Standards for Intelligent Transportation Systems

Review of the Federal Program

Committee for Review of the U.S. Department of Transportation's
Intelligent Transportation Systems Standards Program

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Committee for Review of the U.S. Department of Transportation's Intelligent Transportation Systems Standards Program

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Preface

This study was conducted in response to a request from the U.S. Department of Transportation's (DOT's) Joint Program Office (JPO) that the National Research Council's (NRC's) Transportation Research Board (TRB) undertake a review of JPO's Intelligent Transportation Systems (ITS) Standards Program. NRC appointed the Committee for Review of the U.S. Department of Transportation's Intelligent Transportation Systems Standards Program to review and critique the strategy being used by DOT to encourage rapid establishment of ITS standards.

The committee, composed of experienced professionals in transportation systems development and management, transit operations, automotive technology, telecommunications and electronics, systems engineering, and policy studies, met three times over the course of approximately 6 months to carry out its charge. At these meetings, DOT staff, consultants, and guests (see Appendix A) presented their views and shared their experience with the ITS Standards Program, ITS development, and the broad challenges involved in setting standards for technological systems. In closed deliberative sessions, the committee discussed these matters, drawing on the members' own experience, and developed consensus views on the questions under its charge. In so doing, the committee focused on the ITS Standards Program as a whole, rather than individual standards within the program. This document summarizes the committee's discussions and presents its findings and recommendations.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. Appreciation is expressed to the following individuals for their review of this report: Frederick T. Andrews, Bell Communications Research, Inc. (retired); Don B. Chaffin, University of Michigan; Steven J. Fenves, National Institute of Standards and Technology; Wayne Shackelford, Gresham Smith & Partners; and Chelsea White, University of Michigan.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the committee's conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Lester A. Hoel, University of Virginia, TRB Division Chair for National Research Council Oversight, who was responsible for making certain that an independent examination of this report was carried out in accordance with NRC report review procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

A number of individuals provided invaluable support in the conduct of the study and the preparation of this report. Andrew C. Lemer served as study director and drafted this report under the direction of the study committee and the supervision of Stephen R. Godwin, Director of Studies and Information Services, TRB. Frances E. Holland assisted with committee travel, meeting arrangements, and manuscript preparation. Suzanne Schneider, Assistant Executive Director, TRB, managed the report review process. Nancy A. Ackerman, Director of Reports and Editorial Services, TRB, supervised the report's final preparation; Rona Briere edited the final manuscript.

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Executive Summary

The Joint Program Office (JPO) of the U.S. Department of Transportation (DOT) is responsible for developing a national architecture and standards to encourage the development and deployment of intelligent transportation systems (ITS) technology in the United States. In 1999, JPO asked the National Research Council's (NRC's) Transportation Research Board to undertake a review of JPO's ITS Standards Program. NRC appointed a committee of experienced professionals in transportation systems development and management, transit operations, automotive technology, telecommunications and electronics, systems engineering, and policy studies to review and critique the strategy being used by the program to introduce ITS standards. Specifically, the committee was asked to address the following questions:

- Is the ITS Standards Program's strategy for standards development and adoption appropriate for meeting the program's goals?
- Is the strategy being implemented effectively to continue the needed standards development and to transition the program's focus successfully from standards development, to adoption, to the deployment of standardized products and services? Are the right processes in place, and are DOT's leadership and expertise being appropriately exercised?
- How might the program's current and planned activities be altered or expanded to improve its impact and likelihood of success?

The committee met three times over the course of approximately 6 months to discuss matters related to these questions. On the basis of these discussions, presentations by DOT staff and consultants, reviews of published materials, and the members' own experience, the committee formulated findings on the efficacy of the ITS Standards Program plans, progress, and prospects (responding to the first two questions) and on recommended actions for improving the program in the future (responding to the third question).

GENERAL ASSESSMENT OF THE ITS STANDARDS PROGRAM

The committee finds overall that JPO has taken a generally sensible and orderly approach to the development and implementation of selected ITS standards as a means of aiding the realization of the National ITS Architecture. JPO has relied substantially on established standards development organizations (SDOs) to mobilize and organize stakeholder participation in standards setting. This approach, while not without limitations, is a proven strategy and well accepted in both U.S. and international practice. JPO's efforts to broaden the technical scope and qualifications of participants in standards development are appropriate and warrant continued emphasis, as does the evolution of the JPO program to emphasize support for testing and demonstration, education, and outreach to accelerate the adoption of demonstrably effective standards. Nevertheless, as technology advances and experience is gained with ITS applications, new standards may yet be identified that merit federal support for their development, implementation, and updating; the addition of such standards to the JPO program is clearly warranted.

In this context, the committee makes the following recommendations for further enhancing the effectiveness of the program:

> **Recommendation 1: JPO should describe more explicitly and in greater detail the relationship between the National ITS Architecture and the standards that have been included in the ITS Standards Program. JPO should state more clearly its criteria for determining in the future which proposed standards warrant federal support for their development and deployment. While the potential for contributing to func-**

tional interoperability is certainly a key criterion, contributions to safety, security, technological leadership, international trade, and other valid federal concerns are also justifiable bases for providing federal support.

Recommendation 2: Each ITS standard in the JPO program should undergo an open development and adoption process in which all stakeholders may fully participate, regardless of which SDO provides leadership for the standard's development. This process should include appropriate validation or demonstration prior to final adoption of a proposed standard. To ensure an open process and adequate validation, as well as to ensure that U.S. standards are given full standing in international markets, standards developed with JPO support should meet criteria for approval by the American National Standards Institute (ANSI) as American National Standards, including the criterion that at least one of the organizations responsible for a standard's development be ANSI accredited.

FUTURE DEVELOPMENT AND LONG-TERM SUPPORT OF STANDARDS

Arguments in favor of some degree of national ITS interoperability are compelling. Nevertheless, the committee believes insufficient distinction is being drawn between standards for which national uniformity is truly warranted and those for which variations from one region to another may be acceptable. The committee saw no convincing analyses of the national interests served by including some standards currently in the JPO program or under consideration; such analyses should be more clearly presented.

Recommendation 3: In the future, JPO should devote federal funds to developing only those standards for which there is a clearly stated national need for government support. The statement of need should identify explicitly the standard's role in the realization of the National ITS Architecture.

ITS brings together technologies and professionals from telecommunications, information systems, and transportation system management—diverse disciplinary fields that have not traditionally worked closely together. Much ITS technology is evolving rapidly, raising the prospect that obsolescence could compromise the effectiveness of fixed standards and of the National ITS Architecture itself. The committee concludes that the JPO program has given too little attention to the task of long-term support and updating of the standards developed under the program's auspices to ensure that they do not become obsolete or hinder innovation.

Recommendation 4: JPO should undertake to have the National ITS Architecture reviewed by an independent organization to ensure that technological advances have not rendered underlying assumptions or resulting portions of the architecture obsolete. If portions of the architecture are no longer useful for achieving national interoperability, they should be appropriately modified or deleted.

Recommendation 5: JPO should devise and implement a mechanism to ensure that the National ITS Architecture as a whole is reviewed and updated periodically. This process should entail significant private-sector participation.

Recommendation 6: JPO should develop explicit plans to ensure long-term support and updating of the ITS standards within its program. Long-term support might encompass training and other activities designed to enhance technical proficiency among users of the standards, as well as periodic review and revision to ensure the effectiveness of standards that are implemented.

Recommendation 7: JPO should continue to seek to attract broader private-sector involvement, particularly from such fields as broadband wireless telecommunications and data management. To this end, a technically qualified and independent advisory group should be designated and assigned responsibility for ensuring that the standards are reviewed and updated periodically as appropriate.

RULEMAKING TO ENCOURAGE USE OF STANDARDS

The committee agrees with the principle that ITS standards should be voluntary and is therefore troubled by the prospect of such standards being enforced through the federal rulemaking process as a basis for judging the eligibility of ITS projects for federal funding. While acknowledging that use of the federal rulemaking process may be necessary and appropriate in certain circumstances (e.g., functions related to regulation of the motor carrier industry), the committee is concerned that such rulemaking may not support the underlying objective of having common standards applied throughout the United States. On the whole, the committee believes that the risks of using the rulemaking process to impose individual standards currently included in the JPO program outweigh the possible benefits of adopting those standards as a basis for judging the eligibility of ITS projects for federal funding.

Recommendation 8: JPO and DOT as a whole should use rulemaking sparingly and only when there is a demonstrable need to enforce particular standards to achieve national objectives of ITS interoperability. JPO's assessment of the readiness of any standard for rulemaking should include completion of adequate validation and/or demonstration to ensure that the standard performs as desired. The committee recommends further that rulemaking be undertaken only for standards for which there are clearly established procedures for periodic review and updating to prevent these rules from hindering continued technological innovation.

