ETH Ethernet

The RPU and Network Server (NS) will support the following interfaces:

- RS-232, and
- 10 MB ETHERNET.

The RPU and NS will support the following NTCIP protocol stacks as follows:

- Data Objects-SNMP-Null-PMPP-Twisted Pair and
- Data Objects-SNMP-TCP/IP-Ethernet.

The RWIS system proposed or bid will comply with all mandatory sections of the following NTCIP/ESS standards for data communication:

- NTCIP Document 1204v02.23b NTCIP ESS Interface Standards,
- NTCIP Document 1201v02.26 NTCIP Global Object Definitions, with Amendment,
- NTCIP Document TS 3.2-1996 NTCIP Simple Transportation Management Framework - Amendment 1,
- NTCIP Document NTCIP 2202:2001 version v01.05, NTCIP TP-Internet (TCP/IP and UDP/IP), and
- NTCIP Document 2104:2003 NTCIP Ethernet Subnetwork Profile.

If requested, after bid opening and prior to contract execution, the successful Contractor will supply its Protocol Requirement List (PRL) Table (ref: NTCIP Document 1204v02.23b NTCIP ESS Interface Standards) for this implementation.

The successful vendor will supply the following MIB Files:

- Standard Device MIB files and
- Manufacturer-specific MIB files.

The system will transfer data from each RPU to the existing NS by the NS polling each RPU at a time interval specified by the agency and configured by the Contractor.

2.4. **User Interface.**

Provide equipment for this project that integrates into the existing Department ITS network. The central software shall be installed on an existing server located at the TMC, and shall provide access to RWIS data locally, or by using a widely available Internet Browser (Internet Explorer or Netscape).This central software shall operate the system until the system is integrated into the existing TMC software. The software integration into the existing TMC software is not part of this contract and will be done by others using the previously mentioned API.

The central software will be capable of displaying NTCIP-ESS data as well as feeding a relational database for integration into the TMC software.

The central software shall provide for customer configuration of the display pages. The RWIS sites will provide data to the central software that will include pages configurable as follows. These pages may be configured by end user personnel, or optionally will be configured at the time of installation and setup.

Summary Page. This page shall be configurable to display a 1-line summary of current data for each RPU in the system. The data displayed will include (depending on RPU sensor configuration):

- RPU Name,
- Representative Surface Sensor Name,
- Data Collection Time for the RPU,
- Surface Status for the RPU's representative surface sensor ,
- Surface Temperature for the RPU's representative surface sensor,
- Subsurface Temperature for the RPU's representative subsurface probe,
- Air Temperature,
- Relative Humidity,
- Dewpoint Temperature,
- Precipitation Occurrence,

- Precipitation Intensity and Rate,
- Wind Gust Speed, and
- Average Wind Direction.

The Summary Page shall be configurable to use color to indicate the Surface Status and Precipitation Type. If left unattended, the Summary Page will refresh every 6 min. The title of each data field will also be a link, which will display the Help Screen or Glossary definition for the field. Additional links shall be able to be configured on this page depending on the availability of data such as maps, forecasts, cameras, etc.

Surface Summary Page. The Surface Summary Page shall be configurable to display current data for each surface sensor in the system grouped by RPU. This data will include, at a minimum:

- Surface Sensor Name and number,
- Surface Status,
- Surface Temperature, and
- Subsurface Temperature, if available, for the surface sensor.

In addition, the following RPU data items shall be configurable to display for each group of surface sensors (depending on RPU sensor configuration):

- RPU Name,
- Data Collection Time for the RPU,
- Air Temperature,
- Dewpoint Temperature,
- Average Wind Speed,
- Average Wind Direction, and
- Precipitation Intensity.

The Surface Summary Page shall be configurable to use color to indicate the Surface Status for each surface sensor. If left unattended, the Surface Summary Page will refresh every 6 min. The title of each data field will also be a link, which will display the Help Screen or Glossary definition for the field. Additional links shall be able to be configured on this page depending on the availability of data such as maps, forecasts. Cameras, etc.

RPU Status Page. The RPU Status Page shall be configurable to display all current data for a single RPU. This data will include (depending on RPU sensor configuration):

- RPU Name,
- Data Collection Time,
- Air Temperature,
- Relative Humidity,
- Dew point Temperature,
- Wet Bulb Temperature,
- 24 Hour Minimum Air Temperature,
- 24 Hour Maximum Air Temperature,
- Average Wind Speed,
- Wind Gust Speed,
- Average Wind Direction,
- Wind Gust Direction,
- Precipitation Occurrence,
- Precipitation Intensity, Accumulation and Rate,
- Surface Sensor Name for each surface sensor,
- Surface Status for each surface sensor,
- Surface Temperature for each surface sensor,

- Conductivity (Salinity) for each surface sensor,
- Salinity for each surface sensor, and
- Subsurface Temperature for each Subsurface Sensor.

The RPU Status page shall be configurable to use color to indicate Surface Status and Precipitation Type. If left unattended, the RPU Status Page will refresh every 6 minutes. The title of each data field will also be a link, which will display the Help Screen or Glossary definition for the field. Additional links shall be able to be configured on this page depending on the availability of data such as maps, forecasts, cameras, etc.

