A313a Understanding User Needs for ESS Systems Based on NTCIP 1204 v04 Standard

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1. Module Description

This module is based on recently released NTCIP 1204 v04 (May 2016) standard that covers Environmental Sensor Stations (ESS) and Road Weather Information System (RWIS).

The purpose of this **update**d module (previous module was based on v03 of the standard) is to incorporate necessary changes such as new ESS user needs/requirements and ESS test procedures provided in recently (May 2016) completed work on NTCIP 1204 Standard v04 and reorganized documentation from the previous v03. The module provides participants with information on how to identify the appropriate use of the latest NTCIP 1204 Standard v04 and acquire an ESS system based on what the user is seeking to accomplish; and provides participants with information on how to identify user needs. The focus in this module is placed on Understanding ESS User Needs.

ESS Related Training Modules and Pre-requisites

Agencies preparing a project specification for Environmental Sensor Stations (ESS) based on NTCIP 1204 v04 will need to consult the following three updated sequential modules:

1. A313a: Understanding **User Needs** for ESS Systems based on NTCIP 1204 Standard v04
2. A313b: Specifying **Requirements** for ESS Systems based on NTCIP 1204 Standard v04
3. T313: Applying Your **Test Plan** to the Environmental Sensor Stations based on NTCIP 1204 Standard v04

2. Introduction to ESS and NTCIP 1204 ESS Standard

Environmental Sensor Stations (ESS) are ground -based or pole mounted sensors that collect base level raw weather data from roadways sections or region and transmit data to a central or field location where they are used as part of a Road Weather Information System (RWIS). The module will provide a brief background on RWIS/ESS and show how agencies use weather information to make decisions and issue advisory to motorists and stakeholders.

NTCIP 1204 v04, an NTCIP standards publication, identifies and defines how a management station may wish to interface with a field device to control and monitor pavement sensors, weather stations, air quality sensors, and other equipment related to the monitoring of and response to environmental conditions in an NTCIP-conformant fashion. NTCIP 1204 v04 uses only metric units. NTCIP 1204 v04 provides definitions of data elements for environmental sensor data, including weather data, pavement condition data, water level data, and air quality data. NTCIP 1204 v04 defines requirements that are applicable to all NTCIP environments and it also contains optional and conditional sections that are applicable to specific environments for which they are intended.

How and Why Agencies Use ESS

Transportation system managers use ESS in a variety of ways to improve transportation system operations. The primary uses of ESS data support the following:

a) sharing data with the broader weather community contributes to better weather forecasts
b) improved highway maintenance operations through supporting timely, accurate, and relevant weather forecasting and knowledge of existing road weather conditions
c) more accurate traveler information, which can result in better route planning by travelers and more effective, safer transportation system use
d) improved management of facilities maintenance resources, leading to more timely facilities clearance and improved traveler safety
e) more effective use of advisory and regulatory mechanisms to ensure public safety
f) enhanced monitoring of potential hazardous conditions, to improve transportation system security and traveler safety
g) Facilitate sharing of air quality information collected by sensors in field devices and on mobile platforms

ESS are used to collect information about road and weather conditions, such as precipitation and air and surface temperatures. With the data returned by this ESS, transportation system managers can determine when there are incipient hazardous travel conditions because of precipitation, fog, high winds, snow, ice, and/or flooding. When travel is becoming hazardous because of snow and/or ice, transportation system managers can dispatch road maintenance crews to treat the roads and remove snow and ice if possible.

The following example of ESS user needs is provided in Section 2.

- 2.5.1.3 Monitor Power

  A transportation system operator may wish to monitor the power for the ESS to ensure proper operation.

- 2.5.1.4 Monitor Mobile Station Data

  A transportation system operator may wish to monitor the movements of a mobile ESS and, if it is part of a mobile pavement treatment system, monitor the chemicals being dispersed.

Using ESS with other ITS Devices such as a DMS

Transportation system managers can also use ESS in conjunction with other Intelligent Transportation System (ITS) devices, such as Dynamic Message Signs (DMS-NTCIP 1203 v03), to advise travelers of poor travel conditions or to notify travelers of travel policy changes because of bad weather. For example, foggy conditions could trigger a DMS to display a lowered speed limit in a

high-speed area. Snow and ice conditions could trigger a DMS to display a requirement for travelers to use chains on their tires. Icy conditions on bridges or roadways can also lead to the triggering of a spraying device that sprays anti-icing or de-icing chemicals on bridge or roadway surfaces to improve driving conditions. High water or high wind conditions could trigger a DMS to display a message either recommending that travelers choose a different route or that they reduce their speed to protect themselves against the potential hazard.