U.S. ITS STANDARDS IN A GLOBAL CONTEXT

The committee applauds JPO's efforts to ensure that U.S. ITS technology is well represented in global markets. Aggressive U.S. participation in international ITS standards-setting organizations is not only appropriate, but essential.

Recommendation 9: JPO should continue to participate and support U.S. involvement in appropriate International Organization for Standardization technical committee activities. In addition, greater attention should be given to other opportunities for influencing international standards, for example, through organizations operating under the auspices of the North American Free Trade Agreement or the Asia-Pacific Economic Council.

1

Introduction

For more than a decade, highway planners and engineers have been working actively to realize the dream of smart or intelligent transportation systems (ITS). Such systems collect, store, process, and distribute information relating to the movement of people and goods and apply modern computer and communications technologies to the operation of transportation systems. Their use is intended to improve the performance of highways, transit lines, and other elements of the nation's transportation systems by reducing congestion, increasing travel speeds, improving safety, saving energy, and more.

The task is complex. ITS encompasses myriad products and services, including systems for traffic management, public transportation management, emergency response and incident management, advanced vehicle control and safety, commercial vehicle operations, electronic payment of tolls, railroad grade crossing safety, and potentially many others. The transportation systems themselves are developed and operated by multiple agencies at local, state, and federal levels of government and in the private sector. The decisions and actions of thousands of individuals interact on a daily basis to determine the systems' performance. The means of making these systems "intelligent" entail rapidly evolving electronics and information technologies, as well as time-tested and more slowly changing design and construction methods.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) assigned to the U.S. Department of Transportation (DOT) a substantial role in ITS research, development, and deployment. As defined by Congress in this and subsequent legislation, this role includes establishment of a National ITS Architecture and a set of standards designed to ensure the interoperability of the systems' various components. Since 1991 DOT has invested more than $1 billion in research, development, and deployment of ITS technologies.

The Transportation Equity Act for the 21st Century (TEA-21), enacted in 1998, extended DOT's ITS mandate beyond that of ISTEA. Section 5206 of TEA-21 specifies, in particular, that the ITS program should develop, implement, and maintain the national architecture and supporting standards and protocols needed to promote the widespread use and evaluation of ITS technologies as a component of the surface transportation systems of the United States. The act goes further by explicitly requiring that ITS projects carried out using federal funds "conform to the national architecture, applicable standards or provisional standards, and protocols. . . ."

The National ITS Architecture has been defined as a framework that identifies the functions to be performed by ITS components and the various ways in which the components can be interconnected. To the extent that such an architecture describes multiple systems (e.g., for traffic management, emergency vehicle operations, toll collection), "standards" could refer to all of the definitions, measurements, and configurations that determine each system's characteristics and performance. Each manufacturer of equipment, for example, will have its own standards for its products and services, which may or may not conform to those of another manufacturer or a particular agency. As noted, DOT's legislative mandate includes developing standards that may be applied more generally to achieve interoperability among the products of different manufacturers used in various applications nationwide.

The term *interoperability* refers to the idea that devices from various suppliers, installed in various locations, and used by the diverse public will work together seamlessly throughout the United States and perhaps in other countries. Interoperability has been identified by DOT and many transportation professionals as the primary objective for the setting of ITS standards. Government officials responsible for overseeing the public's investment in these new technologies wish to ensure that ITS devices will communicate effectively with one another and be interchangeable, particularly for vehicles and travelers traversing multiple jurisdictions. Standards are widely used by such officials when they undertake to procure a specific system or installation to specify the required characteristics of equipment, construction, and software. Effective and open standards used in the procurement of new ITS equipment and installations are seen by many professionals as a basis for maintaining active competition among suppliers and for protecting users from the excess costs of selecting a system that becomes prematurely obsolete when newer devices are brought to market.

DOT's Joint Program Office (JPO) administers the ITS Standards Program and has been responsible for oversight of the development of the National ITS Architecture. Standards-setting activities commenced effectively in 1996 and are continuing with the participation of a number of standards development organizations (SDOs)—professional and trade groups that serve as forums for discussion among industry, government, and other interested parties, leading to the establishment of consensus standards that are then adopted as part of the ITS program. JPO has focused its efforts primarily on portions of the ITS infrastructure, leaving to the private sector the primary role of establishing standards for intelligent vehicle components of ITS and those intelligent infrastructure components likely to progress without such active federal encouragement.

JPO's ITS Standards Program has made substantial progress and is now shifting its focus from developing standards to working to accelerate their dissemination and implementation. Mindful of the opportunities presented by such a transition, JPO in 1999 asked the National Research Council's Transportation Research Board to undertake this review of the ITS Standards Program. Specifically, the committee was asked to consider the following questions regarding the ITS Standards Program. First, is the program's strategy for standards development and adoption appropriate for meeting the program's goals? Second, is the strategy being implemented effectively and adjusted to encourage effective deployment of standards developed under the program? Finally, how might the program's current and planned activities be altered, if at all, to improve the program's likelihood of success?

In Chapter 2 the development and principal elements of the program, JPO's standards development strategy as it has evolved since the program's inception, and the program's current status are reviewed. The principal issues identified by the committee as crucial to assessing the program's strategy and effectiveness are summarized in Chapter 3. Finally, the committee's findings and recommendations in response to the questions posed under its charge are presented in Chapter 4, and concerns—such as the maintenance of standards when technology is rapidly evolving—likely to be faced by JPO as the ITS Standards Program continues are described. In addition, those who gave presentations at the committee meetings are identified in Appendix A, an annotated listing of standards encompassed by the ITS Standards Program as of February 2000 is presented in Appendix B, and brief biographies of members of the study committee are provided.

2

Background

ISTEA formally established the development of ITS as a mission of national importance. In doing so, it built on a broad consensus among transportation professionals that emerging new telecommunications, computation, and information management technologies could be applied to significantly enhance the safety and efficiency of all forms of transportation, especially highway transportation. Indeed, ITS activities were initially described more narrowly by the term "intelligent vehicle–highway systems," subsequently evolving to encompass transit as well as private automobiles, goods movement as well as passenger transportation, and rural as well as urban applications. In making a commitment to ITS, Congress sought to exploit these domestic technological advances while also ensuring the nation's global competitiveness as a provider of ITS technologies and a beneficiary of ITS developments worldwide. In this chapter the history of federal involvement in ITS standards development and deployment, the basic concepts underlying these activities, the National ITS Architecture, the ITS Standards Program, the program's standards development strategy and process, and the transition now taking place in the program's focus from standards development to dissemination and implementation are reviewed in turn.

FEDERAL INVOLVEMENT IN ITS DEVELOPMENT AND DEPLOYMENT

ISTEA assigned to DOT primary responsibility for administering the federal government investment in ITS. The legislation also provided for federal support of a separate entity that would bring the private sector and government together to work jointly toward ITS development and deployment. ITS America, an outgrowth of an earlier organization (Mobility 2000), was chosen to play that role. ITS America is today a professional and trade organization whose goal is to foster public–private partnerships aimed at advancing ITS. Members of the organization include government agencies, professional groups, private companies, and others having a stake in the process of ITS development and deployment. These stakeholders participate in various committees and conferences, including an annual meeting and product showcase that regularly attracts thousands of attendees. The organization receives congressionally budgeted, DOT-administered funds to support its activities; these funds account for approximately one-third of ITS America's annual budget.

The Federal Highway Administration (FHWA) initially was assigned the task of establishing DOT's ITS programs. In 1993, FHWA contracted with the Jet Propulsion Laboratory (JPL) to act as the Architecture Manager for development of the National ITS Architecture, envisioned as a guideline or framework for ITS development in the United States. JPL and several other private-sector and quasi-governmental organizations subsequently worked in contractor teams to produce that architecture. Because ITS applications are not restricted to highways, DOT in 1994 established JPO to span the mode-specific perspectives of FHWA, the Federal Transit Administration, and other modal administrations and to assume federal responsibilities for ITS development and deployment.

The need for standards was generally recognized within the ITS stakeholder community, and that recognition was reflected in both legislation and JPO's programs. As work on the National ITS Architecture progressed, standards development was seen as a means to facilitate the rapid emergence of the many user services to be provided under the architecture. The architecture's developers defined several hundred standards requirements that would have to be met to achieve interoperability under the architecture.

Summer 1996 saw the initial release of the National ITS Architecture, and JPO shifted the emphasis of its standards-related activities from identifying requirements to developing standards. The ITS Standards Program, administered by JPO, encompasses the latter activities. The actual work of developing standards is accomplished largely by a number of SDOs, which, as noted in Chapter 1, serve as forums in which representatives of private-sector enterprises (e.g., equipment manufacturers, designers), government, and other interested parties (e.g., user groups) can work together to establish consensus standards for ITS. Those standards are then made generally available for use in procurement, design, and other ITS-related activities. The standards remain voluntary unless they are adopted as specifications or regulations by particular agencies or other entities.

