ITS Standards Advisory
ESS Standard
October 2013

Intelligent Transportation Systems (ITS) Standards Advisories provide the ITS transportation community with information and guidance on the consideration and use of ITS standards.

Environment Sensor Station Background

National Transportation Communications for ITS Protocol 1204 version 03 (NTCIP 1204 v03) describes the Environmental Sensor Station (ESS) Interface Protocol Standard. NTCIP 1204 v03 is a joint standard of the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE), and the National Electrical Manufacturers Association (NEMA). It provides definitions of data elements for environmental sensor data, including weather, pavement condition, water level, and air quality data.

The data is defined using the Simple Network Management Protocol (SNMP) object-type format as explained in RFC 1212 and NTCIP format outlined in NTCIP 8004 v02. Figure 1 depicts the architecture of ESS that is the basis of the Standard.[1] Elements of the controller include the sensor manager, the ESS manager, and the Pavement Treatment System (PTS) manager.

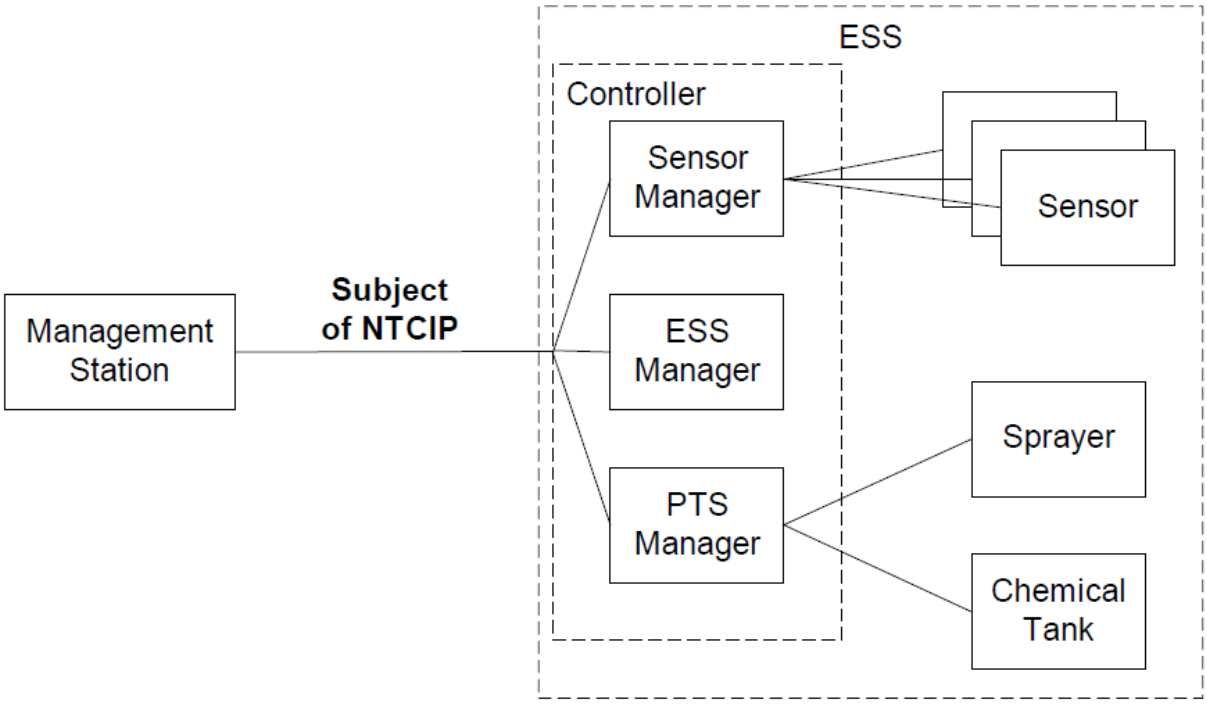

Figure 1. ESS Reference Architecture (from NTCIP 1204 v03)

[1] Throughout the document, "the Standard" will specifically refer to "ESS Interface Protocol Standard."

History

In September 1996, an agreement among AASHTO, ITE, and NEMA was executed to jointly develop, approve, and maintain the NTCIP. These NTCIP standards included a standard covering ESS. Work began in November 1996 and the NTCIP 1204 version 01 was published in 1998 as NTCIP 1204:1998.

