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Intelligent Transportation Systems (ITS) Standards Program Strategic Plan for 2011—2014

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Executive Summary

Enabling an Interoperable Intelligent Transportation System

Intelligent Transportation Systems (ITS) can be defined as the application of advanced information and communications technology to surface transportation in order to achieve enhanced safety and mobility while reducing the environmental impact of transportation. The addition of wireless communications offers a powerful and transformative opportunity to establish transportation connectivity that further enables cooperative systems and dynamic data exchange using a broad range of advanced systems and technologies.

It is the vision of the US Department of Transportation's (USDOT) ITS Program to achieve widespread deployment and use of ITS throughout the United States. In support of this vision, the USDOT established the ITS Joint Program Office (ITS JPO) under the Research and Innovative Technology Administration (RITA). The role of the ITS JPO is to administer a collaborative partnership among the modal agencies with the goal of:

> *Researching and facilitating a national, multi-modal surface transportation system that features a connected transportation environment around and between vehicles of all types, the infrastructure, and mobile devices; and to serve the public good by leveraging technology to maximize safety, mobility, and environmental performance.*

For 2011—2014, the centerpiece of the ITS Program's research plan is a multi-modal research initiative focused on creating safe, interoperable connectivity between vehicles of all types, infrastructure, and mobile devices (referred to as V2x).[1] Achieving connectivity among diverse transportation system components (or, cooperative systems) requires **interoperability**—the assurance that vehicles, devices, equipment, and applications will effectively communicate with one another and as needed. **Such interoperability is only possible with a robust set of standards.**

This document–the ***ITS Standards Program Strategic Plan, 2011—2014***–describes the strategic direction for the USDOT's ITS Standards Program for the next four years. The strategy is predominantly focused on the development of quality standards that directly support the ITS Program's goals for **interoperability, cooperative systems, and a connected transportation environment.**

Since 1996, the USDOT's ITS Standards Program has partnered with industry and the public sector to identify where standards are needed; develop robust, consensus-based standards; and facilitate their implementation and use. Since its inception, the program and its partners have completed approximately 100 standards that have resulted in greater interoperability among ITS centers, field equipment, and traveler information systems.

The USDOT is one participant in the broader collaborative ITS Standards environment which includes global public and private sector participants. This plan addresses the interests and strategic direction of the USDOT's ITS Standards Program which cooperates with a broad stakeholder community to ensure that standards development is a participatory process and that resulting standards are acceptable, relevant to the marketplace, and meet public/consumer needs.

[1] Further details on the ITS Program's current research focus can be found at: http://www.its.dot.gov/research_planning.htm and http://www.its.dot.gov/research.htm.

Looking ahead to the next four years, the strategic direction of the USDOT's ITS Standards Program is focused on collaborative development and completion of standards for connected vehicles and connected infrastructure (referred to as cooperative system standards). The strategy further includes continued identification of new standards needs; support for existing standards; and support that is geared toward engendering widespread use of ITS standards. Throughout the four-year period, the USDOT's ITS Standards Program will remain closely aligned with the goals of the overall ITS Program.

This document, the ***ITS Standards Program Strategic Plan, 2011—2014***, includes the following sections:

I. Introduction. The first section of the document provides an overview of the ITS Standards Program and how the program relates to both the vision for intelligent transportation and the core elements of the USDOT's ITS Research Program (the ITS Standards Program is a cross-cutting support function across the entire research agenda). The introduction summarizes the need for standards and their role in enabling deployment of ITS. Finally, this section reviews the history of the ITS Standards Program and highlights the major accomplishments to date.

II. Enabling an Interoperable Intelligent Transportation System. The second section of the document describes the strategic direction for the ITS Standards Program for the next four years (2011—2014). It describes the program goals and the activities that will be performed to achieve these goals. The components of this section are:

II.A The Target Goal: Delivering Standards for Transportation Connectivity—The ITS Program groups standards into two primary categories:

ITS V2x Cooperative System Standards

Definition: This category includes standards associated with vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-device connectivity**.** These standards are a critical element in enabling the cooperative nature of the transformative, multi-modal technologies and applications that are the current research focus of the ITS Program. These standards are also a critical foundation for fostering commercialization and adoption by stakeholders.

Goal: Ensure completion of quality V2x standards in alignment with the technical research. The goal also includes the identification and development of new standards that are necessary in the development of cooperative systems.

ITS Infrastructure Standards

Definition: This category includes standards that facilitate interoperability between infrastructure components, most often directly connected via wireline. Examples include traffic signal controllers, ramp meters, dynamic message signs, and traffic information centers. Vehicles were not generally included in this effort. These Center-to-Center (C2C) and Center-to-Field (C2F) interconnectivity standards enable intelligent transportation systems to communicate with one another and with the equipment and devices that they control. In this category, approximately 100 standards are already developed and implemented.

Goal: Support ongoing efforts for adoption and maintenance of these standards, and to identify and meet new standards needs.

In addition, the document discusses how USDOT's ITS Standards Program will monitor activities throughout the ITS-JPO, including the Systems Engineering/Revised Architecture Program, the multi-modal research initiatives, other mode-specific research programs (including transit ITS standards), and ITS exploratory research to identify and meet potential new standards needs.

II.B The Process: Leadership, Management, and Quality Assurance—In support of meeting the target goals in an effective manner, the USDOT's ITS Standards Program is pursuing a range of activities that include:

- Developing and maintaining standards in cooperation with domestic and international partners and in a manner that meets the interoperability requirements of the ITS research initiatives.
- Rigorous application of the Systems Engineering Process (SEP) to USDOT-funded ITS standards development to ensure complete and correct standards products that meet stakeholder needs.
- Employing effective program oversight and management by:
  - Engaging ITS-JPO and USDOT modal stakeholders in oversight.
  - Harmonizing standards internationally when in the public interest.
  - Supporting users of ITS standards through targeted technical assistance.
  - Employing the most effective contractual mechanisms for standards development and oversight.
- Maintaining strong connections to the ITS National Architecture Program to ensure Standards-Architecture alignment.

II.C Educating the Community: The ITS Professional Capacity Building Program—To provide the stakeholder community with the skills required to fully benefit from standards-conformant ITS technologies and to facilitate the deployment of ITS standards by agencies, systems integrators, and vendors, the ITS Standards Program will assist in establishing standards training. The training effort will be led by the Department of Transportation's Professional Capacity Building (PCB) program.

II.D Financing and Timing—The USDOT's ITS Standards Program relies on both Federal funding and voluntary contributions of time and effort from stakeholders along with industry cost-sharing. The ITS Standards Program will coordinate its activities with the efforts of the overall ITS Research Program to ensure timely delivery of necessary standards.

III. Conclusion. The last section of the document provides a conclusion that describes the expected impact of this plan on the public, the ITS community and the transportation network.

IV. Appendices. The document includes four appendices that describe:

- The current ITS Standards Program
- International standards activity
- The introduction of the Systems Engineering Process (SEP) to ITS Standards development
- A listing of current ITS standards.

I. Introduction

I.A A Vision of Intelligent Transportation

ITS technology can be defined as the application of information technology to surface transportation in order to achieve enhanced safety and mobility while reducing the environmental impact of transportation.

As described in the *ITS Strategic Research Plan, 2010-2014*[2], the USDOT's ITS Research Program aims to bring enhanced connectivity to transportation through the application of advanced wireless technologies–powerful technologies that enable transformative change. The program envisions:

- A fully connected, information-rich environment where travelers, freight managers, system operators, and other users are fully aware of all aspects of the transportation system's performance across all relevant modes.
- A cooperative system in which highway crashes and their tragic consequences are rare because vehicles of all types and roadside systems work together to:
    - Communicate the events and hazards happening around them.
    - Coordinate action and response among vehicles and their operators to avoid collisions.
- Travelers who have comprehensive and accurate information on travel options—transit travel times, schedules, cost, and real-time locations; driving travel times, routes, and travel costs; parking costs, availability, and ability to reserve a space; and the environmental footprint of each trip.
- System operators who have full knowledge on the status of every transportation asset.
- Vehicles of all types that can communicate with traffic signals to eliminate unnecessary stops and help people drive in a more fuel-efficient manner.
- Vehicles that can communicate the status of on-board systems and provide information that can be used by travelers and system operators to mitigate the vehicle's impact on the environment and/or make more informed choices about travel modes.

The Vision of the ITS Program for the next four years...

To research and facilitate a national, multi-modal surface transportation system that features a connected transportation environment around vehicles of all types, the infrastructure, and carry-in passenger devices to serve the public good by leveraging technology to maximize safety, mobility, and environmental performance.

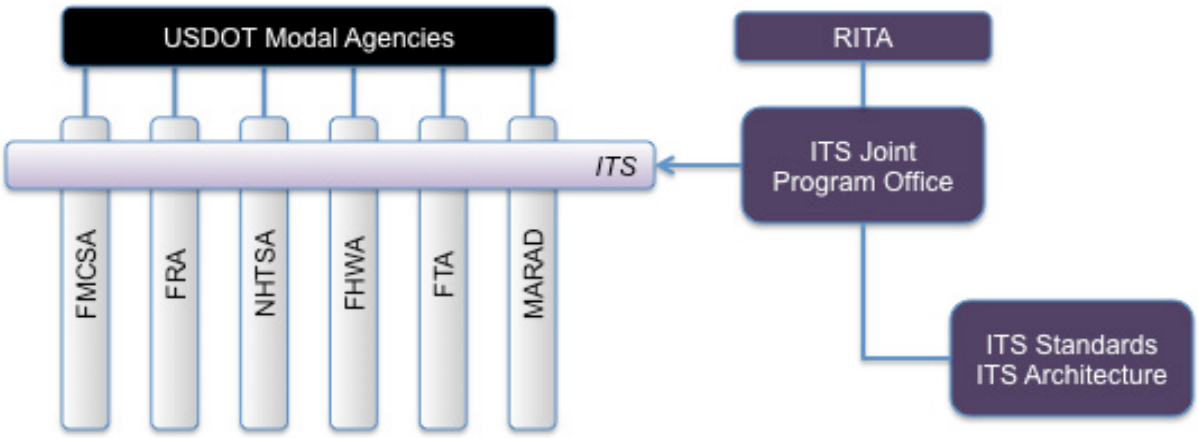
—The ITS Strategic Research Plan, 2010—2014.

[2] Further detail can be found at: http://www.its.dot.gov/research_planning.htm and http://www.its.dot.gov/research.htm.

I.B The US Department of Transportation's ITS Research Program

The ITS-JPO coordinates Federally-funded research and development into ITS technologies, applications, and standards (an effort known as the ITS Program). Six of nine USDOT agencies cooperate with the ITS-JPO on ITS research (Figure 1). The ITS-JPO operates under the policy direction of the USDOT's Research and Innovative Technology Administration (RITA) and is advised by the Administrators and Associate Administrators of the USDOT agencies. For administrative and funding purposes, the ITS-JPO remains under the Federal Highway Administration (FHWA).

Figure 1: Relationships between ITS-JPO and USDOT agencies[3]



The ITS Program and the ITS Standards Program support standards research by:

- Establishing strategic direction to guide future standards development and policies.
- Financially supporting standards development and maintenance efforts.
- Encouraging the use of the systems engineering process (SEP) to facilitate complete and correct standards.

The ITS Program *does not* routinely define the content of ITS standards or mandate the use of specific standards in ITS system deployment. Instead, through the USDOT's ITS Standards Program, the ITS-JPO takes a leadership role in working with stakeholders to facilitate consensus-based industry standards.

[3] Federal Motor Carrier Safety Administration (FMCSA), Federal Railroad Administration (FRA), National Highway Traffic Safety Administration (NHTSA), Federal Highway Administration (FHWA), Federal Transit Administration (FTA), and Maritime Administration (MARAD).

I.C The ITS Research Program: Building Transportation Connectivity

To achieve the vision of enhanced transportation connectivity, the USDOT's ITS Program has established a research agenda comprising four primary efforts:

- **The ITS Program:** The centerpiece of the ITS Program's research plan is exploring the transformative capabilities of wireless technologies in cooperative systems research to make transportation safer, smarter, and 'greener' for Americans. Importantly, this research is intended to achieve a deployable system for transportation connectivity. To do so, the program needs to address three critical research areas:
  - **Applications:** Safety, mobility, and environment applications must be shown to be effective.
  - **Technology:** The supporting technology must be secure and ***interoperable***.
  - **Policy:** The system as a whole must be both publicly acceptable and sustainable.
- **New Mode-Specific ITS Research:** In close cooperation with modal partners, new ITS technologies, strategies, and systems to support specific modes—including freight, transit, and emergency services—are under exploration as part of the research agenda for the next five years.
- **ITS Exploratory Research:** The ITS Program intends to solicit and explore creative ideas for new technologies that can further enhance transportation.
- **ITS Cross-Cutting Support:** In addition to the primary research programs, the ITS Program develops critical elements that provide support across many other research programs, including architecture, standards, technology transfer, professional capacity building, evaluation, and outreach and communications.

The ITS Standards Program is organized as a cross-cutting effort within the ITS Program; its strategic direction is driven by the need to develop standards that are required by the research initiatives and the need to support the successful transition of ITS Program research into deployment.

I.D The Need for Standards: *Ensuring Interoperability*

Intelligent Transportation Systems require logical and physical connections among many diverse entities: from state and local transportation and management systems and tolling devices, to the networks that provide the wireless linkages, to the end users themselves—their vehicles (including private, commercial, and municipal vehicles), passengers' carry-in devices, and applications. The transportation environment is particularly demanding for information technology:

- Vehicles—and the equipment installed in them—are typically on the road for 10, 15, even 20 or more years. They need to interact with an infrastructure and associated services that last for decades.
- Vehicles, infrastructure equipment, devices, and applications are built by a multitude of vendors, manufacturers, and service providers. In addition, any given product may be used in many different cities, states, and even nations—each with its own transportation management authority—over the course of the product 's lifetime.