For those standards development activities included within the JPO program, the SDOs operate for the most part under cooperative agreements with DOT. The agency provides funding for such direct expenses as consultants who provide technical support to the committees of volunteers that develop the standards and travel for public-sector participants in those committees. The time individuals spend in the process is effectively donated by their employer companies or agencies, which generally regard those expenses as justified by the commercial advantages derived from early knowledge of and actual influence on the standards. Critics of the process note that many government agencies and private firms do not have adequate resources to participate effectively. Participating SDOs generally carry out a range of other standards development activities beyond those receiving JPO support.

TEA-21 placed additional emphasis on standards development, requiring specifically that DOT identify standards "critical to ensuring national interoperability or critical to the development of other standards" and undertake to ensure the development of such standards. A report identifying 17 such "critical standards" was submitted to Congress in June 1999, as required by the legislation.

At present, JPO's ITS Standards Program includes approximately 80 standards documents in various stages of development (see Appendix B). JPO officials anticipate that some of the ITS standards, as well as the National ITS Architecture, will be submitted to the federal rulemaking process to become bases for determining the eligibility of ITS projects for federal funding (a subject discussed both later in this chapter and in Chapter 3). Some rulemaking actions have been initiated.

Throughout the above activities, DOT has distinguished two primary elements of ITS: intelligent vehicles and intelligent infrastructure. *Intelligent vehicles* encompass in-vehicle systems designed to assist drivers and intervene in vehicle control to reduce the risk of crashes, help drivers acquire and use information, and facilitate transportation system management (for example, reducing congestion). *Intelligent infrastructure* refers to systems that monitor operating conditions and prevent or respond quickly to alleviate problems, provide improved information to travelers and operators, and support intelligent vehicle operations. For at least two reasons, JPO has made standards for intelligent infrastructure its principal focus for government initiative: first, federal ITS development funds will be used primarily by state and local government agencies to procure ITS infrastructure; second, private-sector developers of in-vehicle systems are likely to be able and willing to develop their own in-vehicle standards without government support.

CONCEPTS UNDERLYING FEDERAL ACTIVITIES

The emergent National ITS Architecture and ITS standards reflect a number of fundamental concepts that have been formally adopted or informally accepted as important to ITS development and deployment in the United States. Arguably the most fundamental of these is the concept that ITS should be developed as *open systems* in which products from many manufacturers can be used interchangeably and new products can be developed with confidence that proprietary designs will not obstruct innovation. Proponents of open systems argue that such systems encourage competition among firms and technologies. Critics claim that the commercial advantages of developing innovative products are substantially reduced when otherwise proprietary ideas must be made generally available, even if licensing fees or other arrangements allow inventors to reap some benefits from their ideas. The Apple personal computer, for example, is based on proprietary standards, arguably a factor that has deterred software developers and limited the market for compatible products. In contrast, IBM's adoption of open standards for the Wintel PC underlies the creation and growth of hundreds of companies producing hardware components, software, and peripheral devices that work more or less interchangeably within the Wintel framework. The prospect of open ITS appeals particularly to state and local agencies that wish to avoid becoming locked in by purchases of proprietary equipment that can be repaired and upgraded only by single suppliers.

Open standards are the mechanism for achieving open systems. Technical standards define explicitly the characteristics and configuration, for example, of ITS components and the interfaces between them, the types of data produced or used by these components, and the ways data are to be communicated among the components.

A fundamental challenge facing the developers of standards is to resolve the tension between two conflicting aims. On the one hand, developers wish to define standards only as required to ensure that their systems perform as desired. Too much or premature standardization, it is feared, may restrict the flexibility and innovation of those who will be responsible for implementing specific applications. On the other hand, developers seek to ensure that diverse populations of intelligent vehicles and intelligent infrastructure will function and interact as necessary to provide safe, effective, and efficient service throughout the nation. Inadequate or untimely standardization risks inefficiencies, losses of service, and hazardous conditions in the nation's transportation system.

The notion that ITS is to be applied throughout the nation gives rise to a second fundamental concept, that of *interoperability*. As noted in Chapter 1, interoperability means that agencies throughout the nation should be able to purchase an ITS component from any of several producers and reasonably expect this component to work with the rest of the agency's system, that mobile users (e.g., automobiles and trucks) should experience the same high level of ITS service as they travel across the nation, and that developers of ITS technology should be assured that the market for their products is truly national in scope. JPO staff reported to the committee that the overarching goal of the ITS Standards Program is to foster the voluntary, widespread use of interoperable ITS by accelerating the development and deployment of ITS standards. While the idea of interoperability is relatively simple, a precise definition of the term has turned out to be more elusive. Interoperability does not necessarily mean that all equipment and procedures must conform to the same standards, although conforming to uniform standards presumably could help ensure that systems meeting the standards will be interoperable. JPO staff declared as recently as June 2000 that "the ITS community is still struggling with being able to define and assess interoperability" (Joint Program Office 2000).

The usage of the term *standards* has remained somewhat imprecise as well. Generally speaking, standards in the present context are documented guidelines or rules specifying the interconnections among elements and the performance required of technologies and products to be used in ITS installations. Standards may define, for example, data elements and message sets used by devices and systems, or certain physical characteristics of a particular device. As defined by the ITS Standards Program, standards also encompass *protocols*, which define how data are to be exchanged among ITS elements, including such matters as addressing, security, and priority of messages. Protocols are collections of rules for moving data elements and messages between devices and systems within the context or framework established by the National ITS Architecture.

NATIONAL ITS ARCHITECTURE

The National ITS Architecture serves as a framework within which standards are developed and used. It describes in detail what types of interfaces should exist between ITS components and how the components will exchange information and work together to deliver certain user services that the architecture's developers agreed should be available from the generic system. The architecture is intended to define the components of a generic ITS, the system's key functions, the organizations involved, and the types of information shared among those components and organizations.

The architecture portrays the future transportation system as sets of interconnected centers, roadside devices, vehicles, and travelers (see Figure 2-1). Data move through this web of interconnected elements; are analyzed and interpreted; and are acted upon to control traffic flows,

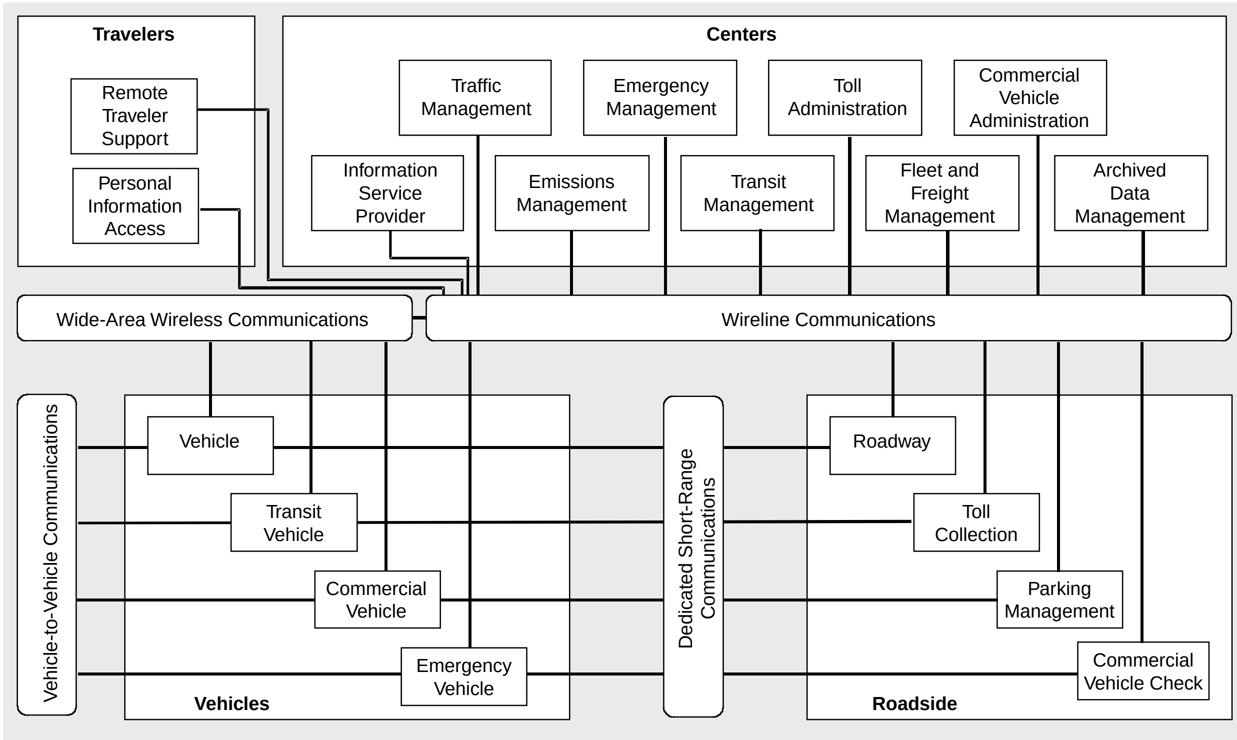

FIGURE 2-1 Schematic view of National ITS Architecture.

collect tolls, route emergency vehicles, report road and track conditions, and the like.