Although transportation system managers are the normal users of ESS, the data from these ESS are sometimes used by emergency management personnel. For example, when flood conditions occur, regardless of their extent, emergency management personnel use data on the depth of water in areas covered by ESS to determine how and when to respond to flooding. Emergency management personnel re-route travelers from flooded areas, in some cases by deploying (in conjunction with transportation system personnel) signs indicating that sections of road are closed because of flooding.

A transportation system manager may also be interested in using an ESS to measure air quality. This data can be used to monitor concentrations of certain chemicals to ensure that they do not exceed toxic levels. For example, tunnel systems frequently use sensors to ensure that carbon monoxide levels stay within safe levels. The data can also provide a valuable resource to air quality management systems to determine the accuracy of predictions. Finally, some research has suggested that air quality hot spots could be monitored to encourage traffic to avoid these areas during problematic periods.

How ESS is deployed: RWIS Architecture Example

The RWIS architecture includes the hardware, software, and communications systems necessary to provide reliable road weather data to support operation and maintenance of roadways.

Fixed Locations: An ESS is typically deployed along the roadside as part of a network of sensors that report their findings to a central management system. The ESS data received at the central system is processed to provide the transportation system manager with intelligence about road weather conditions that can trigger operator action. For example, high wind conditions might trigger a warning to travelers; if the high wind conditions are severe or in an area where they constitute a high risk, they might trigger the closing of a bridge or a section of roadway. Likewise, a network of ESS may also be used to provide the transit system operator information about conditions that affect the health or safety of transit riders. The processing logic could be rather simple (e.g., monitoring high winds) or very complex (e.g., predictions of weather conditions on or near the road). In the latter case, the ESS data would likely serve as one of many inputs; others might include data from the national weather service and other sources.

Transportable and Mobile ESS: However, ESS can also be deployed on a vehicle or a transportable platform (such as on a trailer). Usually, these ESS are atmospheric sensors or pavement sensors, gathering information about snow and ice conditions, pavement conditions, and similar data designed to provide the transportation system manager with information about conditions along a

particular section of roadway. The data from mobile ESS are used to complement those from stationary ESS also deployed along the transportation network.

Recent natural disasters and flooding events in the country have also raised additional utilities and deployment interest in ESS and the following section outlines what is possible in this area.

2.1. ESS Standard's Relationship to the ITS National Architecture

NTCIP 1204 v04 addresses eight (8) National ITS Architecture Flows associated with the operation of an ESS. These flows are:

a) **Environmental Sensors Control:** Data used to configure and control environmental sensors.
b) **Environmental Sensor Data:** Current road conditions (e.g., surface temperature, subsurface temperature, moisture, icing, treatment status) and surface weather conditions (e.g., air temperature, wind speed, precipitation, visibility) as measured and reported by fixed and/or mobile environmental sensors. Operational status of the sensors is also included.
c) **Environmental Conditions:** Current road conditions (e.g., surface temperature, subsurface temperature, moisture, icing, treatment status) and surface weather conditions (e.g., air temperature, wind speed, precipitation, visibility) that are measured by environmental sensors.
d) **Environmental Probe Data:** Data from vehicle safety and convenience systems that can be used to estimate environmental conditions, including measured air temperature, exterior light status, wiper status, sun sensor status, rain, and snapshots of recent events (e.g., traction control or anti-lock brake system activations) may be reported.
e) **Pollution Sensor Control:** Data used to configure and control area pollution and air quality sensors.
f) **Area Pollution Data:** Measured air quality data, including measured levels of atmospheric pollutants including ozone, particulate matter, carbon monoxide, and nitrogen oxides, and operational status of the sensors.
g) **Roadway Treatment System Control:** Control data for remotely located, automated devices that affect the roadway surface (e.g. de-icing applications).
h) **Roadway Treatment System Status:** Current operational status of automated roadway treatment devices (e.g., anti-icing systems).