In contrast, however, electronics and information technology lifecycles are often as short as one to two years.

To deliver the required functionality in this context, intelligent transportation requires ***interoperability***. Interoperability ensures that ITS-enabled vehicles, devices, infrastructure, and applications will effectively communicate with one another and communicate as needed, whether they're built in Michigan or California—or Germany or Japan—and used in Salt Lake City or Miami—or Amsterdam or Shanghai. Ensuring this level of interoperability over the lifecycle of the infrastructure and vehicles that operate within it—while remaining sufficiently flexible to allow for incorporating technological advances into successive generations of vehicle and equipment that must coexist—is a critical challenge of the ITS program. ***Such interoperability is only possible with a robust set of standards.***[4]

I.E Additional Benefits of Standards

Beyond meeting the central requirement of interoperability, a robust set of standards provides enormous additional benefits to ITS stakeholders. For everyone from vehicle manufacturers and aftermarket suppliers to state and local transportation agencies and tolling services, standards serve multiple purposes:

- **Avoiding premature obsolescence:** Transportation equipment and systems represent a significant investment for both end users and the authorities that manage the transportation system. As such, buyers typically place high importance on the expected lifetime of a purchase. By purchasing equipment that conforms to recognized and supported standards, buyers can ensure that the purchased equipment will remain useful and compatible with other devices well into the future.
- **Facilitating coordination among operating agencies:** The surface transportation system in the United States is highly interconnected. Vehicles travel easily from region to region, and incidents in one region can have a significant impact on operations in adjacent regions. Adoption of common standards will ensure that operating agencies can readily exchange information in order to optimize the overall system and that vehicles can easily interact with infrastructure systems independent of their location.
- **Enabling a competitive marketplace:** Consumers, vehicle and equipment manufacturers, and operating agencies seek to optimize trade-offs between cost and system performance. A stable set of robust standards will allow multiple vendors to create a range of equipment that offers different features and characteristics while still ensuring that the equipment will easily interoperate, no matter where it is used or which equipment it needs to interact with. A competitive marketplace will lower initial costs, replacement/upgrade costs, and overall life-cycle costs for ITS equipment.
- **Reducing life-cycle costs:** Equipment maintenance represents a major component of life-cycle system costs. By ensuring that all equipment conforms to the same standards, consumers and agencies will be able to service ITS equipment without having to learn a different set of operating parameters for every piece of equipment of the same general type, reducing training and maintenance costs. In addition, parts and repair services can be sourced competitively rather than being limited to those available from the original equipment manufacturer.

[4] As a mechanism for achieving such interoperability, USDOT may consider formal adoption of ITS standards via regulatory means such as the Code of Federal Regulations (CFR), Title 23, Section 940.

I.F A Brief History of the ITS Standards Program

Legislative Authority

Intermodal Surface Transportation Equity Act (ISTEA) of 1991

Recognizing the need for a well-developed set of standards to promote the deployment of ITS technologies, Congress, under the Intermodal Surface Transportation Equity Act (ISTEA) of 1991, directed USDOT to create a national ITS architecture, develop a standards program, and promote the use of ITS technologies.[5] The USDOT subsequently launched the ITS JPO in 1991. The first National ITS Architecture was released in 1996; by 1999, more than 22 ITS standards had been published.

Transportation Equity Act for the 21st Century (TEA-21) of 1998

Acknowledging the progress made by the ITS Program under ISTEA, Congress passed the Transportation Equity Act for the 21st Century (TEA-21) in 1998, renewing funding for the ITS Program and refocusing the program on adoption and deployment of ITS technologies. In response to provisions in TEA-21, the Federal Highway Administration (FHWA) issued Rule 940 in 2001 and the Federal Transit Administration (FTA) issued a similar Policy[6] requiring that all Federally-funded ITS projects to use a systems engineering process and comply with USDOT-adopted ITS architecture and standards (the Rule and Policy went into force in 2005). By 2004, 40 ITS standards were being used in local ITS projects.

Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005

The ITS Program was renewed again in 2005 with the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). SAFETEA-LU directed the ITS Program to further encourage the use of ITS technologies in mainstream transportation projects.

Recent Changes

Significant developments in the ITS Program occurred in 2009 as the engineering research conducted under the Vehicle Infrastructure Integration (VII) program concluded and a program focused on deployment was initiated. The VII research program had been created in 2001 to study the potential for using dedicated short-range communications (DSRC)—both between vehicles and between vehicles and the roadway—to significantly improve road safety. VII proof-of-concept tests in 2007 demonstrated the feasibility of 5.9GHz DSRC-based safety applications in general, but left open many questions, including how DSRC technologies would find their way into vehicles and the transportation infrastructure.

Today's ITS Program builds from the work under VII but with a number of important differences, as illustrated in Table 1 on the following page.

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[5] The Intermodal Surface Transportation Equity Act (ISTEA) of 1991, Section 6053(b), specifically directed that "the Secretary shall develop and implement standards and protocols to promote the widespread use and evaluation of intelligent vehicle-highway systems technology as a component of the Nation's surface transportation systems."

[6] Reference http://www.ops.fhwa.dot.gov/its_arch_imp/policy.htm for details on the Rule/Policy.

Table 1: Changes from VII to today's ITS Program

Attribute	VII Engineering Research	ITS Program Focused Toward Deployment
Communications technologies	DSRC only	Best technology for intended application (DSRC for safety)
In-vehicle devices	OEM production units only	Aftermarket and retrofit opportunities
Vehicle focus	Light vehicles	All vehicle types
Stakeholder involvement	Limited	Broad engagement
International focus	Limited	Significant international harmonization effort
Program cohesion	Loosely coupled research programs	Strong, collective USDOT support, coordination, and leadership
Deployment focus	Limited – oriented toward prototyping and proof of concept	Strong deployment focus

While developing DSRC-based technologies and applications, the ITS Program will also address a number of critical implementation questions:

- *Are the safety benefits of near-term ITS applications sufficient to support National Highway Transportation Safety Administration (NHTSA) rules requiring DSRC-based safety devices in light and/or heavy vehicles?*
- *What additional non-safety (mobility or environmental) applications might encourage faster adoption of DSRC-based or other communications systems?*
- *How much and what type of roadside infrastructure is necessary to support safety and mobility applications?*

And, importantly, the ITS Program will continue the prior work on standards with a focus on maturing and internationally harmonizing standards in order to enable deployment. Further, the ITS Program will expand its focus to consider all relevant communications technologies for applications other than low-latency safety, for which DSRC currently appears to be the only viable technology.

2007 Study of Options for Streamlining Standards for Intelligent Transportation Systems

In 2007, the Transportation Research Board (TRB) of the National Academies of Science assembled a Committee for *Study of Options for Streamlining Standards for Intelligent Transportation Systems*.* The study reviewed the role, progress, and function of the USDOT's ITS Standards Program since its inception. Three critical findings informed the program's development of the strategic direction for 2011—2014. The findings are:

Report Findings for the ITS-JPO's Consideration	USDOT's Approach
Articulate a strategic vision of the role of standards in furthering the development and use of ITS and define USDOT's role in realizing this vision.	This strategic plan describes a focused role for the USDOT's ITS Standards Program in the next four years–a predominant focus on leading the development, completion, and (where appropriate) international harmonization of V2x cooperative system standards, and a continuing focus on the completion and upgrade of existing ITS infrastructure standards. Included in this role is the needs identification for new standards.
Systematically engage end users in all phases of standards support and explore a variety of processes that involve them to ensure timely and useful standards.	The USDOT's ITS Standards Program is committed to delivering standards in a timely manner. New efforts will be implemented to identify standards-setting activities in other industries (in particular, the telecommunications and automotive electronics industries) that may offer opportunities to adopt best practices for ITS standards development and lifecycle management.
Forge strong connections with other relevant standards activities in the Federal government, in the private sector, and internationally.	The USDOT's ITS Standards Program retains a close relationship to the broader and more global industry-based ITS Standards Program. In partnership, these programs, stakeholders, and volunteers work to identify new needs and discuss how they are met. In the next four years, the USDOT's ITS Standards Program will reinvigorate its international efforts and seek to engage new international partners to lay the foundation for worldwide marketplaces for ITS standards-based products.

* The study committee was convened in response to Section 5307, Part 4 of the *2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users*, which calls on the USDOT to designate a committee of experts to recommend ways to expedite and streamline processes for developing intelligent transportation system (ITS) standards and protocols. USDOT called on TRB to appoint an independent committee to conduct the study. The committee was asked by USDOT to identify the types of support needed for ITS standards deployment and to recommend the role USDOT should play in standards development and deployment.

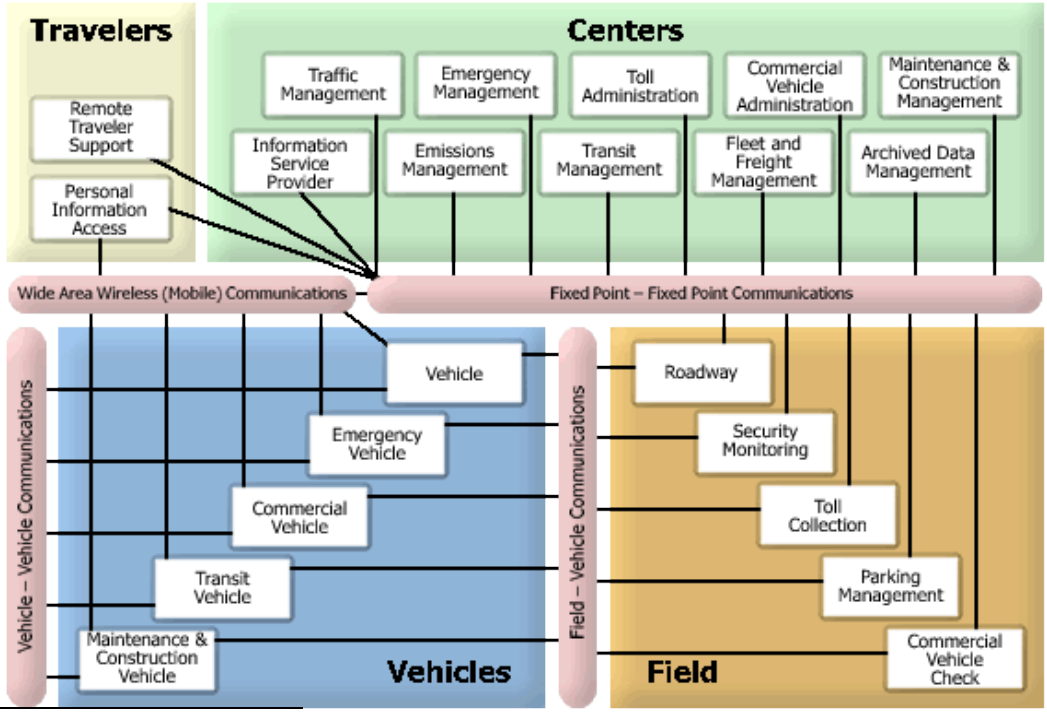
I.G The National ITS Architecture and the Role of ITS Standards

The National ITS Architecture Program is a critical, cross-cutting effort that enables coordinated national adoption of ITS technologies. The National ITS Architecture is a framework around which different ITS implementations can be built. In particular, the National ITS Architecture defines the components and connections that comprise ITS without unduly restricting the specific technologies used to implement them. Transportation agencies and other stakeholders can then use the National ITS Architecture as a guide while tailoring the implementation to their specific needs. The National ITS Architecture defines the following:

- Functions (e.g., gathering traffic information or requesting a route) that must be performed to implement a given ITS application.
- Physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle).
- Interfaces and information flows between the physical subsystems and the communication requirements for those information flows (e.g., wireline or wireless).

Figure 2 below illustrates the major subsystems and interfaces in the National ITS Architecture. There are 22 subsystems ranging from different types of vehicles to different transit management centers. The black lines represent possible data connections between subsystems. The pink ovals represent the four different types of communication methods (wireless, wireline, broadcast, or point-to-point) that may be used to make those connections. More detailed descriptions of ITS applications and functions are available at the ITS Program's website[7].