The number of user services included in the National ITS Architecture has increased slowly since the architecture's initial release in 1996 as industry groups and government agencies have identified new uses for the information that might be collected and transmitted within ITS. The architecture itself has been updated several times to include these new services; DOT staff report that major updates have been published at approximately 12- to 15-month intervals, whereas a website making the complete architecture available on the Internet is revised monthly.

The National ITS Architecture is intended to encompass all services that might be included in particular ITS installations in the United States. The architecture's developers assumed that implementation of all of these services (i.e., the entire National ITS Architecture) within any single metropolitan area, state, or other region is highly unlikely. FHWA recently proposed in a Notice of Proposed Rulemaking (NPRM) that the National ITS Architecture be used to develop local implementations, each being referred to as an "ITS regional architecture." Such a regional architecture would be tailored to meet local needs and could accordingly add to or omit services encompassed by the National ITS Architecture. The NPRM proposes that conformance with the National ITS Architecture, a requirement under TEA-21 for federal funding of ITS projects, be defined as "development of an ITS regional architecture based on the National ITS Architecture, and the subsequent adherence of ITS projects to the ITS regional architecture." The ITS regional architecture would include a concept of operations and a conceptual design "sufficient to support subsequent project design regarding . . . system functional requirements; interface requirements and information exchanges . . . and identification of key standards supporting regional and national interoperability, including uniformity and compatibility of equipment, practices and procedures to deliver ITS services. All ITS projects funded with highway trust funds shall conduct the applicable interoperability tests that have been officially adopted by the US DOT" (*Federal Register* 2000).

ITS STANDARDS PROGRAM

On the basis of the 1996 National ITS Architecture's identification of several hundred standards requirements to ensure ITS interoperability, JPO estimated a need to support the development of approximately 100 standards that might otherwise be developed very slowly or not at all. A DOT-supported survey was developed and distributed to industry leaders by ITS America to solicit views on priorities for standards development and willingness to participate in and sponsor standards development activities. JPO, which monitors all ITS standards development, identified approximately 80 standards relating primarily to ITS infrastructure for inclusion in the ITS Standards Program.

As noted earlier, the ITS Standards Program, which initially focused almost exclusively on standards development, now includes a range of activities intended to support dissemination and implementation of the standards (see Box 2-1). The actual work of standards development and the number of standards encompassed by the program have evolved as working groups within the participating SDOs have gained a more precise understanding of the standards likely to satisfy the requirements derived from the National ITS Architecture.

Box 2-1

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Principal Elements of DOT's ITS Standards Program

- Development—support of SDOs in developing selected consensus standards specified in the National ITS Architecture
- Testing—application of selected standards in realistic settings
- Outreach and education—provision of information and materials supporting standards dissemination (e.g., website, direct mailings, training workshops)
- Technical assistance—field office staff, peer-to-peer activities to assist users of the standards developed
- Policy support—guidance and policy for public agencies implementing ITS

From time to time SDOs propose new standards for inclusion in the ITS Standards Program; the availability of funds and approval by the program's manager are necessary for a standard to be added. Appendix B gives the 80 standards encompassed by the program as of February 2000. JPO staff continue to expect that approximately 100 standards will ultimately be developed with federal support, as was envisioned following the National ITS Architecture's initial release.

By the end of March 2000, 26 federally supported standards had been published by the SDOs and made available for public use; the number had grown to 30 by mid-July. Another 14 standards had completed the approval process in March (see the next section) and were awaiting publication, and 23 were in various stages of the approval process; 18 standards were in development. As new services have been added to the National ITS Architecture, additional standards (e.g., for highway–rail intersections and user services for archived data) have been identified for development and may receive JPO support if funding is available. Federal support for standards development is authorized under current legislation through 2003; ITS professionals anticipate that SDO-based standards development will continue for many years.

As noted earlier, the stated goal of the ITS Standards Program is "to foster the voluntary, widespread use of interoperable ITS by accelerating the development and deployment of ITS standards." JPO staff have identified a number of specific objectives—in addition to interoperability—that guide the ITS Standards Program within the context of this broad goal (see Box 2-2); DOT literature continues to emphasize interoperability as the principal aim among these multiple objectives. As federal support for standards development diminishes, efforts to encourage implementation of the federally sponsored standards will increase. JPO has planned a variety of outreach, education, and technical assistance activities to support these efforts.

Because Section 5206 of TEA-21 explicitly requires that ITS projects carried out using federal funds "conform to the national architecture, applicable standards or provisional standards, and protocols," the ITS Standards Program has assumed an importance and potential authority beyond simply encouraging efficient ITS development. To be eligible for federal funding, ITS projects will have to employ any applicable ITS standards adopted through the federal rulemaking process (although some adopted

Box 2-2

Objectives of the ITS Standards Program

- Promote the ability of public-sector agencies to choose ITS products and services from multiple vendors
- Promote the creation of an innovative ITS market
- Facilitate interoperability at all levels
- Ensure the safety of the traveling public
- Facilitate deployment of ITS technologies
- Support testing and evaluation of standards
- Promote the international competitiveness of American industry

standards may not be applicable to a particular project, e.g., if the project does not include interfaces or equipment covered by the standard). The rulemaking process has been initiated for only one standards area under the JPO program—a proposed specification for active tag technology for dedicated short-range communications for commercial vehicle operations.

TEA-21 also requires that DOT identify and report on "critical standards," those standards believed to be particularly important to ensuring the national interoperability of ITS applications or critical to the development of other standards. DOT's report to Congress on the subject (U.S. Department of Transportation 1999) identifies 17 critical standards—12 "national" standards for interoperability and 5 "foundation" standards proposed to support the development of other standards (see Box 2-3). JPO staff note that these standards, although deemed critical, are not more likely than other ITS standards to be made mandatory through the rulemaking process.

Under TEA-21, if any of the critical standards are not completed by January 2001, DOT is authorized to create "provisional" standards for the missing items. Such provisional standards could then be adopted through rulemaking as requirements for judging ITS project eligibility for federal funding.

Box 2-3

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Standards Identified as Critical

"National" Standards

- Advanced Traveler Information System (ATIS) Message Set [SAE J2354]
- Commercial Vehicle Credentials [ANSI TS 286]
- Commercial Vehicle Safety and Credentials Information Exchange [ANSI TS 285]
- Commercial Vehicle Safety Reports [ANSI TS 284]
- High Speed FM Subcarrier Waveform Standard (now two separate standards) [NEMA]
- Standards for ATIS Message Sets Delivered Over Bandwidth Restricted Media [SAE J2369]
- Information Service Provider-Vehicle Location Referencing Standard [SAE J1746] (also a "foundation" standard)
- On-Board Land Vehicle Mayday Reporting Interface [SAE J2313]
- Standard Specification on Dedicated Short-Range Communications (DSRC) Data Link Layer [ASTM DRAFT]
- Standard Specification on DSRC Physical Layer [ASTM PS 111-98]
- Standard Specification on DSRC at 5.89 GHz Physical Layer [ASTM, in development]
- Message Sets for DSRC, Electronic Toll and Traffic Management, and Commercial Vehicle Operations [IEEE P1455]

"Foundation" Standards

- ATIS Data Dictionary [SAE J2353]
- Advanced Traffic Management System (ATMS) Data Dictionary
- Information Service Provider–Vehicle Location Referencing Standard [SAE J1746] (also a "national" standard)

(*continued on next page*)

Box 2-3 (*continued*) Standards Identified as Critical

- Standard for Data Dictionaries for Intelligent Transportation Systems [IEEE P1489]
- Standard for Message Set Template for ITS [IEEE P1488]

Note: See Box 2-4 for a listing of the SDOs abbreviated in brackets above.

STANDARDS DEVELOPMENT STRATEGY AND PROCESS

The basic strategy of standards development under the ITS Standards Program has been to depend on existing SDOs. ITS is a new and evolving field, and JPO staff characterize their application of this strategy as "learning by doing." That learning—within the context of the growth in ITS technology—began with the legislative mandate that DOT play a role in developing standards and in shaping the nation's ITS architecture and has continued as JPO has provided support for the development and implementation of particular standards.