3. Case study: Understanding How to Use Protocol Requirements List (PRL)

PRL is a first step toward achieving a successful ESS system that is conformant to the ESS standard and ensuring an interoperable system that works as desired. Every ESS procurement specification must incorporate a PRL that meets project user needs.

Readers are directed to familiarize with the structure of the ESS PRL and learn how to prepare a project level PRL.

The PRL provided under Sections 3.3.3 map the user needs defined in Section 2 to the requirements defined in Section 3. The following example illustrates how a Project Level PRL can be developed.

User Needs Column (user simply maps local project need to one in standard)
The user needs are defined within Section 2 of the NTCIP 1204 v03 and the PRL is based upon the user need sections within that Section. The section number and user need name are indicated within these columns. As seen in above PRL, 2.5.1.2 User Need ID and Monitor Winds form a pair that sets the tone for rest of the activities.

Requirements Column (user has NO role in Picking Requirements, standard has done that part)

The requirements are defined within Section 3 and the PRL references the traces from user needs to these requirements. The section number and functional requirements name are indicated within these columns.

Conformance Column: M-mandatory user need must be selected, Optional-O must be selected if project function demands it, and support must be checked YES in next column.

Support / Project Requirements Column

The support column can be used by a procurement specification to identify the required features for the given procurement or by an implementer to identify which features have been implemented. In either case, the user circles the appropriate answer (Yes, No, or N/A) in the support column.

The PRL table can be used by:

a) A user or specification writer to indicate which requirements are to be implemented in a project-specific implementation.
b) The protocol implementer, as a checklist to reduce the risk of failure to conform to NTCIP 1203 v04 through oversight.
c) The supplier and user, as a detailed indication of the capabilities of the implementation.
d) The user, as a basis for initially checking the potential interoperability with another implementation.

4. Sample List of ESS User Needs (shown without Requirements)

The following project level PRL sample is followed by a full PRL Table is a stripped version of Table 6 taken from NTCIP 1204 v04, page 29 shows how ESS user needs are accumulated by developers and organized in the document format. ESS is complete standard and this list covers range of potential user needs by any type of field deployments.

Project Level ESS PRL (users can ONLY add rows; columns cannot be changed).

PRL is a Mapping Table that Provides Standardized Requirement(s) Allocated to Each User Need

Protocol Requirements List (PRL)

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
2.4	Architectural Needs			M	Yes	
2.4.1	Generic Architectural Needs			M	Yes	
2.5	Features			M	Yes	
2.5.1	ESS Manager Features			M	Yes	
2.5.1.1	Generic Features			M	Yes	
2.5.1.2	Monitor Door Status			O	Yes / No	
		3.5.1.2.1	Retrieve ESS Door Status	M	Yes / NA	
2.5.1.3	Monitor Power			O	Yes / No	
		3.5.1.2.2	Retrieve Battery Status	O.1 (1..*)	Yes / No / NA	
		3.5.1.2.3	Retrieve Line Volts	O.1 (1..*)	Yes / No / NA	
2.5.1.4	Monitor Mobile Station Data			Mobile:M	Yes / NA	
		3.5.1.3.1	Retrieve Mobile ESS Movement	M	Yes / NA	NTCIP 1204 v04 does not impose any accuracy requirements. Any accuracy requirements should be inserted here.
2.5.1.5	Determine ESS Type			M	Yes	
2.5.1.5.a	Permanent			O.2 (1)	Yes / No	
2.5.1.5.b	Transportable			O.2 (1)	Yes / No	
2.5.1.5.c (Mobile)	Mobile			O.2 (1)	Yes / No	
		3.5.1.1.1	Retrieve ESS Characteristics	M	Yes	
2.5.1.6	Monitor the Status of the ESS			O	Yes / No	
		3.5.1.3.4	Retrieve ESS Status	M	Yes / NA	
2.5.2	Sensor Manager Features			O.3 (1..*)	Yes / No	