Figure 2: National ITS Architecture physical entities



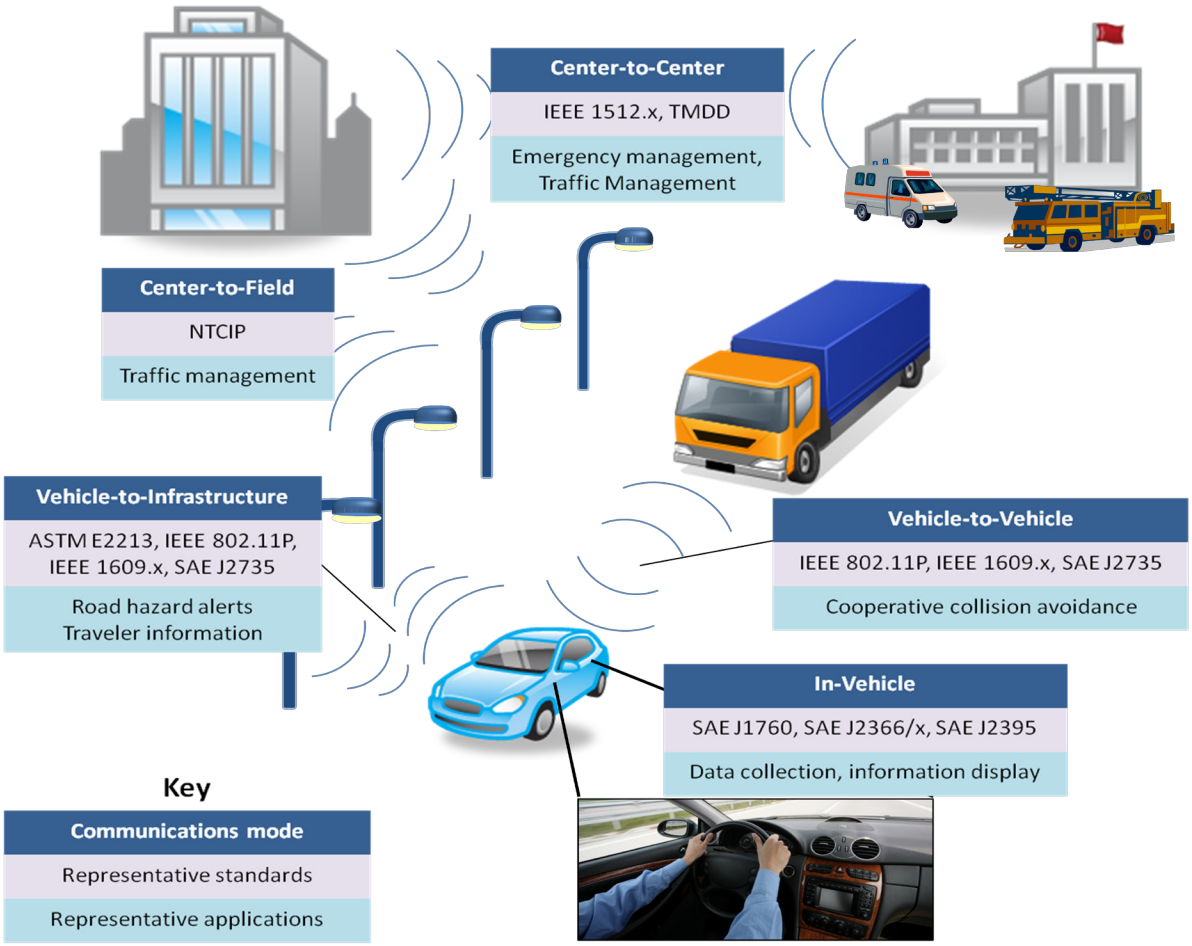
[7] http://www.its.dot.gov/arch/index.htm.

To achieve interoperability, ITS standards are defined at the intersection of ITS subsystems (along the black lines in Figure 2), which represent communications flows along which data is exchanged. Within the National ITS Architecture, the standards define the rules for how ITS technologies connect and how they exchange data—if all ITS systems use the same communication standards, then products manufactured by different vendors will work together, travelers can use one set of ITS hardware in all states and regions, and individual subsystems can be upgraded as technology improves without rendering the rest of the system obsolete. Standards serve one of two specific roles within the ITS system:

- **Information exchange protocols.** These standards define the way information is communicated from one entity to another.
- **Message definitions.** These standards define the meaning of individual messages and, in some cases, the mechanisms by which specific entities are manipulated.

Figure 3 below provides a conceptual illustration of the connections, representative standards, and representative applications supported by the National ITS Architecture.

Figure 3: Representative ITS connections, standards, and applications

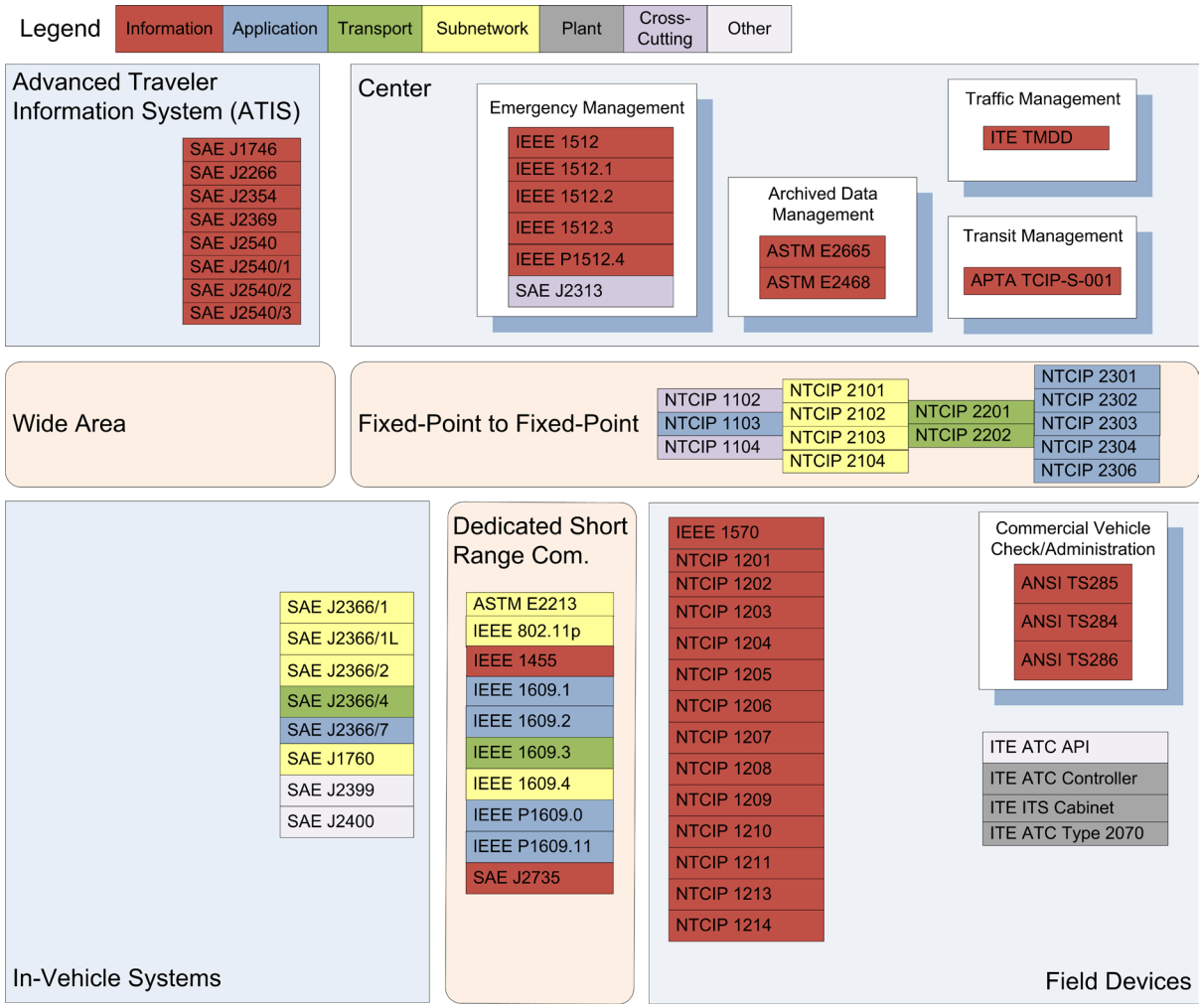


I.H Program Accomplishments

Standards Developed

In its first two decades, the USDOT's ITS Standards Program has been primarily focused on the development of the ITS Infrastructure Standards. Since 1991, approximately 100 standards and supporting documents have been developed or are being developed as part of the ITS Standards Program (see Figure 4 below). The majority of these standards were developed with a combination of USDOT funding support, Standards Development Organization (SDO) efforts, and voluntary contributions by working group members, although several ITS standards were developed without USDOT funding or involvement. Figure 4 and the text on the following pages illustrate and describe the details associated with the standards developed with USDOT support.

Figure 4: ITS Standards within the National ITS Architecture[8]



[8] For further definitions of the categories defined within the legend, refer to page 23 of the National Transportation Communications Interface Protocol Guide (NTCIP 9001) at: http://www.ntcip.org/library/documents/pdf/9001v0406r.pdf.

As previously described, the ITS standards can be logically divided into two primary categories:

- **ITS Cooperative System Standards.** The current standards for connectivity include the IEEE 802.11p and 1609.x and the SAE J2735 standards that primarily support the V2V and V2I (also known as "Field-Vehicle Communications") wireless interfaces shown in Figure 4. These standards allow establishment of a wireless link for V2V and V2I communications (IEEE 802.11p), establish protocols for information exchange across the wireless link (IEEE 1609.x), and define message content for communicating specific information to and from equipment and devices via DSRC or other means (SAE J2735). Future standards will be developed to support the expanded architecture being developed as part of the Systems Engineering Program for vehicle connectivity to the communications environment; these standards are expected to cover additional interfaces beyond the DSRC wireless communications link.
- **ITS Infrastructure Standards:** Since the USDOT ITS Standards Program began, efforts have focused on the development of standards that facilitate interoperability between infrastructure components, most often directly connected via wireline. Examples include traffic signal controllers, ramp meters, dynamic message signs, and traffic information centers (vehicles have not generally been included in this effort). These Center-to-Center (C2C) and Center-to-Field (C2F) interconnectivity standards enable intelligent transportation systems to communicate with one another and with equipment and devices that they control. These standards primarily support the "Fixed Point – Fixed Point Communications" interface shown in Figure 4.

  ITS transit standards are a subset of the ITS Infrastructure Standards. An ITS-JPO/Federal Transit Administration partnership has focused on the ITS standards needs of the public transit community since 1996. Working with the American Public Transportation Association (APTA), the work of the partnership has resulted in the following standards:[9]

  - ***Transit Communications Interface Profiles (TCIP):*** TCIP is the transit component of the ITS family of standards and was released as a balloted APTA standard (TCIP 3.0) in August 2006. A subsequent maintenance release (TCIP 3.0.3) was released in August 2010. The TCIP standard is designed to support a broad range of potential implementations across the transit industry. The breadth and flexibility of the standard are embodied in the very large number of data elements, frames, messages

Selected Achievements of the ITS Standards Program: 1991–2011

- **Approximately 100 ITS standards developed or in process to meet various user and architecture needs.**
- **Introduced a tailored version of the Systems Engineering Process (SEP) for standards development.**
- **Applied the SEP to 10 out of 23 SEP candidate ITS standards.**
- **Developed a standards testing process to validate standards and successfully demonstrated the process using the Dynamic Message Sign (DMS) in cooperation with the Virginia Department of Transportation (VDOT).**
- **Supported widespread deployment of infrastructure standards, including Dynamic Message Signs (DMS), Environmental Sensor Systems (ESS), Actuated Signal Controller (ASC), Ramp Metering (RM), and transit standards.**
- **Demonstrated viability of initial DSRC standards set during VII proof-of-concept testing.**
- **Developed and conducted Professional Capacity Building (PCB) programs to enable effective use of ITS standards in the field.**
- **Signed agreements with the European Union, Japan, and Canada covering International standards harmonization.**

[9] More detail is available at: http://www.aptastandards.com/.

and dialogs that comprise the standard. Many of these TCIP elements are optional, enabling the end user to tailor TCIP to the specific needs of their implementation. To support the tailoring of TCIP in the transit agency and vendor communities, the TIRCE (TCIP Implementation, Requirements & Capabilities Editor) support tool was developed. Version 1.2 of TIRCE was released in December 2009 and is available to any transit agency or vendor, at no charge, to assist in the development of TCIP compliant procurement packages and product specifications. TIRCE will also form the basis for the TCIP training program hosted by the National Transit Institute.

- ***Contactless Fare Media Standard (CFMS):*** CFMS provides regional interoperable standards for fare collection systems. The Contactless Fare Media System (CFMS) Standard, which is a product of Universal Transit Farecard Standards (UTFS), is an open architecture non-proprietary standard encouraging interoperability between transit systems operating within a region. The standard provides the opportunity for more competitive fare system procurement options, increased operational efficiency, reduced system development time, and convenience for transit system patrons.

International Standards Harmonization

The ITS Program continues to cooperate with the international community to develop international ITS standards. The level of international activity has varied significantly over time. In early activity with the international community, the ITS Program funded the position of Secretariat to the International Organization of Standardization (ISO) Technical Committee 204 (TC204); provided representatives on the Asia-Pacific Economic Cooperation (APEC) technical working group; and monitored international activities, providing U.S. experts as appropriate. Since 2006, the efforts have mostly been focused on monitoring selected activities with the exception of active support for the TC204 Working Group 8 (WG8), which is focused on ISO standards development activities related to public transportation and emergency services.

In 2010, however, the ITS Program recognized the potential benefits of increasing activity in international harmonization due to the maturity of select ITS standards and the desire to ensure that, once harmonized, the vehicle platform standards, in particular, enable a worldwide vehicle market. In 2009, the ITS-JPO entered into an agreement with the European Commission and subsequently established the Standards Harmonization Working Group, which is working to execute a plan to harmonize standards around the vehicle platform with the European Commission. Additional agreements have been reached with Canada and Japan.

Deployment Support

The USDOT's ITS Standards Program does more than just support the development of standards; it also supports the needs of standards' users such as equipment manufacturers, ITS program managers, and transportation system engineers. Early ITS deployments revealed that the standards could be improved to better address user needs and requirements. As deployment activity increased, deployers requested assistance with procurement processes to guide deployment of interoperable systems and testing processes to verify conformance to ITS standards.

To support these requirements, the ITS Standards Program has developed:

- A systems engineering process (SEP) tailored for ITS standards developers that includes the development of user needs, requirements, and design content in the ITS standards (see Appendix C for a description of the tailored SEP for standards development).
- Methodologies for ITS standards deployers to verify conformance to selected standards and support interoperability.
- Procurement guides and test procedures to assist in wide-scale deployment for particular ITS standards developed under the SEP.