Reliance on SDOs represents an extension of decades-old practices in the development of highway and transit system design and management standards, and federal policies generally emphasize reliance on industry consensus standards. SDOs include trade groups, professional organizations, and associations of companies. They may be either organizations that undertake standards development as one of several elements of their mission [for example, the American Association of State Highway and Transportation Officials (AASHTO)] or groups that form primarily to develop standards and encourage their use (for example, ASTM). More than 300 SDOs operate in the United States in various areas of technology.

DOT staff have been assisted in many aspects of the development, conduct, and administration of the ITS Standards Program by other professionals working under contract through major quasi-governmental organizations, such as JPL, Mitretek Systems, Battelle, and the Applied

Physics Laboratory. These organizations have provided technical and staff support for development of the National ITS Architecture and some ITS standards, have coordinated activities of SDOs participating in standards development, and are responsible for administering field testing and outreach activities as deployment proceeds.

The survey undertaken after completion of the National ITS Architecture became the basis for soliciting interest from SDOs that might wish to participate in ITS standards development. In many cases, the standards requirements fit well with the missions of one or two organizations, and these SDOs had a clear motivation for assuming leadership in the development of those standards. JPO staff reported that there were a few cases in which there was no clearly defined match between standards requirements and organizations' missions; in those cases, JPO found it more difficult to recruit an SDO to take on the leadership role. JPO proposed providing funding to support four types of activities associated with standards development: (*a*) the engaging of consultants to work with the SDOs' volunteer standards-writing committees, (*b*) travel for public agency participants in the committees, (*c*) testing of prototypes built to the specifications of new standards, and (*d*) efforts to develop international standards. Most funding requests have been for activities of the first two types.

At present, nine SDOs are listed in government publications as participants in the program. Five of these SDOs have signed cooperative agreements with DOT (see Box 2-4).

Each SDO has its own established procedures for developing consensus standards and uses these procedures for ITS standards. In general, committees of experts meet to discuss and resolve issues, review technical materials prepared typically by volunteer participants or consultants engaged by the committee, and decide on the appropriate content of the standards for which they are responsible. SDO staff charged with maintaining a committee's activities typically have no direct role in determining who in particular will participate in standards development, but rather seek to maintain the openness of the process to all interested parties. While there is no assurance that individuals with substantial experience or insight will take part in the development of a particular standard, each participating SDO has established and customary procedures for ensuring that an appropriate cross section of stakeholder views is

Box 2-4

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SDOs Listed as Participants in the ITS Standards Program

- American Association of State Highway and Transportation Officials (AASHTO)*
- American National Standards Institute (ANSI), Committee X12, Electronic Data Interchange
- ASTM*
- Electronic Industries Alliance (EIA)
- 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)

* Organizations that had signed cooperative agreements with DOT as of April 2000.

brought to bear. JPO staff asserted that the demonstrated efficacy of these procedures was an important factor in determining that a given organization was qualified to participate in the ITS Standards Program.

Once the SDO's committee members have reached a consensus, formal ballots are circulated within the SDO to gain organization approval. Balloting typically proceeds in two stages: approval of technical content by the appropriate technical committees, then higher-level approval that the organization's rules of openness, consensus, and due process were followed in the standard's development. Once this approval has been obtained, the standard is published and made available to the public at large. The standard, viewed as intellectual property, belongs to the SDO, and the SDO usually derives revenue from its sale. This revenue typically is used to defray the SDO's costs of developing standards and may also be used to support future updating of standards when such updating is found to be warranted by experience with the standards' use in practical applications, changes in technology, changes in regulations, a need to establish harmony among older and newer standards, or other factors.

Use in practice of the standards thus developed remains voluntary unless and until some authority decides to adopt them as requirements, for example, as part of a building code or a construction specification. As noted earlier, to the extent that ITS standards are adopted through the federal rulemaking process, they become determinants of eligibility for federal funding, but their adoption by agencies that do not seek such funding remains voluntary. JPO staff stated that other ITS standards (i.e., in addition to dedicated short-range communications for commercial vehicle operations) will likely be proposed for adoption through federal rulemaking.

The rulemaking process entails a determination by DOT officials first that there is a significant public benefit to be gained by requiring conformance to the adopted standard, and then that the standard is ready to be adopted. This determination is followed by a request for public review and comment (the NPRM being published in the *Federal Register*) and agency response to comments received. The final rule, whose form could differ substantially from that initially proposed, is then published in the *Federal Register*. The complete rulemaking process, including response to public comments and possibly revision of the proposed rule before it becomes final, typically extends over a period of 18 months or more.

Testing, observation of applications, or other verification that standards function as anticipated may or may not be considered a routine part of an SDO's standards development process. Some SDOs may designate standards as provisional until they have been used successfully for some period of time.

JPO has undertaken a standards testing program to measure the operation, correctness, and completeness of standards under realistic transportation operating conditions; assess the extent to which conforming ITS components are interoperable; and provide information about the performance of the standards to the ITS community. This element of the ITS Standards Program, initiated in March 1999, was in its early stages as of mid-2000.

Testing entails working with state and local transportation officials who are undertaking to procure and install ITS systems and are willing to adopt federally sponsored standards in their designs and specifications. Each such installation typically involves the application of several standards. When multiple suppliers respond to the procurement request and multiple installations are made, observation of their performance allows the testers to draw conclusions about whether the standards are effective.

According to current plans, approximately 50 ITS standards are to be tested. The design of the testing program is based on the results of a workshop that brought together key stakeholders, followed by further discussions and an analysis of relationships among the ITS standards within the context of the National ITS Architecture (Battelle 1999). JPO staff reported that a first field test of six standards used in a dynamic messaging sign installation was completed in March 2000. The test demonstrated that the standards could be used but revealed that some additional specification was required to ensure more reliable product interchangeability.

ITS STANDARDS PROGRAM TRANSITION

As standards development has progressed, emphasis in the ITS Standards Program has shifted toward support for dissemination and implementation. Outreach and education activities will be intended to engage the interest of federal, state, and local transportation stakeholders involved in ITS implementation and provide them with useful information and materials that will help familiarize them with ITS standards and their use. JPO has begun to produce program brochures, fact sheets, implementation guides, sample procurement specifications, case study reports, and other materials to support these activities. Already in place is a substantial library of documents available on the Internet. JPO staff report that a series of DOT-prepared training courses will be offered to present groups of standards to practitioners in areas in which ITS deployments are being considered. In addition, regional DOT Resource Center personnel and a peer-to-peer program will make technical assistance resources available on an as-needed basis.

JPO activities are scheduled to continue at least through 2003, when the authorizations associated with TEA-21 will expire. New transportation legislation will presumably extend the life of the ITS Standards Program.

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Issues Influencing the Effectiveness of the ITS Standards Program

In addressing the questions under its charge (see Chapter 1), the committee discussed a number of issues that influenced its conclusions and recommendations. These issues fall under three broad topic areas:

- Issues bearing on the overall assessment of the standards program, including (*a*) general advantages and disadvantages of having ITS standards, (*b*) the role of the National ITS Architecture as a framework for standards, (*c*) standards-setting processes that could be used for ITS, and (*d*) the standing of U.S. ITS standards in overseas markets;
- Issues bearing on how the standards program might proceed in the future, including (*a*) the specific standards included in the JPO program, (*b*) stakeholder participation, (*c*) the life cycle of standards in relation to evolving technology, and (*d*) federal rulemaking as a mechanism for encouraging the use of standards; and
- U.S. participation in global ITS development and standards setting.

ADVANTAGES AND DISADVANTAGES OF ITS STANDARDS

The committee noted that the development and implementation of ITS standards entail fundamental uncertainties and challenges. First, ITS represents a convergence of technology and professional practices from many fields, including transportation facility engineering, automotive technology, telecommunications, information systems, electronics, and others, that are evolving at different rates and have traditionally had limited interaction. In the present era of rapid technological change, there are numerous examples of competition among alternative standards for various technologies—such as wireless telephones, video recorders, and personal computer operating systems, to cite but a few examples—that demonstrate the potentially costly consequences of investing in a system that quickly becomes obsolete and incompatible with prevailing systems.

Second, the potential markets for ITS infrastructure are small compared with other markets pursued by many of the private-sector participants in ITS development, and highly segmented as well. Although there are more than 250 million motor vehicles registered in the United States, such products as traffic control systems, toll collection equipment, and highway information signage are purchased by governmental and quasi-governmental agencies (e.g., toll authorities) whose total number does not exceed 50,000. Committee members estimated that the total market for traffic signals in the United States represents only about $125 million annually. Similarly, purchases of new transit buses each year likely number in the hundreds nationwide, and the specific characteristics of the vehicles may vary from one transit agency to another. The equipment manufacturers and system integrators that serve these markets typically cannot bear on their own the high costs of the research, development, and marketing required to dominate a new technology, or even to participate in standards development to an extent that characterizes other technology markets.