Efforts began in 2001 to update and enhance the Standard to reflect lessons learned; update new documentation formats; add new features such as the control of automated de-icing equipment; and linking the Standard to a systems engineering process. The resulting NTCIP 1204 version 02 (NTCIP 1204 v02) was published in 2005.

In 2006, work began once again to enhance the Standard. Major revisions included the addition of test procedures. Additionally, the new v03 standard corrected issues that were discovered in the existing v02 standard. These enhancements were completed in 2008 and “NTCIP 1204 v03 Environmental Sensor Station (ESS) Interface Protocol” was published in November 2009.

In 2012, efforts were made to modify the Standard to reflect advancements in environmental sensing technology.

Changes since Last ESS Standards Advisory

NTCIP 1204 v03 added test procedures that are captured in Annex C of the report. These test procedures include a definition of keywords, a table tracing requirements to test cases, and step-by-step test procedures for each test case. In turn, adding the test procedures identified the need for other changes, which are summarized in Annex D, Documentation of Revisions. Additionally, the document title was changed to "ESS Interface Protocol" in v03 to reflect the expanded content, which goes beyond an NTCIP data dictionary.

NTCIP 1204 v03 supports a systems engineering process for procurement, installation, and testing of ESS. The Standard provides the following matrices to support different stages of the project life cycle: it begins with the Profile Requirements List (PRL), continues through the Requirements Traceability Matrix (RTM), and finally proceeds to the Testing Requirements Traceability Matrix (TRTM).

NTCIP 1204 v03 is intended to simplify the process of defining an interoperable interface for any ESS Request for Proposal (RFP). By drilling down into the interface requirements, standardized design details, and testing procedures, the Standard simplifies the procurement process and verifies conformance to the Standard itself. Additionally, the Standard covers the majority of in-vehicle capabilities related to environmental reporting in connected vehicle systems.

The Profile Requirements List

The PRL maps the user needs to the requirements, and is defined in Sections 3.3.7 and 3.3.8 of the Standard. The PRL can be used by:

a) A user or specification writer to indicate which requirements are to be implemented in a project-specific implementation that satisfies their operational needs.

b) The protocol implementer to provide a checklist in order to reduce the risk of failure to conform to the Standard through oversight.

c) The supplier and user to give a detailed indication of the capabilities of the implementation.

d) The user to serve as a basis for initially verifying the potential interoperability with another implementation.

The PRL provides users with a tool to methodically develop their ESS functional requirements by stepping through each element of the system. Figure 2 is an excerpt of the PRL taken from NTCIP 1204 v03.

User Need ID	User Need	FR ID	Functional Requirement	Conformance	Project Requirement	Additional Project Requirements
2.4	Architectural Needs			M	Yes	
2.4.1	Generic Architectural Needs			M	Yes	(See F.1.1)
2.5	Features			M	Yes	
2.5.1	ESS Manager Features			M	Yes	
2.5.1.1	Generic Features			M	Yes	(See F.1.2)
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.6 (1..*)	Yes / No / NA	
		3.5.1.2.3	Retrieve Line Volts	O.6 (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	
		3.5.1.3.3	Retrieve Compressed Mobile Station Data	M	Yes / NA	

Figure 2. PRL Sample Section (from NTCIP 1204 v03)

The Requirements Traceability Matrix

The RTM associates each requirement with its standardized dialog and the related objects. The audience for the RTM includes implementers (vendors and central system developers) and conformance testers. Additionally, other interested parties might use the RTM to determine how particular functions are to be implemented using the standardized dialogs, interfaces, and object definitions.

To conform to a requirement, an ESS shall implement the associated dialog and all objects traced from that requirement; a Management Station shall do the same. By using this matrix, a user ensures that each functional requirement required in the ESS is fully configured in the system specifications. Figure 3 is an excerpt from the RTM taken from NTCIP 1204 v03.