In addition, the ITS Standards Program assists in the establishment of outreach and training for agencies, integrators, and vendors to facilitate the deployment of ITS standards. The outreach and training programs may range from advertising a given standard to providing detailed level training on acquisition and testing. Two separate training programs exist today; they are focused around the stakeholder community's needs:

- Beginning in 2011, the Professional Capacity Building (PCB) program will provide comprehensive training to ITS professionals focused on procuring and deploying a standards-based ITS.
- Another example is that FHWA field personnel are trained to provide technical assistance on the use of ITS standards and provide evaluation and oversight to the processes of procurement and testing of standards-based ITS.

Additional information on the current and historic activities of the ITS Standards Program is included in Appendix A.

II. Enabling an Interoperable Intelligent Transportation System: The ITS Standards Program, 2011—2014

This section describes the four-year strategic approach to activities within the USDOT's ITS Standards Program for 2011—2014. The strategic plan is designed to ensure that the necessary standards are developed and deployed to support the overall goals of the ITS Program's 2010-2014 research agenda.

Importantly, while the primary focus of the USDOT's ITS Standards program is shifting to vehicular connectivity within the context of the current ITS research agenda, the program will not neglect work begun in the past and still underway. This section describes the activities for both categories of standards—ITS V2x cooperative system standards and ITS infrastructure standards. It also outlines the transition of support for the future enhancements of these standards—should it be required—to the appropriate offices within the USDOT, to external Standards Development Organizations (SDOs), or to other partners.

II.A Target Goal: Delivering Standards for Transportation Connectivity

The USDOT's ITS Standards Program places a high priority on supporting the completion of the standards required to deploy interoperable ITS and enable transportation connectivity. While the Federal program will likely lead many of these standards development efforts, the program will also engage with and leverage outside stakeholders as appropriate. The standards for delivering transportation connectivity fall into two categories:

- ITS V2x Cooperative System Standards
- ITS Infrastructure Standards

As the community—including participants in ITS-JPO and USDOT modal research initiatives—identifies needs for modifications to existing standards or needs for additional standards, the USDOT's ITS Standards Program will, as appropriate, launch new standards modification or development activities.

ITS V2x Cooperative System Standards…

… support communication over a wireless link between two or more vehicles and/or between vehicles and fixed or mobile devices. These standards will be the primary focus of the USDOT's ITS Standards Program over the next four years.

The Vision:
V2x cooperative systems standards will ensure that all types of vehicles, equipment, and devices will be able to easily communicate with one another—regardless of the manufacturer—over a secure wireless link to support a new generation of safety, mobility, and environmental applications.

Table 2 on this and the following page describes the standards that currently represent the core cooperative system standards; in particular, those that support a connected vehicle platform. While versions of these standards have already been developed and published, some are currently undergoing revision to support evolving needs. With respect to the current vehicle platform standards, the ITS Standards Program will:

- Continue to support efforts currently underway to update the IEEE 1609.1–1609.5 standards.
- Revise the existing J2735 standard using the SEP and add missing required capabilities (e.g., for transit and truck support).

Table 2: ITS V2x Cooperative System Standards

Standard	Description	Original Publication Date	Current Status
IEEE 802.11p™	This amendment specifies the extensions to IEEE Standard 802.11 for wireless local area networks (WLANs) providing wireless communications while in a vehicular environment.	July 15, 2010	Finalized and published.
IEEE P1609.0	**Draft Standard for Wireless Access in Vehicular Environments (WAVE)—Architecture.** This standard describes the WAVE architecture and services necessary for multi-channel DSRC/WAVE devices to communicate in a mobile vehicular environment.		Draft Standard.

Table 2: ITS V2x Cooperative System Standards (Continued)

Standard	Description	Original Publication Date	Current Status
IEEE P1609.1	**Draft Standard for Wireless Access in Vehicular Environments (WAVE)—Remote Management Services.** WAVE Remote Management Services provides interoperable services to manage WAVE devices that support being managed over the air. It consists primarily of a remote management service, including identification services for these WAVE devices, utilizing WAVE management services defined by IEEE Standard 1609.3 as well as the use of the identification services with the WAVE short message protocol, also defined by IEEE Standard 1609.3.		Draft Standard. Version 2 is under development.
IEEE P1609.2	**Draft Standard for Wireless Access in Vehicular Environments (WAVE)—Security Services for Applications and Management Messages.** This draft standard defines secure message formats and processing. This standard also defines the circumstances for using secure message exchanges and how those messages should be processed based upon the purpose of the exchange.		Draft Standard. Version 2 is under development.
IEEE P1609.3	**IEEE Standard for Wireless Access in Vehicular Environments (WAVE)—Networking Services.** This published standard defines network and transport layer services, including addressing and routing, in support of secure WAVE data exchange. It also defines WAVE Short Messages, providing an efficient WAVE-specific alternative to IPv6 (Internet Protocol version 6) that can be directly supported by applications. Further, this standard defines the Management Information Base (MIB) for the WAVE protocol stack.	December 30, 2010	Finalized and published.
IEEE P1609.4	**IEEE Standard for Wireless Access in Vehicular Environments (WAVE)—Multi-Channel Operations.** This published standard provides enhancements to the IEEE 802.11 Media Access Control (MAC) to support WAVE operations.	February 9, 2011	Finalized and published.
IEEE P1609.11	**IEEE Standard for Wireless Access in Vehicular Environments (WAVE)—Over-the-Air Electronic Payment Data Exchange Protocol for Intelligent Transportation Systems.** This published standard defines the services and secure message formats necessary to support secure electronic payments.	January 9, 2011	Finalized and published.
IEEE P1609.12™/D0.2	**Draft Standard for Wireless Access in Vehicular Environments (WAVE)—Provider Service Identifier (PSID) Allocations.** This draft standard records PSID allocation decisions and is limited to the specification of allocations of PSID values defined in the IEEE 1609 series of standards.		Draft Standard, first version.
SAE J2735, Version 2	Defines the data dictionary and message sets to be used for communicating information in a connected vehicle environment.	November 19, 2009	Revision planned to apply SEP

During the next four years, the ITS Standards Program will conduct the activities in the three areas described below in support of cooperative system standards development and needs identification.

1. Needs identification and development of new V2x Cooperative System Standards

In 2010, the ITS-JPO's System Engineering team launched the development of a core system concept of operations (ConOps). The ConOps identifies user needs and allows for a logical development of a system architecture which will form the revisions and expansion of the National ITS Architecture. Future standards will be identified in at least two ways: by identifying new core system interfaces; and by evaluating the technical research roadmaps that guide development of V2V and V2I capabilities, and which may reveal the need for a new standard or modification of an existing one.[10] The technical research roadmaps include:

- **Safety Applications.** Intended to accelerate deployment of cooperative safety systems that make use of the ability of V2V and V2I to connect vehicles to other vehicles as well as to infrastructure. There are two technical program roadmaps:
  - **Vehicle-to-Vehicle (V2V) safety applications.** Focused on safety applications that make particular use of vehicle-to-vehicle data and interactions.
  - **Vehicle-to-Infrastructure (V2I) safety applications.** Focused on safety applications that rely on communication with the infrastructure to enhance both standalone vehicle safety as well as the safety of vehicle-to-vehicle interactions.
- **Mobility Applications.** Intended to enhance mobility and system management by capturing better information on road conditions (such as congestion, physical road deterioration, and weather), improving system performance, and supporting mobile transactions. Mobility applications encompass two complementary roadmaps:
  - **Real-Time Data Capture and Management.** Focused specifically on data capture and communication between users.
  - **Dynamic Mobility Applications.** Focused on supporting development of the applications that make use of data to improve performance of surface transportation systems.
- **Environmental Applications.** Intended to reduce the environmental impact of surface transportation, these applications both generate and capture environmentally relevant real-time transportation data and use this data to create actionable information to support and facilitate "green" transportation choices for users and operators (to provide "green" transportation alternatives or options) for system operators (to receive detailed, real-time information on vehicle location, speed, and other operating conditions to improve system operation), and for vehicle owners and drivers (to advise on how to optimize the vehicle's operation and maintenance for maximum fuel efficiency). There are two technical roadmaps:
  - **Applications for the Environment: Real-Time Information Synthesis (AERIS).** A relatively new research topic for the ITS-JPO, the "AERIS"[11] research roadmap is focused on establishing a foundational baseline of current technologies, analyzing the industry gaps, and proposing how cooperative systems and data can enable transformation applications for reducing environmental impact.

[10] The most recent version of the ITS research roadmaps can be found at the ITS-JPO web site: http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm.

[11] AERIS stands for *Applications for the Environment: Real-Time Information Synthesis.*

- **Road Weather Applications for Connected Vehicles.** Focused on Applications research to develop greater specificity regarding the impact that weather has on roadways and promote strategies and tools that mitigate those impacts. Such strategies will build upon decision support tools currently undergoing development, testing, and deployment (such as those developed under the Road Weather Management Program, e.g., the *Clarus* Regional Demonstrations and the Maintenance Decision Support System (MDSS)).

The USDOT's ITS Standards Program and partners will evaluate these technical roadmaps and the ConOps to identify the need for new standards that support advancing the ITS Program (e.g., possible human factors standards). Included in this evaluation is an additional focus on how standards may apply and/or need to accommodate motor carriers and transit. Where appropriate, the ITS Standards Program will launch new standards development and/or enhancement efforts to respond to the needs within the research roadmaps and the systems engineering ConOps results.

2. International harmonization of Cooperative System Standards

One objective of the ITS Program is to ensure international harmonization of standards that apply to the vehicle platform when in the public interest.[12] Specifically, the ITS-JPO envisions an outcome in which vehicles from all modes and associated equipment and devices developed in different countries will easily interoperate with those developed and deployed elsewhere, thereby minimizing development costs and increasing the number of vendors that can participate in the increasingly global ITS equipment markets. To support this objective, the ITS Standards Program has engaged with the European Union to harmonize standards around the vehicle platform with European standards under development. Looking forward, the USDOT welcomes participation of other interested international partners and will specifically seek to expand upon recently signed cooperative agreements with the Japanese Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) and Transport Canada.

In November 2009 the USDOT and the European Commission Directorate General for Information Society and Media (DG INFSO) signed the European Union-US (EU-US) Joint Declaration of Intent on Research Cooperation. As part of the declaration, the USDOT and the DG INFSO set a goal to s*upport, wherever possible, global open standards in order to ensure interoperability of cooperative systems worldwide and to preclude the development and adoption of redundant standards.*

A joint ITS Technical Task Force was subsequently formed under USDOT and DG INFSO. This task force then created, among others, the ITS Standards Working Group (ISWG) which is co-chaired by USDOT and the DG INFSO and has the goal of exploring opportunities for harmonizing ITS standards internationally. The ISWG will execute a three-track process to take maximum advantage of harmonization opportunities:

- **Assessment, Recommendations, and Action.** Identify where harmonization opportunities may exist between cooperative systems standards being developed within the European Union and the United States. Support or direct actions necessary to harmonize target standards and identify future opportunities for cooperative standards development.
- **Detailed Agreement for Harmonization Procedures.** Identify and agree upon a means by which governmental bodies can incentivize harmonization for those opportunities identified as mutually beneficial.
- **Gap/Overlap Analysis for Future Standards.** Identify gaps in standards required for deployment of cooperative systems where the development of harmonized standards may be beneficial.

[12] See details at: http://www.its.dot.gov/research/harmonization.htm.

For more details on international harmonization efforts, see Appendix B.

3. Analysis of V2I interfaces with the current ITS infrastructure

As a result of ITS program activities, significant ITS infrastructure capabilities have been defined and deployed. V2I deployment activities must ensure effective interaction with these capabilities. The USDOT's ITS Standards Program will evaluate the current ITS infrastructure to identify interface requirements with the ITS Program. Where appropriate, the program will launch new standards development efforts to support these interfaces.

ITS Infrastructure Standards…

… permit transportation centers and their supporting systems to communicate with one another and with equipment and devices that they control.

The Vision:
Infrastructure standards will help leverage and extend existing technology investments into additional road, transit, rail, and marine applications, such as active traffic management, rail safety, and coordination of maritime freight.

Going forward, the USDOT's ITS Standards Program will support ongoing needs identification and development as needed for current and future ITS infrastructure standards. Specifically, the program will conduct needs identification and development for standards in three areas:

1. Mode-specific research initiatives

While the program's focus within the 2011—2014 timeframe will be on cooperative system standards, the program will continue to identify, develop, and improve standards covering infrastructure, vehicle, transit, motor carrier, and other ITS technologies. These activities will include, in particular, standards identified in the following list of ongoing mode-specific research initiatives:[13]

- Active Traffic Management (ATM)
- Smart Roadside
- Commercial Vehicle Information Systems and Networks (CVISN) Core and Expanded Program
- Intelligent and Efficient Border Crossings
- Multi-Modal Integrated Payment Systems
- ITS Maritime Applications
- ITS Rail Exploratory Initiative

In support, the ITS Standards Program will conduct the following activities:

- Include mode-specific standards in the standards life-cycle management plan.
- Link SDOs and stakeholder communities with lessons-learned in mode-specific research in order to improve existing standards.
- Encourage the use of SEP in mode-specific research.
- Assist in building identification and exploitation of standardization opportunities into research programs from the outset.
- Seek to remain aware of technology advances, standards activities, and best practices in other industries (e.g., the telecommunications and automotive electronics industries) that may have an impact on ITS and mode-specific research initiatives.

[13] The ITS Strategic Research Plan contains more information on each of these research initiatives at: http://www.its.dot.gov/mode_specific.htm.