Finally, the overall market structure for ITS is changing as new services and technologies are introduced. For example, applications of global positioning systems in transportation are likely to grow dramatically and will be an increasingly significant part of the ITS infrastructure now that technology formerly restricted to military use has been released to the public. If past experience is a guide, one may expect that new participants will enter the ITS arena, others will drop out, and relationships among participants will shift.

In the face of such uncertainty and change, establishing standards is arguably a way to influence the course of ITS development, to reduce the aggregate costs of all stakeholders, and to limit the risks faced by individual stakeholders. Proponents claim that standards may protect safety and other public interests not adequately reflected in the routine operations of a private-sector marketplace. The committee noted, however, that standards are not obviously necessary; one might argue that adoption of standards limits innovation by raising obstacles to new technology that does not conform to those standards. Manufacturers and their individual customers can develop and implement functioning ITS installations that meet specific needs without reference to more widely used standards. In such cases, it may be argued that the absence of standards supports product differentiation and fosters customer loyalty.

In addition, stakeholders bear costs associated with developing standards, sometimes quite substantial and sometimes distributed disproportionately to the potential benefits of having those standards. As discussed later in this chapter, there are several ways of developing standards, but all entail many hours of professional time, as well as direct costs for travel, publication, and other activities aimed at reaching consensus or otherwise establishing a standard among competing alternatives. Neither manufacturers nor purchasers are necessarily enthusiastic about paying these costs. They willingly do so, however, when they perceive advantages to be gained.

The anticipated advantages of standards in the ITS arena include creation of larger markets by reducing the variations among systems purchased by various agencies and by lowering the costs to both manufacturers and system owners of upgrading older legacy systems with newer technology (e.g., by facilitating what is sometimes termed “backward compatibility” of new components and procedures). Committee members commented, for example, that equipment manufacturing companies with only $20 million in annual sales could face the need to make million-dollar investments in new operating software. In addition, some ITS standards could have a definite impact on matters of public safety in the nation’s transportation system. For these reasons, the committee found arguments in favor of ITS standards and some degree of government participation in their development to be persuasive. Yet the extent of ITS standardization and government involvement in such efforts ought to depend on market-related factors, the committee agreed, and these factors featured prominently in the committee's deliberations.

ROLE OF THE NATIONAL ITS ARCHITECTURE

The National ITS Architecture plays a substantial role in defining the future ITS market. DOT defines the architecture as the "consistent framework" within which standards are developed. The architecture was not initially considered to be an issue within the scope of this study. For several reasons, however, the committee found it could not discuss the ITS standards program effectively without explicitly considering the architecture.

First, TEA-21 requires that ITS projects carried out using federal funds conform to the architecture. While there presumably is flexibility in how such conformance is determined, the committee was concerned about DOT's Notice of Proposed Rulemaking on the National ITS Architecture, in particular about how precisely that architecture or a regional architecture derived from it might be used to determine whether particular ITS projects are eligible for funding. Second, the committee agreed that the framework established by the architecture shapes in a fundamental way how developers think about ITS components and their interactions. The architecture is intended to be independent of technology, but if technology were to change fundamentally to enable new services or radically different interactions, segments of the architecture could become faulty or obsolete. The standards developed within that framework would then be unlikely to function effectively to achieve the overall goals of ITS. Finally, the architecture is widely acknowledged to be a living document that requires updating. The committee found it could not discuss changes in the scope and content of the ITS Standards Program without considering how those changes might relate to the architecture itself.

The committee agreed that DOT's efforts to update the architecture are necessary and helpful. New services have been added, and the architecture's overall description is revised and republished regularly. However, the committee was concerned that the architecture may be approaching obsolescence at a more fundamental level. One reason for this concern is that the Internet, now a pervasive communications medium, was not yet a significant market factor in 1992 when the architecture was developed, nor were emerging Web-based data-system integration applications. Another reason is the almost complete absence of references to advances in broadband wireless communications in presentations and publications reviewed by the committee that describe plans for the ITS Standards Program. Finally, the committee observed that certain user services and data exchanges have apparently been abandoned in that no efforts are being made to implement them, but they have not been removed from the architecture.

Committee members expressed their belief that ITS now being designed could be kept in service for perhaps 15 years, but new products anticipated within the next 5 years may supersede present systems on a commercial basis. Government agencies will be the primary buyers of most ITS infrastructure elements, and many government agency budgeting and procurement processes constrain the ability to replace otherwise functional systems made obsolete by rapid technological change. Even under the best of circumstances, then, ITS users in a given region may experience a decade of service levels below what can be delivered by systems meeting up-to-date standards. Regular review and updating of the architecture, the committee agreed, is likely to be a prudent undertaking.

STANDARDS-SETTING PROCESSES

Any significant engineered system is likely to depend on several different types of standards. For example, physical or equipment standards describe the hardware used in an ITS installation. Functional or configuration standards describe what each piece of equipment and its controlling software is supposed to do and how the pieces interact. Performance standards, possibly a special instance of functional standards, specify what the assemblage of hardware and software is to do overall in terms of reliability, response time, and the like. Policy or protocol standards determine how analyses are to be performed, what overall rules are to be used in making decisions, or what concerns for public safety or human behavior are to be given priority in setting other standards.

These various types of standards are in turn of particular interest to certain groups of system developers and users. Physical or equipment standards, for example, are the concern particularly of manufacturers and installers. Designers and engineers are likely to deal most closely with matters covered by functional or configuration standards. System purchasers and users are vitally concerned with performance standards. And policy or protocol standards frequently span matters of concern to purchasers, designers, and manufacturers.

In general, standards development requires the balancing of sometimes divergent interests of multiple stakeholders. The committee considered a number of different approaches that have been taken to setting standards in practice and agreed that no single approach is likely to be well suited to the development of all types of standards. Table 3-1 summarizes characteristics and examples of alternative standards development processes that have been used in practice. The processes are given in the table roughly in order of increasing levels of formal organization, permanence, and government involvement or sanction. As shown, all of the models have been applied to produce standards relevant to the ITS experience.

The SDO approach used in the ITS Standards Program involves government-sanctioned professional groups and thus would appear nearer the bottom of Table 3-1 rather than the top. Committee members observed that the SDO-based model is inherently slow and cumbersome as compared with other approaches to standards development and is thus less likely than some other approaches to perform well in the face of rapidly evolving technology. The committee therefore questioned whether those other approaches might be more appropriate for development of some or all of the standards encompassed by the ITS Standards Program, particularly those for which development work has not yet been initiated. As previously noted, JPO officials anticipate that approximately another 20 standards may be proposed for development with federal support.

The committee observed that JPO's decision to focus primarily on standards for intelligent infrastructure clearly establishes an appropriate affinity for the SDO approach, which represents an extension of traditional practices in highway design and construction. Committee members noted, however, that some as yet undeveloped standards might be

TABLE 3-1 Models of Standards Development Processes

Institutional Structure/ Control Stance	Characteristics	Standards Examples
Unstructured multideveloper network	Development is cooperative Consensus emerges over time in market context (e.g., among producers and users)	Linux/Apache software Commodity building components (e.g., nails, dimensional lumber) Simple peer-to-peer computer networks
Laissez-faire competition for dominance	Innovation is free, subject to market forces First-to-market, capitalization influence is dominant Users may experience incompatibilities and rapid obsolescence	VHS versus Beta videotape formats Microsoft DOS/Windows for PC Web browsers: Netscape versus Microsoft versus others QWERTY typewriter keyboard
Multicompany consortium (*keiretsu*)	Reduces market risk for members Raises barriers to entry; may restrict innovation Limits access; may involve monopolistic practices	Code division versus time division multiple access cellular telecommunications systems Symbian (Nokia, Ericsson, Psion) wireless information devices
Trade or industry group forum	Reduces market risk for participants Can enable broad producer participation May exclude user interests May involve monopolistic practices	Portland Cement Association, Asphalt Institute structural design standards Infrared Data Association communication standards Bluetooth initiative for radio-frequency networking
Professional or user group forum	May lack obvious financing sources and incentives to participate May enhance attention to factors of less interest to producers (e.g., public safety, operating costs)	National model building codes AASHTO highway design standards "PC" car light-rail transit vehicle W3 Consortium for Internet protocol

(*continued on next page*)

TABLE 3-1 (*continued*) Models of Standards Development Processes

Institutional Structure/ Control Stance	Characteristics	Standards Examples
Government-sanctioned development organization	Enhances compliance with standards once adopted Often must accommodate many interests	Global System for Mobile Communications cellular telecommunications system ISO standards [e.g., Simple Graphic Markup Language (SGML) data formatting (ISO 8879)]
Government fiat, enforceable regulatory standards	If effective, ensures compliance with standards	*Manual on Uniform Traffic Control Devices* Department of Defense standards for agency procurements Environmental Protection Agency automotive air pollution emission standards

formulated most effectively using other approaches, such as industry consortia, similar to examples found higher up in Table 3-1. The committee agreed that some further examination of alternative standards development processes might be especially useful in dealing with portions of the National ITS Architecture in which enabling technologies are rapidly evolving. Alternative approaches to the development of ITS infrastructure standards might in some cases prove to be faster, less demanding of public-sector financial support, or otherwise superior to the traditional SDO-based model.