Req. ID	Dialog	Requirement	Object ID	Additional Requirements/Object
3.5.1		**ESS Manager Requirements**		
3.5.1.1		**ESS Configuration Requirements**		
3.5.1.1.1	**F.3.1**	**Retrieve ESS Characteristics**		
			5.2.1	**essNtcipCategory**
			5.2.2	**essNtcipSiteDescription**
			5.3.1	**essTypeofStation**
			5.4.1	**essLatitude**
			5.4.2	**essLongitude**
			5.5.1	**essReferenceHeight**
3.5.1.1.2	**F.3.1**	**Retrieve Compressed Station Metadata**		
			5.3.8	**essStationMetaDataV3Block**
3.5.1.1.3	**F.3.3**	**Configure ESS Manager**		
			5.2.2	**essNtcipSiteDescription**
3.5.1.2		**ESS Status Monitoring Requirements**		
3.5.1.2.1	**F.3.1**	**Retrieve ESS Door Status**		
			5.3.2	**essDoorStatus**

Figure 3. RTM Sample Section (from NTCIP 1204 v03)

Testing Requirements and the Test Case Traceability Table

All test cases covered by this testing requirements documentation require the Device Under Test (DUT) to be configured for the site and connected to a test application. This is shown in Figure 4. A data analyzer may also be used to capture the data exchanged between the two components.

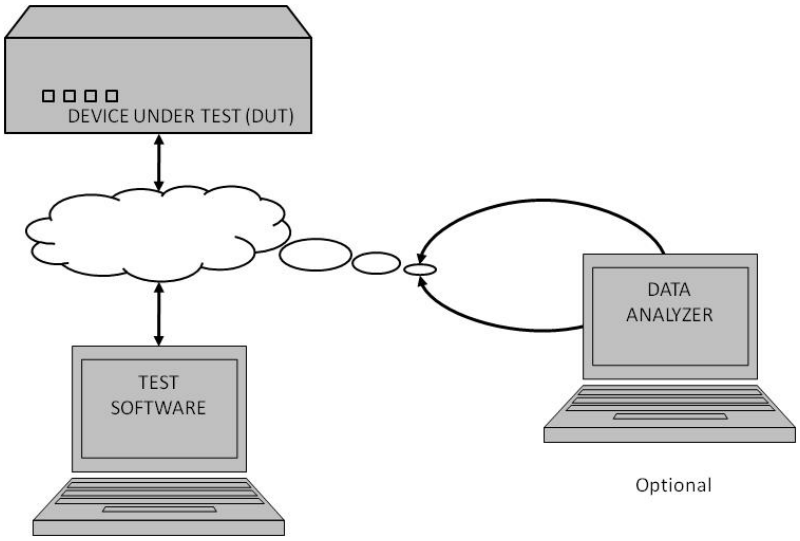

Figure 4. Field Device Test Environment (from NTCIP 1204 v03)

The Test Case Traceability Table details test case requirements and aids users in identifying and completing required testing using the established testing procedures. It methodically takes the user through the ESS and allows them to detail all test cases. A sample of this table is shown in Figure 5.

Requirement		Test Case	
ID	**Title**	**ID**	**Title**
3.5	***Data Exchange Requirements***		
3.5.1	***ESS Manager Requirements***		
3.5.1.1	***ESS Configuration Requirements***		
3.5.1.1.1	***Retrieve ESS Characteristics***		
		C.2.3.1.1	***ESS Characteristics***
3.5.1.1.2	***Retrieve Compressed Station Metadata***		
		C.2.3.1.2	***Retrieve Compressed Station Metadata***
3.5.1.1.3	***Configure ESS Manager***		
		C.2.3.1.1	***ESS Characteristics***
3.5.1.2	***ESS Status Monitoring Requirements***		
3.5.1.2.1	***Retrieve ESS Door Status***		
		C.2.3.1.3	***Retrieve ESS Door Status***
3.5.1.2.2	***Retrieve Battery Status***		
		C.2.3.1.4	***Retrieve Battery Status***

Figure 5. Sample Portion of Test Case Traceability Table (From NTCIP 1204 v03)

USDOT Guidance on ESS Standards

The United States Department of Transportation (USDOT) offers the following guidance regarding NTCIP ESS standards.

USDOT strongly encourages State and local agencies to use ESS standards. ESS standards are mature and offer immediate benefits for agencies by: 1) providing interoperability between ESS and other NTCIP-compatible field devices running on common communications channels, and 2) enabling simplified administration of ESS subsystems. Check the resources in the section below for help with systems assessment, migration, integration, and procurement. In particular, assistance is available to help you decide whether to implement standards-based ESS now with NTCIP 1204 v03. Our recommendations are organized by ESS deployer experience:

Current users of standards-based ESS: Monitor the development of NTCIP 1204 v03 to determine the timing of an upgrade from previous ESS versions that will support your vision for future ESS usage.

Those considering using standards-based ESS: ESS standards offer an ideal opportunity to introduce standards-based ITS into your agency's operations.