2. Current and emerging ITS infrastructure technologies

Since 1996, the collaborative partnership has resulted in the publication of more than 40 standards that support Center-to-Center and Center-to-Field communications. While a number of these standards have been successfully deployed, some standards have not yet been appropriately tested and deployed. Therefore, a number of infrastructure standards have been identified as eligible for application of the SEP. The USDOT's ITS Standards Program will provide ongoing support through the following activities:

- **Complete current infrastructure ITS standards development activities.** Finalize remaining incomplete standards and apply the SEP to standards when deemed appropriate by the ITS-JPO.
- **Test infrastructure standards through actual deployment, simulation, and other appropriate means.** Several state and municipal agencies are currently planning to test a number of infrastructure standards (including, in particular, the ITE Traffic Management Data Dictionary (TMDD, version 3) through actual deployment. Findings from such deployment activities will be used to refine existing standards and inform future developments. Additional test activities will be undertaken to ensure that developed standards are suitable for their intended purposes.

In addition, the USDOT's ITS Standards Program will continue to monitor and evaluate emerging infrastructure technologies, launch new standards development efforts as needed to support these new technologies, and remain aware of advances and best practices from other industries.

3. Standards identified through other ITS research initiatives

The USDOT's ITS Standards Program anticipates that new standards may be identified through other ITS research initiatives that are currently underway; for instance, the new ITS Exploratory Research Challenge might identify new applications. As the need for new standards emerge, the USDOT's program, its modal partners, and industry and the standards development community will evaluate how these standards apply to advancing the research of the ITS Program or advancing the state-of-the-industry. Further analysis will be conducted to determine whether existing standards, if enhanced, can serve the needs. Where appropriate, the USDOT's ITS Standards Program will launch new development or enhancement efforts based on the systems engineering process.

II.B The Process: Leadership, Management, and Quality Assurance

To achieve the goal of completing the standards required to deploy interoperable ITS, the USDOT's ITS Standards Program will emphasize effective leadership, management, and quality assurance throughout its activities. Five functions will be applied to ensure quality standards:

(1) **Developing and maintaining standards in cooperation with industry stakeholders.** The USDOT's ITS Standards Program supports standards development through contractual mechanisms with independent SDOs as well as by other means, which may include directly contracting for standards-related work efforts or use of other innovative means to acquire the necessary services.

(2) **Assuring quality by applying the Systems Engineering Process (SEP) to the development process.** The SEP is a powerful mechanism for ensuring the quality of standards under development. As such, the USDOT's ITS Standards Program believes it is essential for organizations to use the SEP in the development of ITS standards where appropriate.

(3) **Managing standards throughout the life cycle.** Effective life cycle management will ensure that the USDOT's ITS Standards Program appropriately focuses its efforts on new and continuing standards development while transitioning responsibility for mature standards to organizations who can best support them.

(4) **Employing effective program oversight and management.** The USDOT's ITS Standards Program will continue to ensure use of the most effective means for developing, maintaining, and implementing ITS standards. Included are efforts to (1) engage ITS-JPO and modal managers in oversight, (2) harmonize standards internationally, (3) support users of ITS standards through targeted technical assistance, (4) employ the most effective contractual mechanisms for standards development and oversight, and (5) provide assistance to USDOT management.

(5) **Maintaining strong bi-directional connections with the National ITS Architecture Program to ensure Standards-Architecture alignment.** The USDOT's ITS Standards program will also ensure that it maintains effective cooperation with the Systems Engineering/Revised Architecture program currently underway.

These five functions are described in greater detail in subsequent pages.

ITS Standards Program Principles and Policies

In order to achieve the goals of the ITS Research Program, the USDOT's ITS Standards Program will adhere to the following principles:

Open Standards: *The ITS Standards Program will support the collaborative development of open, consensus standards whenever possible.*

Harmonization and Cooperation when Appropriate: *To avoid redundant standards and optimize the use of resources, the ITS-JPO will seek to internationally harmonize standards and/or engage in cooperative international standards development when in the public interest.*

Research Program Support: *The USDOT's ITS Standards Program will work with ITS-JPO research initiatives and provide technical support to assist in early identification of interfaces for standardization and development of appropriate open standards to ensure that research products will result in "standards-friendly" technologies.*

Best Practices: *Standards will be developed in a manner that embodies technical excellence and achieves optimal system performance and public benefit.*

Developing and maintaining standards in cooperation with ITS community stakeholders

The USDOT's ITS Standards Program supports standards development and maintenance in several ways:

- ***Contracts with Standards Development Organizations.*** Historically, the ITS-JPO has relied on SDOs for most standards development activities. Going forward, the USDOT's ITS Standards Program anticipates continuing to contract with SDOs as appropriate to manage any or all aspects of the standards development process, including:
    - Standards development.
    - Needs/opportunity assessment.
    - Stakeholder outreach.
    - Standards maintenance.

- ***Direct contracts for standards-related work.*** Although the USDOT's ITS Standards Program has typically relied on SDOs for standards development, other methods may be appropriate under certain circumstances. On at least one previous occasion, the program has reached out to experts using direct contracts. In the future, the ITS-JPO will continue to make use of alternative approaches to SDO-based standards development when advantageous. Such activities may include:
    - Drafting standards.
    - Revising standards.
    - Other standards-related analysis, development, and maintenance activities, as appropriate.

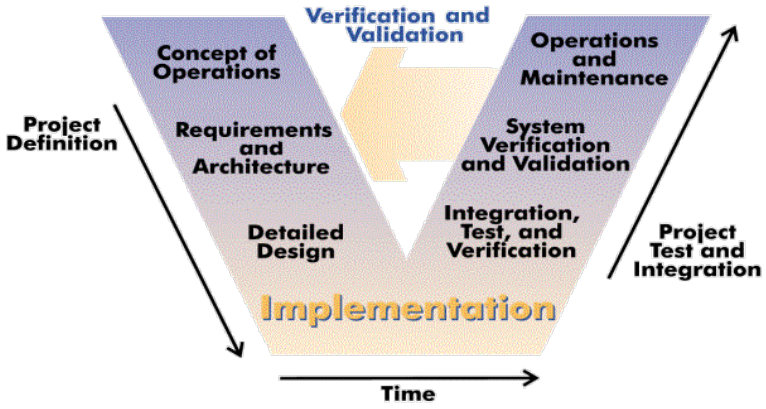
Assuring quality by applying the SEP to the development process

The SEP is a methodical approach for developing and managing complex systems. By identifying user needs in a concept of operations (what the system is supposed to do) before building the hardware or software components (how the system works), systems engineering processes lead to higher-quality systems, a higher level of stakeholder participation, better documentation, and shorter project development cycles.

All ITS standards that deal directly with the operational or maintenance activities in a system should be developed with a systems engineering process (see Figure 5 on the next page). When applied to standards development, the systems engineering process starts with the identification of user needs (in the Concept of Operations stage, as shown in the diagram), requirements development (in the Requirements and Architecture stage), and the design solutions (in the Detailed Design stage). As standards development moves through implementation, test procedures are developed in the Integration, Test, and Verification stage of the systems engineering process.

The use of SEP assures that standards are high quality and that each standard contains clear documentation linking the standard with ITS applications and user needs. Within the next four years, the USDOT's ITS Standards Program is seeking to complete the SEP for operational or maintenance ITS standards (as deemed appropriate). An additional goal is to develop methods to verify that ITS products conform with ITS standards—without such "testability", it is impossible to be certain that a product o fully conforms with a given standard.

Figure 5: ITS Standards life cycle and the Systems Engineering Process



Standards also play a role in the systems engineering process as applied to the deployment of a standards-conformant system. Specifically, the standard contributes to the integration, test, and verification stages by reducing the effort required to procure and test the system.

Out of the approximately 100 standards and supporting white papers, 23 deal directly with operations or maintenance activities (see Appendix C). Of these 23 standards, ten have undergone or are currently undergoing the SEP. In the 2011—2014 timeframe, the USDOT's ITS Standards Program will:

- Assess the need to initiate the SEP for the remaining 13 eligible ITS standards as deemed appropriate by the ITS-JPO.
- Initiate the SEP for eligible ITS standards as determined by the assessment.
- Enforce the use of a SEP on all new standards projects as deemed appropriate.
- Train SDOs and ITS professionals on the process, methods, and benefits of the SEP.

Managing standards throughout their life cycle

As part of its strategic plan, the ITS-JPO envisions a Standards Program that is focused on new and developing standards. This would require that the USDOT's ITS Standards Program transition the responsibility for mature and stable standards to other organizations. There are two critical elements in achieving this vision:

- A community of organizations must be available to accept and maintain standards relevant to their mission.
- Current standards must be carefully transitioned to the appropriate stakeholders who can accept oversight responsibility throughout a standard's life cycle.

For the USDOT's ITS Standards Program, three primary components make for effective standards life cycle management and help determine when a standard is ready for transition:

- Using the criteria shown in Figure 6 on page 30, the ITS-JPO periodically evaluates standards under its oversight.
- Based on the determination, the ITS-JPO either:

- Transfers oversight of mature standards to other organizations[14], including :
  - Negotiating and executing agreements with other USDOT agencies outlining their specific oversight responsibilities for mature and stable standards.
  - Closing out SDO funding from ITS-JPO for relevant ITS standards (note that further funding of standards transferred to other organizations is left to the discretion of the responsible agency or SDO).
- Retains oversight including monitoring standards documents, providing funding for standards development, and leading enhancement/update efforts. Currently, there are approximately 100 standards and supporting white papers in existence, a number of which require further development support or near-term revisions. Also, a number of standards have not been modified for over five years and future modifications, if any, are expected to be minor. As a result, within the next four years, the ITS Standards Program will conduct a review process to identify and prioritize funding for these required efforts (as noted in Figure 6).

- Based on these decisions, the ITS-JPO updates the ITS-JPO Standards Life Cycle Management List to reflect current development activities and new oversight responsibilities.

Figure 6: Standards maintenance decision process

Evaluation Criterion		RESULT:
1. Is the standard currently being modified?	**YES►**	**ITS-JPO Retains Responsibility**
NO▼		
2. Will the standard need major revisions within the next five years?	**YES►**	**ITS-JPO Retains Responsibility**
NO▼		
3. Is there some other compelling reason for the ITS-JPO to maintain oversight?	**YES►**	**ITS-JPO Retains Responsibility**
NO▼		
4. Is the standard abandoned or subsumed by other standards?	**YES►**	**Remove from list of ITS Standards**
NO▼		
5. Does the standard require direct USDOT oversight?	**YES►**	**Transition to other USDOT agency or retain oversight within ITS-JPO**
NO▼		
RESULT: Transition to SDO/Other Community Responsibility		

[14] See Appendix D for the list of ITS standards organizations, as of November 2010, that are best positioned to support their maintenance and use.

Employing effective program oversight and management

To oversee and manage ITS standards development, the USDOT's ITS Standards Program will interact with and provide support to a range of internal and external organizations. The program will coordinate these interactions as follows:

- ***ITS-JPO cooperative program oversight***

  Identifying needs for potential new standards and launching new standards development activities can only be done in conjunction with other program managers within the ITS-JPO and modal partners. Accordingly, the USDOT's ITS Standards Program will place a high priority on the continued successful cooperation with these program managers and modal partners. In particular, the program will provide ongoing technical support to ITS-JPO research initiatives to assist in early identification of potential standards needs and opportunities and to assist in exploiting such opportunities. The program will help program managers identify interfaces for standardization and support development of appropriate open standards to ensure that research products result in "standards-friendly" technologies.

- ***International harmonization***

  To ensure that US standards are appropriately harmonized with international standards (as a means of providing enhanced benefits while preserving the objectives and requirements of local markets), the USDOT's ITS Standards Program will work closely with international partners to:

  - Identify beneficial opportunities to harmonize US ITS standards with standards used in other countries/regions (starting with the European Union).
  - Act to increase likelihood that harmonization opportunities are appropriately pursued by participating countries/regions.

  While such harmonization efforts are targeted currently at standards around the vehicle platform, it is possible that these harmonization efforts may indirectly affect other standards, such as the ITS infrastructure standards, as well.

- ***Technical assistance***

  The USDOT's ITS Standards Program provides technical assistance to state and local transportation agencies in the form of training and guidance tailored to their local needs. As localities upgrade existing systems, ITS technical assistance helps agencies create lower-cost, interoperable ITS deployments that conform to national standards using systems engineering processes. The technical assistance programs exist to help ensure that deployed intelligent transportation systems:

  - Meet agency expectations.
  - Use ITS standards-conformant components.
  - Support deployment of interoperable ITS systems.

  Over the next four years, the ITS-JPO will continue to work with the USDOT modal organizations to help train technical assistance teams on ITS standards and on the systems engineering concepts used to deploy them. Standards-related ITS technical assistance programs connect individuals involved in new ITS implementations with professionals who have pioneered the use of ITS standards and who have successfully applied systems engineering methods.

Through these technical assistance programs, local and state transportation agencies can obtain the following:

- Information on existing ITS standards.
- Assessments of their existing system.
- Guidance on which standards are relevant to their local transportation system plans.
- Assistance developing appropriate contracting and procurement mechanisms for standards-conformant ITS programs.
- Evaluation of systems to verify conformance to ITS standards specifications.

- ***Use of appropriate contractual mechanisms***

  To ensure the quality of ITS standards, program and project oversight will be carried out through a number of different mechanisms. The USDOT's ITS Standards Program will continue to oversee and work closely with SDOs who manage standards-related activities. In addition, the program will provide substantial oversight and management of development and deployment activities carried out under other contractual vehicles. Finally, the program will provide appropriate oversight to early deployment activities to ensure such deployments conform to relevant cooperative system and ITS infrastructure standards.

Three major technical assistance programs are used by the ITS Program:

- ***ITS Standards Field Support Team***: A group of FHWA and private sector specialists who provide short-term, on-call training and assistance focused on the procurement and testing of standards-based systems.
- ***Early Deployment Assistance***: USDOT personnel and private-sector specialists who help refine deployment processes and verify the ITS standards used on early adopter projects.