Agency prepares a customized project PRL by selecting YES

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Support	Additional Specifications
2.4	Architectural Needs			M	Yes	
2.4.1	Generic Architectural Needs			M	Yes	
2.5	Features			M	Yes	
2.5.1	ESS Manager Features			M	Yes	
2.5.1.1	Generic Features			M	Yes	
2.5.1.2	Monitor Door Status			O	Yes / No	
2.5.1.3	Monitor Power			O	Yes / No	
2.5.1.4	Monitor Mobile Station Data			Mobile: M	Yes / NA	
2.5.1.5	Determine ESS Type			M	Yes	
2.5.1.6	Monitor the Status of the ESS			O	Yes / No	
2.5.2	Sensor Manager Features			O.3 (1,*)	Yes / No	
2.5.2.1	Monitor Weather Conditions			O.4 (1,*)	Yes / No / NA	
2.5.2.1.1	Monitor Atmospheric Pressure			O.5 (1,*)	Yes / No / NA	
2.5.2.1.2	Monitor Winds			O.5 (1,*)	Yes / No / NA	
2.5.2.1.3	Monitor Air Temperature			O.5 (1,*)	Yes / No / NA	
2.5.2.1.4	Monitor Relative Humidity			O.5 (1,*)	Yes / No / NA	
2.5.2.1.5	Monitor Precipitation			O.5 (1,*)	Yes / No / NA	
2.5.2.1.6	Monitor Solar Radiation			O.5 (1,*)	Yes / No / NA	
2.5.2.1.7	Monitor Visibility			O.5 (1,*)	Yes / No / NA	
2.5.2.1.8	View Environmental Image			O	Yes / No	
2.5.2.2	Monitor Pavement			O.4 (1,*)	Yes / No / NA	
2.5.2.2.1	Monitor Pavement Surface Condition			M	Yes / NA	
2.5.2.2.2	Monitor Icing Conditions			O	Yes / No / NA	
2.5.2.2.3	View Pavement Image			O	Yes / No	
2.5.2.3	Monitor Subsurface Conditions			O.4 (1,*)	Yes / No / NA	
2.5.2.4	Monitor Human Readings			O.4 (1,*)	Yes / No / NA	
2.5.2.5	Monitor Water Level			O.4 (1,*)	Yes / No / NA	
2.5.2.6	Monitor Air Quality and Biohazards			O.4 (1,*)	Yes / No / NA	
2.5.2.7	Monitor Mobile Weather Profile			O	Yes / No / NA	
2.5.3	Pavement Treatment System Manager Features			O.3 (1,*)	Yes / No / NA	
2.5.4.2	Backward Compatible with NTCIP 1204 v02			O	Yes / No / NA	
2.5.4.3	Backward Compatible with NTCIP 1204 v03			O	Yes / No / NA	
F.1.1	Generic Architectural Needs					
F.1.1.1	Provide Live Data			M	Yes	
F.1.1.3	Provide Off-line Log Data			O	Yes / No	
F.1.2	Generic Features					
F.1.2.1	Retrieve Device Identity			M	Yes	
F.1.2.2	Control External Devices			O	Yes / No	

NOTE: ALL Mandatory M User needs must be selected YES to conform to standards, Optional-O may be selected YES if the local project has identified optional needs.

5. References to Standards

- NTCIP Joint Committee: NTCIP 1204 v04 Object Definitions for Environmental Sensor Stations – www.ntcip.org (NEMA NTCIP Coordinator approval for public Draft release pending)
- *NTCIP 1201 Version v03.13a, National Transportation Communications for ITS Protocol, Global Object Definitions* (www.ntcip.org)
- IEEE 830-1998 - IEEE Recommended Practice for Software Requirements Specification

6. Glossary

Term	Definition
C2C	Center to Center
C2F	Center to Field
DMS	Dynamic Message Signs
ESS	Environmental Sensor Station
FMS	Freeway Management System
MIB	Management Information Base
NTCIP	National Transportation Communications for ITS Protocols
PRL	Protocol Requirements List
PTS	Pavement Treatment Systems
RPU	Remote Processor Unit
RTM	Requirement Traceability Matrix
RWIS	Road Weather Information System
SEP	Systems Engineering Process
SNMP	Simple Network Management Protocol
TMC	Traffic Management Center
Agency Specification	A document that has been prepared by an agency to define requirements for a subject item or process when procured by the agency.
Compliance	A condition that exists when an item meets all of the requirements of an agency specification.
Concept of Operations	A document that describes the purpose for a system project, including a description of the current and proposed system, as well as key user needs that the new system is required to address.
Conformance	A condition that exists when an item meets all of the mandatory requirements as defined by a standard. It can be measured on the standard as a whole, which means that it meets all mandatory (and applicable conditional) requirements of the standard or on a feature level (i.e., it conforms to feature X as defined in section X.X.X), which means that it meets all mandatory (and applicable conditional) requirements of the feature.