Atmospheric History Page. The Atmospheric History Page shall be configurable to display 12 hours of atmospheric data such as air temperature, wind, and precipitation history data for a single RPU ordered most recent to least recent. The Atmospheric History Page will include (depending on RPU sensor configuration):

- RPU Name,
- History Time Period,
- Data Collection Time for each history data snapshot,
- Air Temperature,
- Relative Humidity,
- Dew point Temperature,
- Average Wind Speed,
- Wind Gust Speed,
- Average Wind Direction,
- Precipitation Occurrence, and
- Precipitation Intensity, Accumulation and Rate.

The Atmospheric History Page shall be configurable to use color to indicate the Precipitation Type. The Atmospheric History Page will include links to access the previous or next 8 hours of history data. Using these links, the user will be able to navigate back through any history data available for an RPU. The title of each data field will also be a link, which will display the Help Screen or Glossary definition for the field. The data currently displayed on the Atmospheric History page will be linked to the data displayed on the Surface History Pages. The Atmospheric History Page will include an Export link, which will allow the user to export the data in CSV format to be used by an external application. This data shall also be capable of feeding a relational database of the TMC software.

Surface/Atmospheric History Page. The Surface/Atmospheric History Page shall be configurable to display 12 hours of atmospheric and surface history information. Data will include history data for the user selected surface sensor and atmospheric data from a single RPU ordered from most recent to least recent. The Surface/Atmospheric History Page will include (depending on RPU sensor configuration):

- RPU Name
- History Time Period
- Data Collection Time for each history data snapshot
- Surface Status for the selected surface sensor
- Surface Temperature for the selected surface sensor
- Subsurface Temperature for the selected surface sensor
- Air Temperature
- Relative Humidity
- Dew point Temperature
- Average Wind Speed
- Wind Gust Speed
- Average Wind Direction
- Precipitation Occurrence
- Precipitation Intensity and Rate

- The Surface/Atmospheric History Page shall be configurable to include links to access the previous or next 8 hours of history data. Using these links, the user will be able to navigate back through any history data available for an RPU. The title of each data field will also be a link, which will display the Help Screen or Glossary definition for the field. The Surface/Atmospheric History Page will include an Export link, which will allow the user to export the data in CSV format to be used by an external application. This data shall also be capable of feeding a relational database of the TMC software.urface/Precipitation History Page

The Surface/Precipitation History Page shall be configurable to display 12 hours of precipitation and surface history information. Data will include history data for the user selected surface sensor and precipitation data from a single RPU ordered from most recent to least recent. The Surface/Precipitation History Page will include (depending on RPU sensor configuration):

- RPU Name
- History Time Period
- Data Collection Time for each history data snapshot
- Surface Status for the selected surface sensor
- Surface Temperature for the selected surface sensor
- Subsurface Temperature, if available, for the selected surface sensor
- Freeze Point Temperature for the selected surface sensor
- Conductivity (Salinity) for the selected surface sensor
- Precipitation Occurrence
- Precipitation Intensity, Accumulation and Rate

The Surface/Precipitation History Page shall be configurable use color to indicate the Surface Status and Precipitation. The Surface/Precipitation History Page will include links to access the previous or next 8 hours of history data. Using these links, the user will be able to navigate back through any history data available for an RPU. The title of each data field will also be a link, which will display the Help Screen or Glossary definition for the field. The Surface/Precipitation History Page will include an Export link, which will allow the user to export the data in CSV format to be used by an external application. This data shall also be capable of feeding a relational database of the TMC software.

History Graph. The History Graph will present a line graph representation of historical temperature data for a single RPU. The data displayed on the graph will include (depending on RPU sensor configuration):

- Surface Temperature for each sensor
- Freeze Temperature for each sensor
- Surface status for each sensor
- Precipitation intensity for each sensor
- Air Temperature
- Dew point Temperature

The History graph shall be configurable to allow the user to customize the display of data according to their needs. The History graph shall support the ability to modify the scale of the graph based on the information that is being displayed. Additionally, the History graph shall support the ability to select various historical data including, but not limited to:

- Air Temperature
- Dew Point Temperature
- Surface Temperature
- Precipitation Accumulation

The history graph shall be configurable to allow the user to determine what items will be shown in the legend of the graph. The legend shall be able to be turned on or off depending on the user's needs.

Help Screen or Glossary Page. In addition to the RWIS data pages, the user interface (UI) will include a Help Screen or Glossary Page, which defines each of the data items displayed and other important terms. Every screen view or Web page will provide links to the Help Screen or Glossary Page to provide convenient access to on-line help.

Map Pages. At a minimum, the UI will include an overlay map (Regional map). The available map formats will include Link maps, Status maps, and Overlay maps. The following table outlines the differences between the map formats:

Capability	Link	Status	Overlay
Links to RPU Status page	**Yes**	**Yes**	**Yes**
Atmospheric and surface data displayed in table on side of page	**No**	**Yes**	**Yes**
Requires a Java compatible browser	**No**	**No**	**Yes**

A link map will usually be a top-level map, which provides a means for navigating between data for different RPUs. Clicking on an RPU site noted on the map will display another page showing the current data for the selected RPU.