STANDING OF U.S. STANDARDS IN OVERSEAS MARKETS

The committee agreed that SDOs have an important function in the development of standards to be used in international markets. Even standards initially developed by industry consortia or informal professional associations may be formalized through adoption by international organizations such as the International Organization for Standardization

(ISO). DOT and representatives of U.S. SDOs participate in ISO to present U.S. perspectives and seek adoption of standards consistent with U.S. interests.

Existing international agreements define, within this context, what procedures are appropriate and proper for standards development. Within the United States, the American National Standards Institute (ANSI) administers and coordinates private-sector voluntary standardization and accredits standards developers that follow acceptable procedures. All of the SDOs presently participating in JPO's ITS Standards Program, with the exception of the Institute of Transportation Engineers (ITE) and AASHTO, are accredited by ANSI. ITE reports that its procedures are fully in conformance with ANSI requirements and that the organization intends to secure accreditation. AASHTO permits voting only by its members—state transportation agencies—and thereby fails to conform to ANSI requirements. AASHTO notes that its committees consult regularly with commercial firms and that its involvement is primarily with data dictionaries and protocols that have little direct relationship to manufacturing interests; the issue of ANSI certification may therefore be less important. However, the committee discussed at some length the importance of ANSI certification for ITS standards development.

Committee members remarked that Canadian agencies have chosen to become involved extensively in ISO as a means of influencing ITS standards, whereas U.S. agencies and manufacturers have found it more difficult to justify the travel costs of substantial ISO participation, in part because they focus primarily on the U.S. domestic market. In addition, ISO procedures apply a "one country, one vote" policy for standards adoption, apparently putting the United States at a disadvantage relative to the increasingly united European nations. Committee members familiar with ISO activities asserted, however, that relationships among multinational firms operating in international markets are frequently more influential than governmental alliances in determining the outcome of standards-adoption discussions.

Committee members suggested that issues of U.S. influence on international ITS standards are largely inseparable from U.S. trade and industrial policy as a whole. While concern for international markets is recognized in the JPO program, it appeared to the committee not to have been a substantial factor shaping the strategy for ITS standards development. Committee members observed that European ITS providers are entering the U.S. market and may be expected to become an increasingly significant source of competition. If U.S. providers are to survive and prosper as a force in the global market, greater effort may be necessary to give the U.S. ITS Standards Program a more influential voice in international standards development forums.

On these grounds, the committee agreed that reliance on ANSI-accredited SDOs for development of all ITS standards included in the JPO program may be justified. Committee members were told by ANSI staff that if a standard is to be submitted to the institute for adoption as an American National Standard, at least one of the SDOs that developed the standard must be ANSI accredited. Standards for which AASHTO is primarily responsible may thus be submitted for ANSI adoption if AASHTO works jointly with an accredited organization.

STANDARDS INCLUDED IN THE PROGRAM

In its discussions of standards development processes, the committee noted that standards for tag readers for automated toll collection (an application of dedicated short-range communications), for example, are being developed by a consortium of manufacturers. On the other hand, the physical characteristics of the advanced transportation controller (ATC) cabinet, the container for electronic components, was assigned to an SDO as part of the ITS Standards Program. While recognizing that the ATC cabinet standard is a convenient basis for developing specifications and popular with agencies undertaking ITS projects, the committee was aware of no compelling arguments why this standard could not have been developed just as well without the government's involvement.

Committee members noted that some of the items now included in the JPO program (see Appendix B) are reports or reference documents rather than standards in the conventional sense of the term. They noted also that the ATC cabinet is not unique among items included in or proposed for the JPO program that might just as well be developed without SDO involvement and government sponsorship. Finally, the committee observed that the relationship to the interoperability of components in the National ITS Architecture is not equally apparent for all items within the JPO program that do easily qualify as standards.

The committee did not find among the presentations and documents explaining the JPO program a clearly stated algorithm or usable criteria for determining in the future what elements of the evolving National ITS Architecture require standards (rather than, for example, guidelines or exemplary illustrations) to ensure crucial aspects of national interoperability or address other federal interests, thus warranting development with federal support. The committee also found no clear rationale for determining whether program objectives other than interoperability necessitate the development of standards. Finally, it was not apparent to the committee from the program materials or staff presentations how funds are to be allocated in the future to standards development and other JPO activities.

Such explanations, the committee agreed, would make the ITS Standards Program more intelligible to the community of practitioners and the broader public and are important for determining whether standards proposed for development should be incorporated into the program. The committee was not able to agree, for example, on whether there is adequate justification for undertaking the development of national standards for archival data services, particularly with regard to the potential contribution of such standards to ITS interoperability. Some members expressed concern that the standards might be imposed through federal rulemaking, while others suggested that significant advantages may be gained through the adoption of common formats for ITS data collection and storage. Similarly, the committee noted that ITS infrastructure, understandably the primary focus of JPO's attention, cannot be entirely separated from in-vehicle systems. Some standards for the latter are in fact included in the Standards Program, but the committee did not find a clear explanation of how interoperability is to be ensured across the spectrum of standards for intelligent vehicles and intelligent infrastructure. The committee agreed that the many stakeholders in ITS standards development would gain from readily accessible and explicit explanations of the anticipated relationships of specific standards and groups of standards to JPO's several program objectives, as well as to the larger goals of rapid and effective deployment of ITS technology.

STAKEHOLDER PARTICIPATION

The committee observed that the range of stakeholders in ITS standards development is rather broad and considered whether the JPO program is effectively drawing on all important perspectives. The segmented nature of the domestic ITS market, as already noted, necessarily limits the ability of private-sector manufacturers and system integrators to participate in SDO-based standards development activities.

The committee noted that ITS America appropriately and necessarily occupies a prominent place in the standards development process. The organization's broad membership of private companies, academic institutions, professional and trade associations, and government agencies suggests that it should be an ideal forum within which all stakeholders can make themselves heard. ISTEA and TEA-21 established that an institution distinct from the federal government should receive support for the sorts of activities undertaken by ITS America; as the organization designated to receive that support, ITS America receives a significant fraction of its operating budget from federal funds, and these funds are used effectively to support the activities of technical committees, a well-attended annual meeting and exposition, and other activities that facilitate the exchange of ideas and expertise among the many stakeholders in ITS development.

However, the funds are administered by FHWA, giving that agency the appearance of particular influence on the ITS America programs. Independent observers might be skeptical, the committee noted, of the willingness of ITS America staff and members to question too aggressively JPO's plans and activities. The committee observed also that the nature of the organization's activities requires that staff members devote considerable time to organizing meetings and other events, possibly limiting its attractiveness as a career opportunity for senior professionals.

The committee agreed that an organization independent of DOT is valuable as an advisor and reviewer of the JPO program and other DOT-sponsored ITS activities. To be effective, that organization should have technically qualified staff or consultants with the expertise and ability to draw on a wide range of industry and government participants, and the independence needed to make candid assessments and recommendations to JPO. The committee noted that such an organization could be effective, for example, in ensuring that the National ITS

Architecture and ITS standards are kept up to date as the underlying technology advances.

Committee members remarked that the SDO process has worked well but is generally susceptible to problems of ensuring high-quality professional participation in standards development. The SDOs depend on voluntary participation in their various committees and for the most part lack means to recruit or select participants. Reflecting on the scope of technologies and professional practice involved in ITS, the committee agreed that JPO's planned activities aimed at education and training to enhance the knowledge of practitioners should help increase the likelihood that ITS deployment will yield the anticipated benefits.

LIFE CYCLE OF STANDARDS

The committee observed that the initial development of a standard is only the first stage in its influence over a period of years. After development, the standard must be disseminated into practice and then periodically updated as experience is gained and technology evolves. Eventually, some standards will be superseded by changes in technology or practice and fall into disuse. The value of standards should be considered within the context of this entire life cycle.

The committee estimated that advances in ITS technology are moving at a pace of 6 to 18 months between significant events (i.e., the "product cycle"), while the inherently slow, committee-intensive SDO-based standards development process is moving in intervals of 2 to 4 years. For standards submitted to the federal rulemaking process, an additional 12 to 18 months elapses between initial consensus and final adoption. The ITS Standards Program faces the risk that standards will be old once they are developed and thus could slow the pace of innovation, at some cost to U.S. industry and road users. Committee members described cases in which government agencies had lagged behind industry in adopting standards that provided greater levels of safety or other performance improvements, so that users who adopted the newer, higher standards were technically in violation of federal regulations.