Term	Definition
Dialogs	A sequence of information or message exchanges.
Environmental Sensor Station (ESS)	A location that includes a remote processor unit (RPU) connected to one or more sensors for the collection of environmental or meteorological data. It may also include a pavement treatment system (PTS). Note: The acronym ESS may also be used as a plural.
Feature	A service provided by / behavior of the device.
Protocol Requirements List (PRL)	A table mapping user needs with its associated requirements. This table allows procurement personnel to specify the desired features of a DMS or can be used by a manufacturer to document the features supported by their implementation. Requirement A condition or capability needed by a user to solve a problem or achieve an objective.
Specification	The project-specific detailed requirements for a DMS to be purchased by an agency or a statement by a manufacturer defining the detailed features provided by the DMS. Within NTCIP 1203 v03, 'specification' often refers to the text contained in the 'Additional Project Requirements' column of the PRL.
Transportable	In the context of an ESS, an ESS capable of being relocated, but its environmental sensors and pavement treatment devices do not operate while moving.
User Need	The business or operational problem (opportunity) that must be fulfilled to justify purchase or use. While this is termed a 'user need' within the NTCIP community, it reflects needs of all stakeholders.
Requirements Traceability Matrix (RTM)	A table that links the requirements to the corresponding dialogs and objects.

7. References

- NTCIP Joint Committee, *NTCIP 9001 NTCIP Guide Version 04*. NTCIP Joint Committee, July 2009. http://www.ntcip.org/library/documents/
- United States Department of Transportation, *Systems Engineering Guidebook for Intelligent Transportation Systems Version 3.0*. USDOT, November 2009. http://www.fhwa.dot.gov/cadiv/segb/
- Best Practices for Road Weather Management, v3, FHWA, FHWA-HOP-12-046
- Michigan DOT, Road Weather Information System Concept of Operations, June 2007; www.michigan.gov/documents/mdot/RWIS_Concep...
- *Weather-Responsive Traffic Management – Concept of Operations. FHWA, 2003:* ops.fhwa.dot.gov/weather/best practices/WeatherConOps0103.pdf
- Iowa DOT Video Clip on ESS: *http://www.iowadot.gov/maintenance/weather.html*

Study Questions

1. **Which of the following is NOT a Correct Statement Related to the ESS Standard?**
    a) Standard Supports RWIS.
    b) Standard Supports Communications Interface.
    c) Provides Traceability Tools.
    d) States Sensor Hardware Requirements.

2. **Which of the following is NOT Part of the ESS Standard?**
    a) Collection of atmospheric and environmental data.
    b) Monitoring the status of the ESS.
    c) Determining if an ESS is a permanent, transportable, or mobile.
    d) Creating a Weather Advisory Message on a Variable Message Sign (VMS).

3. **Which of the following is NOT a correct approach to preparing the project PRL?**
    a) Select YES Architectural needs.
    b) Select Mandatory ESS Manager features ONLY.
    c) Select YES project-specific features.
    d) Let the vendor select ESS features.

4. **Which of the following is a False Statement related to an ESS specification?**
    a) ESS specification includes a PRL.
    b) Conformance requires only meeting mandatory user needs.
    c) Compliance requires only mandatory user needs.
    d) Vendor must use the project PRL.

8. Icon Guide

The following icons are used throughout the module to visually indicate the corresponding learning concept listed out below, and/or to highlight a specific point in the training material.

1) **Background information:** General knowledge that is available elsewhere and is outside the module being presented. This will be used primarily in the beginning of slide set when reviewing information readers are expected to already know.

2) **Tools/Applications:** An industry-specific item a person would use to accomplish a specific task, and applying that tool to fit your need.

3) **Remember:** Used when referencing something already discussed in the module that is necessary to recount.

4) **Refer to Student Supplement:** Items or information that are further explained/detailed in the Student Supplement.

5) **Example:** Can be real-world (case study), hypothetical, a sample of a table, etc.

6) **Checklist:** Use to indicate a process that is being laid out sequentially.