A Status map is similar to a Link map except that the data will be displayed in a table on the same page as the map.

An Overlay map will function in most ways like a Status map except it will allow color-coded icons to be displayed directly on the map. Overlay maps will be further divided into two types of maps, Regional and Site maps.

A Regional map will have only RPU sites on the map. Clicking on an RPU site noted on the map will display the current atmospheric data for the RPU and selected sensor data for the sensor that has the worst-case surface status. Overlay maps of RPUs will be color-coded based on the associated sensor that has the worst-case surface status.

A site map will have one or more RPU sites as well as all the sensors associated with the RPUs. All current data is displayed in data tags on the map.

Site overlay maps only: A site map will display all of the data for each RPU on the map. Each RPU and sensor on the map will be associated with a data tag. By default, an RPU tag will display (depending on RPU sensor configuration):

- Air Temperature,
- Average Wind Direction,
- Average Wind Speed,
- Dew point Temperature,
- Precipitation Occurrence,
- Precipitation Intensity and Rate, and
- Relative Humidity.

By default, each sensor tag will display:

- Subsurface Temperature,
- Surface Status, and

- Surface Temperature.

2.5. **Network Server to User Interface Data Communication.**

The Network Server (NS) will support the following forms of data communication to the User Interface (UI):

- Direct LAN/WAN connection between the NS and UI,
- Direct RS-232 connection between the NS and UI, and
- Remote access via telephone lines.

All data communication between the Network Server (NS) and User Interface (UI) will be performed utilizing TCP/IP (Transmission Control Protocol / Internet Protocol) or PPP (Point-to-Point Protocol).

Remote access via telephone lines will use standard Microsoft Windows Remote Access Services (RAS).

2.6. **Passive Pavement Sensor.**

Furnish and install passive pavement sensor(s) as shown on the project plans. The passive 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. 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 passive, 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 75 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 500 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 - Absence of moisture on the surface sensor.
- Trace Moisture - Pavement Moisture above freezing (no precipitation).
- Wet - Precipitation has occurred and there is a continuous film of moisture on the pavement sensor.
- Chemically Wet - 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 - Continuous film of ice and water mixture at or below freezing (32°F) with insufficient chemical to keep the mixture from freezing (active precipitation).
- Ice Watch - 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.

2.7. **Subsurface Temperature Probe.**

Furnish and install the subsurface temperature probe(s) in the roadway near a surface sensor at a depth of 17 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 75 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 500 ft. from the RPU.

2.8. **Additional Sensors.**

In addition to the sensors listed above, the Contractor shall furnish and install the following sensors:

Air Temperature/Relative Humidity Sensor. The Air Temperature/Relative Humidity Sensor will have an air temperature-sensing element that operates over the temperature range of -40°F to 140°F. The relative humidity sensing element will be of the "capacitance type" and have a measuring range of 10 to 100% RH.

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 in a solar/wind-radiation shield.

Wind Monitor. The Wind Monitor sensor will be installed at the standard meteorological height of approximately 30 ft. above ground level. The sensor may be a combination wind speed and direction sensor of lightweight corrosion-resistant construction.

The sensor will have an operating range of 0 to 164 ft/sec, with a survival operation limit of 279 ft/sec. Accuracy will be $\pm$1 ft/sec. Wind speed sensitivity shall be 3.6 ft/sec. Wind direction accuracy shall be $\pm$ 3% with linearity within 1°. Wind direction sensitivity shall be no more than 1.6 ft/sec.

Rain Gauge. A 12 in. Tipping Bucket Rain Gauge shall be provided to monitor accumulated rainfall. Event resolution will be 0.01 in. Accuracy of the rain gauge shall be ±1.5% for 0 to 2 in/hr and ±3% for 2 to 6 in/hr. Operating temperature range is from 32°F to 140°F.

The rain gauge shall accommodate standpipe, bridge (bracket) or tower mounting.

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.

3.1. **RWIS System Commissioning.**

Upon completion of the RWIS system equipment installation, the system vendor shall 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.

Prior to 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 5 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 12-mo. period from the RWIS commissioning date. The passive in-pavement sensors will be covered by a parts only lifetime warranty.

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 shall warranty the RPU for a period not less than 36 mo., atmospheric sensors for a period not less than 12 mo. and passive in-pavement sensors for a period of not less than 12 mo. (parts only). 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.

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. Provide a training location. Provide 1 copy of the course material for each person. Provide training in the following areas of interest and as shown on the plans:

- 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, by each individual RWIS component installed, or by the foot of cable 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 "Installation of Road Weather Information System", "Passive Pavement Sensor", "Subsurface Temperature Probe", or "Sensor and Probe Cable". This price is full compensation for furnishing, placing, testing all materials and equipment, software licensing for interim solution, and all tools, labor, supplies, and incidentals.