- ***Peer-to-Peer Program***: A network of over 120 USDOT-approved ITS professionals available to consult on all aspects of ITS planning, design, deployment, testing, and operations.

- ***Assistance to USDOT management***

  As outlined previously, standards play a critical role in USDOT deployments, market- and consumer-adoption, and use of cooperative systems and ITS infrastructure technologies. To ensure appropriate standards-conformance in such deployments, the USDOT's ITS Standards Program will provide assistance as necessary to USDOT management at all levels within the ITS-JPO, RITA, and the modal agencies. Note that such assistance will be limited to early deployers to verify ITS standards and procurement and testing processes.

Standards-Architecture alignment

Under the ITS program, the ITS-JPO is working to create a revised ITS system architecture as part of a significant V2x Systems Engineering effort. The USDOT's ITS Standards Program will work closely with the USDOT's National ITS Architecture Program to:

- Ensure that the architecture remains updated as new cooperative system and ITS infrastructure standards are created or existing standards updated.
- Act on any standards needs identified as part of the Architecture Program.

II.C Educating the Community: The ITS Professional Capacity Building Program

The USDOT's ITS Professional Capacity Building (PCB) Program provides comprehensive training for a successful ITS workforce. As the focus of the ITS research shifts to adoption, the ITS PCB Program is responding to better meet the emerging needs of ITS professionals throughout government, private sector, and academic workforces with an expanded ITS Standards training curriculum. The vision: the PCB will help develop a community of professionals with the knowledge and skills to manage, procure, and deploy standards-based intelligent transportation systems.

Training Goals:
Comprehensive training materials that help ITS professionals understand and use the ITS standards using systems engineering principles.

Training Outcomes:
A growing cadre of ITS professionals proficient in the deployment of standards-conformant ITS technologies that satisfy user needs.

Figure 7: The PCB Assessment Cycle

In order to provide a strong knowledge base for ITS practitioners, the ITS Standards Program is developing a new set of ITS PCB training modules focused on understanding, procuring, developing, testing, and using ITS standards and standards-based systems (see Figure 7).

The new training program will include the following functions:

- Involve industry stakeholders to ensure technical content meets the training needs.
- Create modules with different audiences in mind (see Table 3).
- Create training in a modular format to provide flexibility for trainees.

Table 3: PCB Audiences

Audience	Role in standards
Decision Makers	Select IT investments and coordinate regional ITS activities
Project Managers	Run state and local ITS programs
Engineering Staff	Implement the technical elements of ITS programs
Developers/Coders	Produce the hardware and software that make up ITS subsystems
Researchers	Conduct fundamental research leading to new ITS capabilities

II.D Financing and Timing

The USDOT's ITS Standards Program anticipates continuing its efforts as directed under the current SAFETEA-LU legislation (as previously described) and/or its successors. The program is financed through a variety of mechanisms, including:

- **ITS-JPO research program budgets.** The ITS-JPO research initiatives support the USDOT's ITS Standards Program by ensuring that standards needs identification activities are built into research program plans. Where appropriate, these research programs will also allocate additional funding for the analysis of standards opportunities and potential follow-on standards development activities.
- **Stakeholder participation.** The USDOT's ITS Standards Program will continue to rely on leveraging the voluntary participation of interested stakeholders in the standards working groups who perform the difficult work of drafting and finalizing standards as they are a critical element to the success of the ITS standards work. Additional participation via other means includes providing input through public stakeholder outreach efforts by participating in workshops and providing feedback on standards activities.
- **Industry cost-sharing.** Industry participants often share the cost of identifying, developing, and maintaining standards by providing personnel to support standards development efforts.
- **Modal research program budgets.** As with the ITS-JPO research programs, modal research programs also ensure standards needs identification activities are built into research program plans. Where appropriate, these research programs will allocate funding to the USDOT's ITS Standards Program.
- **The ITS Standards Program budget.** Finally, the ITS Standards Program relies on specific budget allocations for standards efforts.

The timing of the USDOT's ITS Standards Program activities is primarily governed by the timing of ITS-JPO research initiatives. ITS cooperative system standards, in particular, will be developed as needed to support the efforts of the ITS-JPO and modal research programs. Particular dependencies include:

- **Safety applications.** The safety program will conduct a "safety pilot" over the next three years to evaluate the potential for V2V and V2I safety applications under real-world conditions. The USDOT's ITS Standards Program will monitor this safety research to identify implications for standards development and maintenance activities.
- **Mobility applications.** Existing ITS standards (including both the current standards for connectivity and the ITS Infrastructure Standards) already support significant capabilities in the area of mobility. The Real-Time Data Capture and Management and Dynamic Mobility Applications research programs will further flesh out requirements and capabilities over the next four years. The USDOT's ITS Standards Program will continue to support these efforts as appropriate to identify new standards needs and opportunities.
- **Environmental applications.** The environmental applications research program is still evolving. The ITS Standards Program will monitor environmental applications research activities to identify standards needs and opportunities.

III. Summary and Conclusions

Over the next four years, the ITS-JPO and its partners will pursue an expansive research program intended to bring transformative change to transportation through the application of advanced wireless technologies. The vision: a national, multi-modal surface transportation system that features a connected transportation environment around vehicles of all types, the infrastructure, equipment, and devices to serve the public good by leveraging technology to maximize safety, mobility, and environmental performance.

Achieving this vision of a national fully connected and interoperable system demands a robust set of stable standards. As a critical component of this research effort, the USDOT's ITS Standards Program will collaboratively develop the required suite of mature, complete, and correct standards and, when in the public interest, internationally harmonize the standards. In addition, the program will support the maintenance of these standards either directly or indirectly. Finally, the Program supports training of the stakeholder community and ITS workforce in deploying standards-conformant ITS products.

Much work has already been done. Since 1991, the program and its partners have developed approximately 100 standards and supporting white papers. In addition, the USDOT's ITS Standards Program has developed a tailored systems engineering process for ITS standards developers, methodologies for ITS standards deployers to verify conformance and support interoperability, and procurement guides and procedures to assist in wide-scale deployment of particular ITS standards. Finally, there are training and technical assistance programs to support ITS professionals and FHWA field personnel in the use of ITS standards.

But much work remains. Through 2014, the USDOT's ITS Standards Program will build on the achievements of the program to date to support the deployment of a fully interoperable, connected transportation environment and will:

- **Deliver a robust set of V2x cooperative system and ITS infrastructure standards in alignment with the needs of the ITS Program's research agenda.**
- **Provide leadership, management, and quality assurance for ITS standards development.**
- **Educate the community on the appropriate use and deployment of standards-conforming ITS technologies.**
- **Work to meet the financing and timing needs of standards activities for the ITS-JPO and modal partner research activities.**

As an outcome of these efforts, the USDOT's ITS Standards Program will deliver the standards required to support deployment of fully interoperable ITS; support or transition the life-cycle management and maintenance of these standards; and provide for a well-trained, qualified cadre of ITS professionals who are capable of effectively deploying standards-conformant ITS technologies. In short, the USDOT's ITS Standards Program will support the overall ITS research and speed progress toward the development of a connected and fully interoperable surface transportation system and toward achieving the safety, mobility, and environmental benefits that such a system can enable.

Appendix A—Description of the Current ITS Standards Program

Overview of Current Program

The USDOT's ITS Standards Program was started in 1991 as part of the department's implementation of the Intermodal Surface Transportation Equity Act (ISTEA) *Section 6053(b)* and was renewed in 1998 with the Transportation Equity Act for the 21st Century (TEA-21) and continues under current legislation (SAFETEA-LU). The mandates established for the ITS Standards Program in these two acts were:

- Develop and implement standards and protocols to *promote widespread use* of ITS technologies
- *Promote compatibility* among intelligent vehicle-highway systems technologies

In 2005 the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) *Section 5307(a)* expanded the above mandate by adding *Standards Maintenance*. From these mandates an overall goal was derived to develop standards that facilitate the deployment of interoperable transportation systems.

To achieve this overall goal, the ITS Standards Program uses a conventional four-stage life-cycle for each standard:

- Standards development
- Deployment support
- Testing
- Maintenance

Each standard that has gone through the above life cycle was proposed or selected as part of a standards planning process. The process included input from the National ITS Architecture and from proposals that came from industry participants through the standards development organizations (SDOs). Each of these life-cycle stages is described in the subsections below.

Originally, the USDOT's efforts were primarily focused on infrastructure-related standards. While other applications were addressed (e.g., vehicle-to-infrastructure or transit), overall the financial focus was on developing standards to support infrastructure applications.

Principal Standard Development Organizations (SDOs) involved in US ITS Standards

- American Association of State Highway and Transportation Officials (AASHTO)
- American National Standards Institute (ANSI)
- American Public Transportation Association (APTA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Institute of Transportation Engineers (ITE)
- National Electrical Manufacturers Association (NEMA)
- Society of Automotive Engineers (SAE)
- Telecommunications Industry Association (TIA)

Standards Development

USDOT established a partnership with selected SDOs to identify and develop ITS standards. The SDOs employed a consensus process involving agency representatives, vendors, vehicle manufacturers, integrators, consultants, and universities. At least four types of documents are included in the USDOT's ITS Standards Program:

- Information needed for a given interface.
- The protocol stack for an interface; covers a variety of protocols to address different architectures.
- Equipment, cabinets, application programming interfaces, and controller hardware.
- General category, used to define standards development approaches and act as guides for using ITS standards or reports on ITS standards-related projects.

ITS standards documents used to define interfaces have been or are undergoing development, and cover the following example types of interfaces (see Table 4):

Table 4: Types of interface examples

Center to Center (C2C) interfaces, between transportation management centers, covering the following example applications:	Center to Field (C2F) interfaces, between transportation management centers and field devices, covering the following example applications:	Field to Field interfaces, between transportation devices in the field, with the following example application:
• Data Archival • Incident Management • Rail Coordination • Traffic Management • Transit Management • Traveler Information	• Signal Priority • Data Collection/Monitoring • Dynamic Message Signs • Environmental Monitoring • Lighting Management • Ramp Metering • Traffic Signals • Vehicle Sensors • Video Surveillance • Probe Data Service • Positioning Services and intersection geometries • Driver alerts for critical safety situations (e.g., intersection safety • Driver advisories (e.g., situational awareness) • Eco Friendly	• Highway Rail Intersection (HRI)
Center to Vehicle/Traveler interfaces, between centers (e.g., transportation management and information service providers) and vehicles or devices, covering the following example applications:	**Field to Vehicle interfaces, between field devices and vehicles, with the following example applications:**	**Vehicle to Vehicle interfaces, between vehicles, with the following example applications:**
• Fare card collection • Mayday • Transit Vehicle Communications • Traveler Information • Probe Data Service • Positioning Services and intersection geometries • Driver alerts for critical safety situations (e.g., intersection safety • Driver advisories (e.g., situational awareness) • Eco Friendly	• Probe Data Service • Positioning Services and intersection geometries • Signal Priority • Toll/Fee Collection • Traveler Information • Driver alerts for critical safety situations (e.g., intersection safety • Driver advisories (e.g., situational awareness) • Preemptive action (e.g., crash avoidance and mitigation) • Eco Friendly	• Driver alerts for critical safety situations (e.g., intersection safety) • Driver advisories (e.g., situational awareness) • Preemptive action (e.g., crash avoidance and mitigation)

A first-generation set of ITS standards was developed using a design-centric approach. This approach defined message and object solutions but did not capture or specify needs, requirements, and dialogs. Early deployments revealed that the design-centric approach left gaps in addressing user needs and requirements and did not facilitate widespread deployment of interoperable systems. In 2001, a systems engineering process was proposed and later adopted for use on new and revised ITS standards to address these gaps in user needs and requirements.

USDOT has also been involved with developing International ITS standards primarily through the International Organization for Standardization (ISO). The results of this involvement include the development of *Transportation Information and Control Systems – Requirements for an ITS/TICS Data Registry and ITS/TICS Data Dictionaries* (ISO 14817) and *Transportation Information and Control Systems – Data Interfaces Between Centres for Transport Information and Control Systems* (ISO 14827 Parts 1 and 2). International ITS standards are developed in the ISO Technical Committee 204 (TC204), which incorporates 18 working groups related to ITS standards. The 2007 Transportation Review Board's (TRB) *Study of Options for Streamlining Standards for ITS* observed that the ITS Standards Program needed to foster an environment in which government agencies benefit from the competitive and innovative marketplace for ITS products and services. In the TRB panel's view, USDOT involvement in international standards forums is essential to achieve these goals.

Deployment Support

The purpose of deployment support is to promote wide-scale use of ITS standards in projects. Currently, the deployment program is focused on helping agencies deploy ITS standards. Deployment support activities are managed by FHWA's Office of Operations. Activities include:

- Developing processes and tools to help with procurement and testing activities for ITS standards dealing with interfaces.
- Developing guides to help deploy ITS standards on projects.
- Developing workshops to educate agencies and others in procuring interfaces for equipment and systems using ITS standards.
- Developing at least one workshop to educate agencies on the process of testing equipment and systems using ITS standards.
- Developing and delivering courses on ITS standards to help the transportation community understand the importance and benefits of using the ITS standards.
- Developing papers and pamphlets for outreach purposes.
- Developing case studies to capture lessons learned from projects implementing ITS standards.
- Providing Peer-to-Peer support.
- Providing deployment technical support for early adopters of ITS standards.

Testing

The purpose of testing ITS standards is to evaluate the standard's ability to facilitate the deployment of interoperable systems and to ensure that systems correctly incorporating ITS standards can be built economically and perform as desired.