Those with legacy ESS systems considering migrating to standards-based ESS: Migrating from proprietary to standards-based ESS can be complicated, but will provide both immediate and long-term benefits. Use the resources cited in this document to find peer agencies that are making or have completed the transition.

ESS Application Level Standards in Use

Rolling Out ESS

With the migration in the NTCIP 1204 v03 to a systems-engineering approach, the Standard is ready to be the basis for all ESS procurements in the United States. At a minimum, users are encouraged to use the Standard in open procurements. Using established standards when procuring systems or applications allows for fuller and more open procurements, and enhances competition, both initially and in subsequent procurements for system upgrade or migration.

The Federal Highway Administration (FHWA) Road Weather Management Program at http://ops.fhwa.dot.gov/Weather/ is a wealth of information on Road Weather Information Systems (RWIS) and ESS, including publications and an events calendar. Of particular note is the Road Weather Information System Environmental Sensor Station Siting Guide Version 2.0.[2] This publication aids users in procurement of RWIS systems through the examination of siting considerations and criteria, metadata needs, and provision of checklists.

Examples of State RWIS specifications that cite the NTCIP standards are available on the Aurora Program website at: http://www.aurora-program.org/matrix.cfm. Aurora is an international partnership of public agencies working on RWIS.

Relevance to USDOT Research Initiatives, the National ITS Architecture, and the National Congestion Initiative

ESS supports the following USDOT Research Initiatives:

- **Integrated Corridor Management (ICM) Systems –** With ICM[3], the various institutional partner agencies manage the transportation corridor as a system, rather than the more traditional approach of managing individual assets. They manage the corridor as an integrated asset in order to improve travel time reliability and predictability, help manage congestion, and empower travelers through better information and more choices.
- **National ITS Architecture –** The National ITS Architecture[4] is the definitive framework that will guide deployment of ITS in the United States for the next 20 years or more.
- **Connected Vehicles –** A multimodal initiative is underway that aims to enable safe, interoperable, and networked wireless communications among vehicles, the infrastructure, and passengers' personal communications devices. This connected vehicle research is being sponsored by USDOT and others to leverage the potentially transformative capabilities of wireless technology to make surface transportation safer, smarter, and greener. USDOT research is supporting the development and testing of connected vehicle technologies and applications to determine their potential benefits and costs. Connected vehicle data offer the next opportunity to transform road weather management by dramatically expanding the amount and geographic scope of the data (due to mobile observations of moving vehicles), as well as the specificity of road-segment information. To date, most road-weather observations are still somewhat regional in nature. Connected vehicle data provide the opportunity to pinpoint where and how weather is affecting the roadways, leading to greater understanding of the scope of road treatments and mitigation strategies during inclement weather, better information quality provided to drivers and travelers, and improved details for producing more targeted traffic management strategies. If successfully deployed, connected vehicles will ultimately

[2] http://ntl.bts.gov/lib/30000/30700/30705/14447.pdf.
[3] http://www.its.dot.gov/icms/index.htm
[4] http://www.its.dot.gov/exit/iteris_arch.htm?link=http://www.iteris.com/itsarch/

enhance the safety, mobility, and quality of life for all Americans, while helping to reduce the environmental impact of surface transportation.

- **RWIS –** RWIS[5] typically consists of sensors, remote processing units (RPU), central processing units (CPU), communications equipment, computer workstations, RWIS software, and links to data acquisition services such as the National Weather Service and other meteorological services. USDOT's research into RWIS seeks to maximize the value of a RWIS investment and develop practical lessons learned that can be applied throughout the transportation industry.
- **Maintenance Decision Support System (MDSS) –** MDSS[6] takes state-of-the-art weather forecasting and data from sensors in and around roadways and merges them with computerized winter road maintenance rules of practice. The result is guidance that provides treatment recommendations customized for specific routes based on forecasts of surface conditions. Approximately 14 states are deploying MDSS.

Standards Resources

Technical assistance for ESS (as well as other applications) is available in a number of formats:

- **The ITS Standards Program website** is the first stop for information on the ESS standards. The site contains a wealth of information on ITS standards, including the current status of the ESS standards.
- **The Road Weather Management website** provides many resources on RWIS applications, including user forums, training, and publications.
- **An ITS Specialist** is available at each of the four FHWA Resource Centers to provide guidance on issues related to ITS standards. Visit www.fhwa.dot.gov/field.html for contact information.
- **The ITS Field Support Team** is a technical assistance program sponsored by the ITS Standards Program. Visit: http://www.ops.fhwa.dot.gov/int_its_deployment/standards_imp/stdsteam.htm for more details. The ITS Field Support Team offers intensive consultation and support on a broad range of standards-related issues, including:
  - Assessment of current system
  - Development of project specifications
  - Review of existing contracts and specifications
  - Identification of appropriate contracting and procurement mechanisms
  - Development of test plans
  - Evaluation of systems for contract compliance and conformance to specifications

Training

The ITS Professional Capacity Building (PCB) Program is administered by the Research and Innovative Technology Administration (RITA) and provides comprehensive, accessible, and flexible ITS learning for the transportation industry. By using the program, public agencies can build and sustain a capable and technically proficient ITS workforce, and transportation professionals can develop their knowledge, skills, and abilities while furthering their career paths.

[5] Benefits can be found at: http://www.itsbenefits.its.dot.gov/its/benecost.nsf/SingleCostTax?OpenForm&Query=Road%20Weather%20Management.
[6] http://www.meridian-enviro.com/mdss/pfs/.

Free Training

The ITS PCB Program offers 24 online modules that cover a broad range of issues related to ITS standards, including introductory concepts related to ITS standards, and in-depth content on needs assessment, design specifications, requirements, and testing. Module 18 (T313) Applying Your Test Plan to the NTCIP 1204 V03 ESS Standard focuses specifically on the ESS standard. **All modules are FREE of charge.**

Members of ITE are encouraged to access these same modules from the ITE website in order to obtain information about professional development hours and continuing education units.

The Consortium for ITS Training and Education (CITE) offers the following RWIS courses that include discussion of ITS standards. **Courses are free to employees of U.S. local, State, regional, metropolitan, and Federal government agencies:**

- Road Weather Information Systems (RWIS) Equipment and Operations
- Weather Responsive Traffic Management (WRTM)

Other Training

- The National Highway Institute offers Principles and Tools for Road Weather Management (FHWA-NHI-137030A), an instructor-led course that focuses on strategies for addressing road weather problems encountered in highway maintenance and operations. The course discusses technologies and applications used in RWIS, including the ESS standard.
- Training is available on the ESS Standard through the ITE and the ITS Program. To learn more about the program or available training opportunities go to http://www.pcb.its.dot.gov/ or http://www.ite.org/education/clearinghouse/search.asp?StartRec=1. General ITS standards training resources are also available on the ITS Standards Program website.

Standards Available for Free

NTCIP standards are available for download at no cost on the NTCIP website.

Getting Involved

Please contact the NTCIP Coordinator to inquire about the **ESS Working Group**:

NTCIP Coordinator

National Electrical Manufacturers Association

1300 North 17th Street, Suite 1752

Rosslyn, Virginia 22209-3806

Email: ntcip@nema.org

Contact the ESS Working Group Chair, Gene Martin, for information on participating in the standards development process. His email is: e.martin@vdot.virginia.gov.

The following ESS standards resources are recommended for learning more about ITS ESS standards.

- **ITS Standards Program website**
- **ITS Standards Field Support Team** is a technical assistance program sponsored by the ITS Standards Program. The ITS Field Support Team offers intensive consultation and support on a broad range of standards-related issues, including assessment of a current

system, development of project specifications, review of existing contracts and specifications, identification of appropriate contracting and procurement mechanisms, and development of test plans. For more details, visit http://www.ops.fhwa.dot.gov/int_its_deployment/standards_imp/stdsteam.htm

- **ITS Standards Fact Sheets** are concise, plain English descriptions of ITS standards.
- **ITS PCB Talking Technology and Transportation (T3) Webinars** are short, 1.5 hour exchanges on specific topics. The T3 Archives include**:**
    - Best Practices for Developing an Integrated and Effective Road Weather Information System (RWIS)
- **ITS Peer-to-Peer is a FHWA, Federal Transit Administration, and Federal Motor Carrier Safety Administration Technical Assistance program** that provides public sector transportation stakeholders with a convenient method to tap into the growing knowledge base of ITS experience and receive short-term assistance.
- **ITS Helpline (866-367-7487)** to reach trained staff who will assist with locating resources, websites, and documents that relate to operations and ITS.
- **NTCIP 9001 v04, the NTCIP Guide**

ESS Standards

The following section lists standards that can be used in an ESS deployment. Note: The "Type" column indicates whether the standard defines data or communications (and, for communications, it delineates which layer of the link from physical to message definition). "Standards Development Organization (SDO) Status" denotes the standard's current development status as determined by the working group that oversees its development. "Comment" refers to any additional information related to the status of the standard.