The National Transportation Communications for ITS Protocol (NTCIP) Testing and Conformity Assessment (TCA) working group has developed guidelines for standards developers to help achieve the above goals for

NTCIP standards. These include guidelines such as NTCIP 8007 (Testing and Conformity Assessment Documentation within NTCIP Standards Publications) and NTCIP 9012 (Testing and Conformity Assessment User Guidance to the Issues for Center-to-Field Communications and Field Devices).

Testing of ITS standards currently consists of two types. The first and more familiar type is to test standards that are design-centric. The second type is to test standards that are requirements-centric.

The first type of testing was conducted at sites that deployed one or more ITS standards to evaluate the "suitability, effectiveness, and contribution to interoperability and interchangeability of ITS standards"[15]. For each test, a set of core functions was identified, as part of the test, to help verify how conformant implementations were implemented. The end product, of this first type of testing, is a report identifying conformance to the standard(s), and identified issues that need to be addressed by later revisions of the standard(s).

USDOT conducted a second type of testing for some NTCIP standards that contain user needs and requirements. The purpose was to verify the completeness and correctness of the Dynamic Message Sign (DMS) standard, the DMS Procurement Guide, and the DMS Test Procedures. This testing also evaluated processes used by the agencies to procure and test during a project life cycle. Feedback was provided to the NTCIP DMS Working Group on how useful, complete, and correct the standard is from the users' perspective when used in an actual project.

Maintenance

The purpose of the maintenance stage is to support renewals at appropriate intervals and to update approved standards. In 2003, an agreement was established between USDOT and some of the SDOs for maintenance of their respective ITS standards. This agreement provides for free distribution of selected published standards over the Internet, and for upgrading these standards by the participating SDOs in exchange for USDOT-provided maintenance funding.

The funding of the SDO representatives for their time as managers of their standards programs; any travel associated with program management is accounted for in the maintenance funding life-cycle stage.

Status of Current Program

Each subsection below describes the current status of ITS standards of each life-cycle stage relative to the purpose for each stage.

Development Status

As of 2011, a total of 98 standards have been developed as part of the ITS Standards Program; of these, 65 are related to information and protocol interfaces and 10 are related to equipment and Application Programming Interface (API) specifications. The remaining documents are guides for the development of standards, white papers, reports on implementations or testing, and guides for the use of standards. Of the 75 standards used for deploying interfaces, equipment, and APIs, 23 are eligible for the SEP. An ITS Standard is eligible for the SEP if the standard deals directly with the operational or

[15] Final Test Report, For Advanced Traveler Information Systems (ATIS) and Related Standards as Deployed by the Nebraska Department of Roads, page 9, by Battelle Memorial Institute, 14 March 2008.

maintenance activities in a system and its operational user needs are not already addressed in another ITS Standard. For example, NTCIP 1202, Actuated Signal Controller (ASC), deals with the operational activities of a traffic signal system, is therefore eligible for the SEP. Of the 23 ITS standards eligible for the SEP, 10 have been or are currently going through the SEP.

The ITS-JPO involvement with the development of international ITS standards has evolved since program inception. The involvement has ranged from: funding the position of Secretariat to ISO TC204, providing representatives on the Asia-Pacific Economic Cooperation (APEC) technical working group on ITS, monitoring activities, and providing US experts, to reducing the involvement to monitoring selected activities. The ITS-JPO is currently evaluating the level of commitment needed to support its objectives. In 2010, the ITS-JPO entered into an agreement with the European Commission and established the Standards Harmonization Working Group. ITS-JPO attended several international standards meetings in 2010, provided experts to international meetings, and jointly developed with the European Commission, a plan to harmonize standards around the vehicle platform.

Deployment Status

It is estimated that approximately 50 percent of the ITS interface standards have been deployed (if all or part of an ITS Standard was implemented in a project). However, the extent of the market penetration of ITS standards for projects that can use them is unclear. Of the NTCIP ITS standards deployed, the following are the most widely used:

- NTCIP 1202 Actuated Signal Controller (ASC)
- NTCIP 1203 Dynamic Message Signs (DMS)
- NTCIP 1204 Environmental Sensor Systems (ESS)
- ITE Traffic Management Data Dictionary (TMDD)

These deployments have identified the following key lessons that will help accelerate deployments, once resolved:

- Procurement processes have been developed to help achieve the goal of facilitating the deployment of interoperable systems, but these processes are generally unknown by the transportation community.
- ITS standards that have gone through the SEP contain user needs and requirements necessary for facilitating the deployment of interoperable systems.
- Consistent testing methods are needed to determine conformance.
- Inconsistent implementations still exist due to ambiguities in ITS standards.
- Incomplete standards (that do not satisfy all user needs) result in extensions that are implemented using proprietary solutions.

Once an ITS standard has been approved by the SDOs, feedback from deployments are provided to the SDOs for correction as part of the maintenance effort.

Testing Status

ITS-JPO has sponsored testing at six sites to evaluate a total of 14 ITS standards that were developed using a design-centric approach. The findings from these evaluations were provided as input to the associated ITS standards working groups.

The requirements-centric form of testing has so far only been conducted for the NTCIP Dynamic Message Sign (DMS) version 2 standard. Lessons learned from the procurement and testing activities have been extracted and have been submitted along with the test procedures, developed as part of the testing, to the NTCIP DMS Working Group.

Maintenance Status

Currently, 92 of the 98 first-version (v.1) ITS standards have been approved by the SDOs and are now in the maintenance stage. Of the total 98 ITS standards, 88 are available (i.e., online, hard copy, or both) from SDOs as first versions and, in some cases, updated versions. Three of the SDOs are providing the latest version of ITS standards available without charge to users under the terms of the maintenance partnership. This distribution agreement is renewable annually. Thirty of the approved ITS standards have completed or are in the process of completing revisions (amendments, version 2, or version 3).

It is anticipated that additional revisions will be needed as more ITS standards are deployed.

The maintenance effort includes addressing issues and corrections from feedback from ITS standards deployments.

Appendix B—International Standards Activity

This section identifies the purpose of, describes a general plan for, and defines the criteria unique to ITS-JPO involvement in international ITS standards activities.

Purpose of ITS-JPO's Participation in International Standards Activities

The overall purpose for ITS-JPO's involvement with international ITS standards is to develop, when possible and to the greatest extent practical, harmonized international standards in order to facilitate the development and deployment of globally interoperable ITS systems and equipment. In addition, ITS-JPO recognizes that international experts and government groups involved with ITS standards can offer significant technical expertise and lessons learned to augment the knowledge base of U.S. experts; and that access to this expertise can be leveraged through international partnerships.

Benefits of international cooperation include:

- The leveraging of international expertise to help develop technically sound standards.
- Building on lessons learned and sharing experiences with the use and maintenance of standards.
- Encouraging open standards development processes that provide appropriate transparency and input from international stakeholders.
- Creating greater opportunities for access to markets for equipment manufacturers in order to encourage competition and innovation.
- Encouraging a global vendor community that allows domestic purchasers of ITS equipment to access the greatest availability of high quality products at competitive prices.
- Facilitating cross-border information sharing and opportunities to improve the free flow of goods and people.

To accomplish this, ITS-JPO will cooperate with international partners to identify areas of interest for harmonization and develop a general course to harmonize ITS standards. For the period covered by this strategic plan, the primary focus will be on standards that support vehicle connectivity.

Basic Concepts for Harmonizing International Standards

ITS-JPO and its modal partners have developed a set of basic concepts to guide their involvement in international ITS harmonization. These concepts are:

- Establish, with respective international government partners, a need and desire to evaluate and harmonize standards.
- Establish, with respective governments and representative SDOs, agreements on the process and resources to use.
- Form a task force to execute the work.
- Conduct high-level evaluations to determine candidate standards for harmonization and to create a prioritization list for detailed assessment.
- Conduct a detailed assessment on candidate standards to determine extent of variation between candidate standards.
- Propose recommendations for harmonization based on detailed assessment and feedback from SDOs.
- Involve SDO partners, working group chairs (involved with the development of domiciled ITS-JPO sponsored ITS standards), and subject matter experts.
- Using this input, review the detailed assessment and recommendations and determine level of involvement and funding (based upon harmonization proposal assessment criteria). This determination will also include an assessment for ongoing involvement at international ITS standards bodies, market potential in the United States, impact to U.S. constituents, and the role for the ITS-JPO involvement due to industry environment.

Appendix C—Introduction of the Systems Engineering Process (SEP) for ITS Standards Development

A first-generation set of ITS standards was developed using a design-centric approach. The design-centric approach defined message and object solutions but did not capture or specify needs, requirements, and dialogs. Early deployments revealed that the design-centric approach left gaps in addressing user needs and requirements, and did not facilitate the wide spread deployment of interoperable systems. In 2001, a systems engineering process was proposed and later adopted for use on new and revised ITS standards to address these gaps in user needs and requirements.

The current program goals have been partially met to improve standard quality and to verify the standard addresses user operational needs. Additionally, ITS technologies are being implemented to support infrastructure deployments and ITS standards are being used in deployments. Deployers are requesting help in procurement processes to guide deployment of interoperable systems and in testing processes to verify conformance to ITS standards. The ITS Standards Program has recently focused on the following efforts to aid in deployment of interoperable systems:

- An SEP has been tailored for ITS standards developers to include the development of user needs, requirements, and design solutions (dialogs and message or object sets) in the ITS standards.
- A methodology has been established for ITS standards deployers to verify conformance to the standards and to verify the standards support interoperability.
- Procurement guides and test procedures have been developed, by USDOT, to assist in wide-scale deployment for some ITS standards containing user needs, requirements, and design solutions.

Tailoring of the Systems Engineering Process for ITS Standards Development

*The International Council on Systems Engineering (INCOSE) defines systems engineering as "...an interdisciplinary approach and means to enable the realization of successful systems.: The process is comprised of a set of tasks that "...focus on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem."***

The INCOSE process offers a globally well-respected best practice that provides a base from which the process can be customized to fit standards and development needs. For ITS standards development, specific portions of the INCOSE process have been adopted and/or modified to best meet needs. When followed, this customized process has shown itself to enable the development of high quality standards.

*** For further detail, see: http://www.incose.org*

Analysis of the ITS-JPO goals and objectives for 2011—2014 reveal an evolution that broadens the focus of the program from just deployment of infrastructure to a more comprehensive focus that includes vehicle connectivity applications. Therefore, vehicle-to-vehicle and vehicle-to-infrastructure interfaces require more investment in the future. ITS standards that support infrastructure applications are

necessary to enable the collection and distribution of information required by vehicle connectivity applications (e.g., NTCIP 1202 will also be used in the connected vehicle environment). For this reason, the ITS Standards Program focus (1) shifts towards the development of ITS standards to support vehicle connectivity applications, and (2) continues the process of modifying ITS standards to support infrastructure interoperability and add procurement guides and test procedures that support their wide-scale deployment. The development and modification of ITS standards will use the SEP where appropriate.

The following two tables describe the status of 23 ITS standards in relation to the SEP. The first table (Table 5) identifies 10 ITS standards that have or are currently going through the SEP. The second table (table 6) identifies 13 ITS standards that should be considered for the SEP. The ITS Standards Program and modal partners will assess those that are on the list to determine which ones to move forward based on priorities (support for V2V/V2I, etc.).

Table 5: ITS Standards that have been or are undergoing the SEP

Short Title	Std ID	SEP Status	Comments
Standard for Transit Communications Interface Profiles	APTA TCIP-S-001 3.0.0	To be determined	The standard has not yet been evaluated for completeness and correctness; therefore its status is unknown.
Object Definitions for Dynamic Message Signs (DMS)	NTCIP 1203 v2	Complete	
Object Definitions for Environmental Sensor Stations (ESS)	NTCIP 1204 v2	Complete	Published
Data Element Definitions for Transportation Sensor Systems (TSS)	NTCIP 1209v2	Complete	
Field Management Stations (FMS) - Part 1: Object Definitions for Signal System Masters	NTCIP 1210 v1	In process	
Object Definitions for Signal Control and Prioritization (SCP)	NTCIP 1211 v2	In process	
Object Definitions for Electrical and Lighting Management Systems (ELMS)	NTCIP 1213 v2	Complete	
Object Definitions for Signal Monitoring Unit (SMU)	NTCIP 1214 v1	In process	
Traffic Management Data Dictionary (TMDD) Standard for Center-to-Center Communications	ITE TMDD v3	Complete	Published
Dedicated Short Range Communications (DSRC) Message Set Dictionary	SAE J2735 v3	Just started	

Table 6: ITS Standards to be considered for the SEP

Short Title	Std ID	SEP Status	Comments
Advanced Transportation Controller (ATC) Standard Specification for the Type 2070 Controller	ITE ATC Type 2070	Consider	This standard is to be considered with the ATC Controller SEP effort
Commercial Vehicle Credentials	ANSI TS286	Consider	
Standard for Common Incident Management Message Sets for Use by Emergency Management Centers	IEEE 1512 -2006	Consider	This standard to be considered along with the rest of the IEEE 1512 set of standards
Standard for Traffic Incident Management Message Sets for Use by Emergency Management Centers	IEEE 1512.1-2006	Consider	This standard to be considered along with the rest of the IEEE 1512 set of standards
Standard for Public Safety Traffic Incident Management Message Sets for Use by Emergency Management Centers	IEEE 1512.2-2004	Consider	This standard to be considered along with the rest of the IEEE 1512 set of standards
Standard for Hazardous Material Incident Management Message Sets for Use by Emergency Management Centers	IEEE 1512.3-2006	Consider	This standard to be considered along with the rest of the IEEE 1512 set of standards
Standard for Common Traffic Incident Management Message Sets for Use in Entities External to Centers	IEEE P1512.4	Consider	This standard to be considered along with the rest of the IEEE 1512 set of standards
Standard for Wireless Access in Vehicular Environments (WAVE) - Over- the-Air Data Exchange Protocol for Intelligent Transportation Systems (ITS)	IEEE P1609.11	Consider	This is a standard used for wireless communications
Object Definitions for Actuated Traffic Signal Controller (ASC) Units	NTCIP 1202 v2	Consider	
Object Definitions for Closed Circuit Television (CCTV) Camera Control	NTCIP 1205	Consider	
Object Definitions for Data Collection and Monitoring (DCM) Devices	NTCIP 1206	Consider	
Object Definitions for Ramp Meter Control (RMC) Units	NTCIP 1207	Consider	
Message Set for Advanced Traveler Information System (ATIS)	SAE J2354	Consider	This standard is being evaluated for support of V2V/V2I applications

Appendix D—Current ITS Standards

Appendix D lists all of the ITS standards that have been published or are in development as of November 2010. The standards are grouped by subsystems of the National ITS Architecture. The relationship between the ITS standards and the National ITS Architecture is also illustrated in Figure 4 on page 13 which categorizes the standards using color to denote their NTCIP level.