For further information on each of the ESS standards, see the ITS Standards Fact Sheets. Information about the standards development process is available on the ITS Standards Program website.

Table 1. Standards in an ESS Deployment

Standard	Document Title	Description	Type	SDO Status	Comment
NTCIP 1204	Object Definitions for ESS	Defines data found in road-weather information stations and air quality sensors	Data Dictionary	Version 03 Published October 2009	
NTCIP 1201	Global Object Definitions	Defines data, such as time, to be used in multiple device types including ESS	Data Dictionary	Version 03 published December 2010	
NTCIP 1102	Base Standard: Octet Encoding Rules (OER)	Encoding/decoding rules to prepare data for transmission or to decode data before sending it to an application	NTCIP Base Standard	Version 01 Published October 2005	
NTCIP 1103	Simple Transportation Management Protocol (STMP)	Rules for exchanging data with little overhead for interoperability of transportation devices operating over limited	NTCIP Base Standard	Version 02 Published July 2010	

Standard	Document Title	Description	Type	SDO Status	Comment
		bandwidth links			
NTCIP 8004	Structure and Identification of Management Information (SMI)	Defines how the NTCIP effort defines and registers its data, including how the SNMP MIB information is mapped into the ITS Data Registry	NTCIP Base Standard	Version 02 Published June 2010	
NTCIP 2301	Application Profile for Simple Transportation Management Framework (STMF)	Application, presentation, and session layer protocols to provide simple information management services	Communications Protocol Profile – Application Layer	Version 02 Published July 2010	
NTCIP 2201	Transportation Transport Profile	Defines a transport profile to transmit data when devices are directly connected to the central controller or computer and do not require network services	Communications Protocol Profile – Transport Layer	Version 01 Published September 2005	
NTCIP 2202	Internet (Transmission Control Protocol/Internet Protocol (TCP/IP) and User Datagram Protocol/Internet Protocol (UDP/IP)) Transport Profile	Transport and network layer protocols to provide connectionless and connection-oriented transport services	Communications Protocol Profile – Transport Layer	Version 01 Published December 2001	
NTCIP 2103	Subnet Profile for Point to Point Protocol using RS 232	Rules for using the point-to-point protocol over RS-232-related circuits for interoperability of devices linked by dial-up circuits	Communications Protocol Profile – Subnet Layer	Version 02 Published December 2008	
NTCIP 2104	Subnetwork Profile for Ethernet	Provides interoperability for devices that communicate over local area network (LAN) interfaces	Communications Protocol Profile – Subnet Layer	Version 01 Published February 2002	
NTCIP 8007	Testing and Conformity Assessment Documentation within NTCIP Standards	Defines the rules and guidelines to be used by the other NTCIP working groups when they produce NTCIP test documentation	NTCIP Base Standard	Version 01 Published May 2008	

Standard	Document Title	Description	Type	SDO Status	Comment
	Publications				

Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
DUT	Device Under Test
ESS	Environmental Sensor Station(s)
FAQs	Frequently Asked Questions
FHWA	Federal Highway Administration
ICM	Integrated Corridor Management
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
LAN	Local Area Network
MDSS	Maintenance Decision Support System
MIB	Management Information Base
NEMA	National Electrical Manufacturers Association
NTCIP	National Transportation Communications for ITS Protocol
OER	Octet Encoding Rules
PRL	Profile Requirements List
PTS	Pavement Treatment System
RFP	Request for Proposal
RPU	Remote Processing Unit
RTM	Requirements Traceability Matrix
RWIS	Road Weather Information System
SDO	Standards Developing Organization
SMI	Structure of Management Information
SNMP	Simple Network Management Protocol
STMF	Simple Transportation Management Framework
STMP	Simple Transportation Management Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TRTM	Testing Requirements Traceability Matrix
USDOT	United States Department of Transportation
UDP/IP	User Datagram Protocol/Internet Protocol

We would like to hear from you. Please send your comments on how we can make this Advisory more useful to you. If you have any questions about the content of this Advisory, contact Steve Sill at the USDOT's ITS JPO at steve.sill@dot.gov or (202) 366-1603.