Within the Architecture, an ITS standard serves one of three roles: information exchange, message definition, and device management (see the introduction for full descriptions). Each standard's role is indicated in the fourth column in the table. Some additional standards listed in the table provide supporting information to standards and system developers rather than serving one of these three roles.

The table also indicates whether each standard has completed the SEP, is in the process of being revised using the SEP, is being considered for future SEP work, or is not applicable to the SEP.

Entries in italics in gray text are standards that are no longer in use. Standards that are no longer in use also show "Not in Use" in the SEP column.

Table 7: ITS standards published or in development as of Nov. 2010 (submitted by the ITS Architecture group)

Architecture Group	Std ID	Short Title	Role	Comments
Archived Data Management	ASTM E2259-03	Standard Guide for Archiving and Retrieving ITS-Generated Data	Supporting Documentation	Complete
	ASTM E2468-05	Standard Practice for Metadata to Support Archived Data Management Systems	Message Definition	Complete
	ASTM E2665-08	Standard Specifications for Archiving ITS-Generated Traffic Monitoring Data	Device Management	Complete
Advanced Transportation Controller	ITE ATC API	Application Programming Interface (API) Standard for the Advanced Transportation Controller (ATC)	Device Management	Being developed
	ITE ATC Controller 5..2	Advanced Transportation Controller (ATC)	Device Management	Complete
	ITE ATC Type 2070	Advanced Transportation Controller (ATC) Standard Specification for the Type 2070 Controller	Device Management	Under consideration for SEP
	ITE ITS Cabinet	ITS Standard Specification for Roadside Cabinets	Device Management	Being developed with SEP
Advanced Traveler Information System	SAE J1663	Truth-in-Labeling Standard for Navigation Map Databases	Supporting Documentation	Complete
	SAE J2266	Location Referencing Message Specification (LRMS)	Message Definition	Complete
	SAE J2313	On-Board Land Vehicle Mayday Reporting Interface	Message Definition	Complete
	SAE J2354	Message Set for Advanced Traveler Information System (ATIS)	Message Definition	Under consideration for SEP
	SAE J2369	Standard for ATIS Message Sets Delivered Over Reduced Bandwidth Media	Message Definition	Complete

Architecture Group	Std ID	Short Title	Role	Comments
	SAE J2540	Messages for Handling Strings and Look-Up Tables in ATIS Standards	Message Definition	Complete
	SAE J2540/1	RDS (Radio Data System) Phrase Lists	Message Definition	Complete
	SAE J2540/2	ITIS (International Traveler Information Systems) Phrase Lists	Message Definition	Complete
	SAE J2540/3	National Names Phrase List	Message Definition	Complete
	SAE J2630	Converting ATIS Message Standards from ASN.1 to XML	Message Definition	Complete
Center-to-Center	APTA TCIP-S-001 3.0.0	Standard for Transit Communications Interface Profiles	Message Definition	In evaluation for SEP
	ITE TM 1.03	*Standard for Functional Level Traffic Management Data Dictionary (TMDD)*	*Message Definition*	*Not in Use*
	ITE TM 2.01	*Message Sets for External TMC Communication (MS/ETMCC)*	*Message Definition*	*Not in Use*
	ITE TMDD v3	Traffic Management Data Dictionary (TMDD) and Message Sets for External Traffic Management Center Communications (MS/ETMCC)	Message Definition	Complete
	ITE TMDD Guide	TMDD & MS/ETMCC Guide Standard for Functional Level Traffic Management Data Dictionary (TMDD) and Message Sets for External Traffic Management Center Communications	Supporting Documentation	Complete
	NTCIP 1104	Center-to-Center Naming Convention Specification	Message Definition	Complete
	NTCIP 2304	Application Profile for DATEX-ASN (AP-DATEX)	Information Exchange	Complete
	NTCIP 2306	Application Profile for XML Message Encoding and Transport in ITS Center-to-Center Communications (C2C XML)	Information Exchange	Complete
	NTCIP 9010	XML in ITS Center-to-Center Communications	Supporting Documentation	Complete
Center-to-Field	*NTCIP 1101*	*Simple Transportation Management Framework (STMF)*	*Information Exchange*	*Not in Use*
	NTCIP 1103	Transportation Management Protocols (TMP)	Information Exchange	Complete
	NTCIP 1202	Object Definitions for Actuated Traffic Signal Controller (ASC) Units	Message Definition	Under consideration for SEP
	NTCIP 1203	Object Definitions for Dynamic Message Signs (DMS)	Message Definition	Complete
	NTCIP 1204	Object Definitions for Environmental Sensor Stations (ESS)	Message Definition	Complete
	NTCIP 1205	Object Definitions for Closed Circuit Television (CCTV) Camera Control	Message Definition	Under consideration for SEP
	NTCIP 1206	Object Definitions for Data Collection and Monitoring (DCM) Devices	Message Definition	Under consideration for SEP
	NTCIP 1207	Object Definitions for Ramp Meter Control (RMC) Units	Message Definition	Under consideration for SEP
	NTCIP 1208	*Object Definitions for Closed Circuit Television (CCTV) Switching*	*Message Definition*	*Not in Use*
	NTCIP 1209	Data Element Definitions for Transportation Sensor Systems (TSS)	Message Definition	Complete

Architecture Group	Std ID	Short Title	Role	Comments
	NTCIP 1210	Field Management Stations (FMS) - Part 1: Object Definitions for Signal System Masters	Message Definition	Being developed with SEP
	NTCIP 1211	Object Definitions for Signal Control and Prioritization (SCP)	Message Definition	Being developed with SEP
	NTCIP 1213	Object Definitions for Electrical and Lighting Management Systems (ELMS)	Message Definition	Complete
	NTCIP 1214	Object Definitions for Conflict Monitor Units (CMU)	Message Definition	Being developed with SEP
	NTCIP 2001	*Class B Profile*	*Message Definition*	*Not in Use*
	NTCIP 2101	Point to Multi-Point Protocol Using RS-232 Subnetwork Profile	Information Exchange	Complete
	NTCIP 2102	Point to Multi-Point Protocol Using FSK Modem Subnetwork Profile	Information Exchange	Complete
	NTCIP 2103	Point-to-Point Protocol Over RS-232 Subnetwork Profile	Information Exchange	Complete
	NTCIP 2201	Transportation Transport Profile	Information Exchange	Complete
	NTCIP 2301	Simple Transportation Management Framework (STMF) Application Profile	Information Exchange	Complete
	NTCIP 2302	Trivial File Transfer Protocol (TFTP) Application Profile	Information Exchange	Complete
	SAE J1746	ISP-Vehicle Location Referencing Standard	Message Definition	Complete
Other Communications	NTCIP 1102	Octet Encoding Rules (OER) Base Protocol	Information Exchange	Complete
	NTCIP 2104	Ethernet Subnetwork Profile	Information Exchange	Complete
	NTCIP 2202	Internet (TCP/IP and UDP/IP) Transport Profile	Information Exchange	Complete
	NTCIP 2303	File Transfer Protocol (FTP) Application Profile	Information Exchange	Complete
Commercial Vehicle Check	ANSI TS284	Commercial Vehicle Safety Reports	Information Exchange	Complete
	ANSI TS285	Commercial Vehicle Safety and Credentials Information Exchange	Information Exchange	Complete
	ANSI TS286	Commercial Vehicle Credentials	Information Exchange	Under consideration for SEP
Dedicated Short Range Com.	ASTM E2213-03	Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems - 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications	Information Exchange	Complete
	IEEE 1455-1999	Standard for Message Sets for Vehicle/Roadside Communications	Message Definition	Complete
	IEEE 1609.1-2006	Standard for Wireless Access in Vehicular Environments (WAVE) - Resource Manager	Device Management	Complete
	IEEE 1609.2-2006	Standard for Wireless Access in Vehicular Environments (WAVE) - Security Services for Applications and Management Messages	Message Definition	In process of development
	IEEE 1609.3	Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services	Information Exchange	Complete

Architecture Group	Std ID	Short Title	Role	Comments
	IEEE 1609.4-2006	Standard for Wireless Access in Vehicular Environments (WAVE) - Multi-Channel Operation	Information Exchange	Complete
	IEEE 802.11p	Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part II: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification	Information Exchange	In process of development
	IEEE P1609.0	Standard for Wireless Access in Vehicular Environments (WAVE) - Architecture	Supporting Documentation	Complete
	IEEE P1609.11	Standard for Wireless Access in Vehicular Environments (WAVE) - Over- the-Air Data Exchange Protocol for Intelligent Transportation Systems (ITS)	Information Exchange	Under consideration for SEP
	SAE J2735	Dedicated Short Range Communications (DSRC) Message Set Dictionary	Message Definition	Being developed with SEP
Emergency Management	IEEE 1512 -2006	Standard for Common Incident Management Message Sets for use by Emergency Management Centers	Message Definition	Under consideration for SEP
	IEEE 1512.1-2006	Standard for Traffic Incident Management Message Sets for Use by Emergency Management Centers	Message Definition	Under consideration for SEP
	IEEE 1512.2-2004	Standard for Public Safety Traffic Incident Management Message Sets for Use by Emergency Management Centers	Message Definition	Under consideration for SEP
	IEEE 1512.3-2006	Standard for Hazardous Material Incident Management Message Sets for Use by Emergency Management Centers	Message Definition	Under consideration for SEP
	IEEE P1512.4	Standard for Common Traffic Incident Management Message Sets for Use in Entities External to Centers	Message Definition	Under consideration for SEP
Field-to-Field	IEEE 1570-2002	Standard for the Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection	Information Exchange	Complete
Human Factors	SAE J1757	Standard Metrology for Vehicular Displays	Supporting Documentation	Complete
	SAE J2365	Calculation of the Time to Complete In-Vehicle Navigation and Route Guidance Tasks	Supporting Documentation	Complete
	SAE J2395	ITS In-Vehicle Message Priority	Supporting Documentation	Complete
	SAE J2396	Definitions and Experimental Measures Related to the Specification of Driver Visual Behavior Using Video Based Techniques	Supporting Documentation	Complete
	SAE J2399	Adaptive Cruise Control (ACC) Operating Characteristics and User Interface	Device Management	Complete
	SAE J2400	Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements	Device Management	Complete

Architecture Group	Std ID	Short Title	Role	Comments
In-Vehicle	*SAE J1708*	*Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications*	*Information Exchange*	*Not in Use*
	SAE J1760	ITS Data Bus Data Security Services	Device Management	Complete
	SAE J2355	ITS Data Bus Architecture Reference Model Information Report	Supporting Documentation	Complete
	SAE J2366/1	ITS Data Bus - IDB-C Physical Layer	Device Management	Complete
	SAE J2366/1L	ITS Data Bus - Low Impedance Stereo Audio	Device Management	Complete
	SAE J2366/2	ITS Data Bus - Link Layer	Information Exchange	Complete
	SAE J2366/4	ITS Data Bus - Thin Transport Layer	Information Exchange	Complete
	SAE J2366/7	ITS Data Bus - Application Message Layer	Information Exchange	Complete
Supporting	NTCIP 1201	Global Object Definitions	Message Definition	Complete
Wide Area Mobile Com.	*EIA 794*	*Data Radio Channel (DARC) System*	*Information Exchange*	*Not in Use*
	EIA 795	*Subcarrier Traffic Information Channel (STIC) System*	*Information Exchange*	*Not in Use*
Other	IEEE SH94633-SH94638	The Survey and Analysis of Existing Standards and those Under Development Applicable to the Needs of the Intelligent Transportation System (ITS) Short Range and Wide Area Wireless and Wireline Technologies	Supporting Documentation	Complete
	NTCIP 8003	Profile Framework	Supporting Documentation	Complete
	NTCIP 8004	Structure and Identification of Management Information	Supporting Documentation	Complete
	NTCIP 8005	NTCIP 8005 Process, Control & Info Mgmt Policy	Supporting Documentation	Complete
	NTCIP 8007	Testing and Conformity Assessment Documentation within NTCIP Standards Publications	Supporting Documentation	Complete
	NTCIP 9001	NTCIP Guide	Supporting Documentation	Complete
	NTCIP 9012	Testing Guide for Users	Supporting Documentation	Complete
	SAE J2352	Mayday Industry Survey Information Report	Supporting Documentation	Complete
	SAE J2372	Field Test Analysis Information Report	Supporting Documentation	Complete
	SAE J2373	Stakeholders Workshop Information Report	Supporting Documentation	Complete
	SAE J2539	Comparison of GATS Messages to SAE ATIS Standards Information Report	Supporting Documentation	Complete

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