The committee agreed that ITS standards themselves and any government regulations based on those standards definitely will require periodic review and updating. Their perception of the scale of the domestic ITS infrastructure market led some committee members to question whether SDOs that have become involved in developing ITS standards on the basis of their past experience in selling such standards to designers and manufacturers may derive unexpectedly low revenues from the standards developed. Faced with the costs of updating these standards, SDOs may find that ITS infrastructure standards, viewed as intellectual property, are liabilities rather than assets for the organizations that own them. Thus longer-term federal financial support to SDOs may be required to ensure adequate maintenance of the ITS standards they develop.

The committee also discussed the role of field testing as a means of determining whether newly developed standards are likely to be effective and suitable for application. JPO's testing program is in its early stages, so the committee had only a limited basis for assessing its likely effectiveness. The testing program is extensive and does appear to encompass essentially all of the items included in the JPO program that will in fact function as standards, but it is focused on how hardware and software function rather than on standards' longer-term impact within systems that include transportation users. Even so, JPO staff reported that initial tests of standards for variable message signs had not been entirely successful in that components from different manufacturers were not in fact interoperable. The committee expressed its concern that the Standards Program appears to lack well-articulated plans for verification and updating of standards following their adoption by the responsible SDOs.

Committee members remarked that telecommunications standards in several European countries, for example, are considered provisional until they have been used successfully in practice for several years. They noted also that ANSI procedures address needs for verification and updating. It may be appropriate to consider ITS standards developed with federal sponsorship in a similar manner, with periodic review and updating being included within the scope of initial agreements for standards development. Testing and demonstration would then become particularly high priorities among JPO's future activities.

FEDERAL RULEMAKING AS A MECHANISM TO ENCOURAGE USE OF STANDARDS

The committee discussed at some length the merits of adopting ITS standards as the basis for judging an ITS project's conformance to the

National ITS Architecture and eligibility of the project for federal funding. The committee recognized that TEA-21 specifies conformance with the National ITS Architecture as a condition for federal funding. The rulemaking action initiated during the period of the committee's deliberations to adopt the National ITS Architecture as a flexible framework for state agencies developing regional architectures may therefore be a necessary minimum action to indicate that the law is being implemented. The committee remarked, however, on what appeared to be a fundamental mismatch between the imposition of fixed standards and the concept that those standards should be developed and applied through consensus among the various stakeholders in ITS development.

The committee noted that there are other reasons beyond complying with TEA-21 requirements that potentially justify use of the rulemaking process to enforce ITS standards. DOT has distinct regulatory functions, for example with regard to the motor carrier industry, that may be affected by ITS standards. DOT staff reported that JPO is developing criteria for determining the readiness of particular standards for rulemaking but were unprepared to estimate how many of the standards in the program might ultimately be reviewed under these criteria. On the whole, the committee agreed that the risk of a standard becoming obsolete before it reaches the end of the rulemaking process is significant and could either discourage the use of federal funds for development of individual ITS projects (thereby slowing the progress of ITS) or reduce the effectiveness of ITS by encouraging the undertaking of projects embodying capabilities and practices that are less than the best available.

U.S. PARTICIPATION IN GLOBAL ITS DEVELOPMENT AND STANDARDS SETTING

Underlying much of the committee's discussion was the knowledge that, as noted earlier, the ITS marketplace is global in scope and the government's role in ITS standards development is inextricably related to U.S. trade policy. Committee members noted the substantially more widespread use of cellular telephones (measured as a percentage of the population using cellular devices) in Europe than in the United States. This greater usage may be attributable to the early adoption of a common standard (the Global System for Mobile Communications, or GSM) among the European nations; in contrast, as many as six different systems are offered by various service providers in the United States. The committee agreed that the proliferation of differing standards has slowed the progress of certain cellular services in this country.

The committee observed that European manufacturers, and possibly Asian manufacturers as well, are entering the U.S. ITS market and could establish standards by virtue of commercial dominance. The committee expressed concern that U.S. manufacturers and designers are unable or unwilling to devote adequate resources to influencing international standards development through organizations such as ISO. More active participation, the committee agreed, is essential to expanding the market for U.S. ITS technology. More active participation would also improve the compatibility of U.S. equipment and software interfacing with ITS components offered by foreign suppliers that compete successfully in the U.S. market. The committee agreed further that JPO is an appropriate organization to encourage and coordinate that participation.

The committee noted that participation in other venues, in addition to ISO, may be warranted. The North American Free Trade Agreement has given rise to activities that could present opportunities for setting ITS standards throughout the Americas. Such organizations as the Asia-Pacific Economic Council could present similar opportunities in the Pacific Rim countries. The committee agreed that such opportunities warrant attention from DOT and other government officials responsible for providing resources to support U.S. commercial interests abroad.

4

Findings and Recommendations

Throughout its discussions, the committee was mindful that the development and application of ITS technology represent an exciting advance in transportation, offering the prospect that the nation's substantial infrastructure investments can be used more efficiently and equitably to yield new benefits for the system's users and the nation as a whole. DOT's ITS Standards Program will undoubtedly have an important impact on the progress of this advance.

The committee was also mindful that the program is undergoing transition, responding to experience gained with ITS development during the past several years. Within the program itself, standards developed by participating SDOs are entering the stages of field testing and dissemination. At the same time, the technologies underlying ITS are evolving rapidly, and ideas that will shape the federal legislative successor to TEA-21 are being discussed in various forums. The committee recognized the opportunities offered during this time of transition to make useful contributions to the future of the ITS Standards Program. At the same time, the committee was aware of the complexities, posed by substantial uncertainties and many competing interests, faced by DOT staff and others concerned with the program's direction and management.

On the basis of its understanding of these various opportunities and complexities, as reflected in its framing of the issues discussed in Chapter 3, the committee formulated an overall assessment of the ITS Standards Program and recommendations for the program's future direction. These findings and recommendations are presented in this chapter. First is the committee's general assessment of the ITS Standards Program and how the program might be modified to enhance its efficacy. Second, the future of ITS standards and the government's role in ensuring that those standards continue to make positive contributions to ITS development and deployment are considered. Third, recommendations that address the particularly thorny issue of the use of the federal rulemaking process to enforce the application of particular ITS standards are given. Finally, the future role of the program with respect to international ITS standards is briefly addressed.

GENERAL ASSESSMENT OF THE ITS STANDARDS PROGRAM

While some professionals may question whether any government involvement in ITS standards development is needed, the committee agrees with the underlying philosophy that there is an essential and productive federal role in the process, based on concerns for public safety and the efficacy of public investments in new technology. In addition, the small market represented by ITS infrastructure applications in any one state (or even nationwide) as compared with the scale of other markets for the technologies embodied in ITS supports a persuasive argument that common nationwide standards are unlikely to emerge as quickly through private-sector action alone as with government encouragement. More specifically, the committee agrees generally with JPO's basic objective that ITS standards should encourage the development of a strong and open national market for ITS technology.

The committee recognizes that setting standards for a complex sociotechnical system that includes many producers, many governmental and private-sector users, and a range of rapidly evolving technologies inherently entails many challenges. In the face of these challenges, the committee concludes that JPO has taken a generally sensible and orderly approach to the development and deployment of selected ITS standards as a means of aiding the realization of interoperability under the National ITS Architecture. JPO has relied substantially on established SDOs to mobilize and organize stakeholder participation in standards setting, a widely used and proven strategy that is well accepted in both U.S. and international practice.

The strategy is not without limitations, however. With its many committees, formal balloting, and limited ability to attract or select individual participants, the SDO process is inherently slow moving, labor-intensive, and potentially conservative in the face of emerging new technology. In addition, JPO has relied on the SDOs to motivate standards setting within the context of the published National ITS Architecture, which, despite DOT's effort to provide periodic updates of its components, is itself susceptible to technological obsolescence. It was not clear to the committee whether alternative models—for example, the use of industry consortia—were explicitly considered when the JPO strategy was formulated. The committee nevertheless recognizes the advantages of working with existing and recognized organizations to implement a new program and applauds JPO's efforts to broaden the technical scope and qualifications of participants in the standards development process.

Also unclear to the committee are the specific criteria and assessment process through which standards proposed for development with federal support are determined to be appropriate for inclusion in the JPO program. The objectives of the program are well stated and reasonable, but the committee views as debatable the likely contributions of the various standards to national interoperability. The committee concludes that insufficient distinction has been drawn between standards for which national uniformity is truly warranted and those for which variations from one region to another may be acceptable, and is not convinced that analyses of national interests have clearly justified the inclusion of some standards in the JPO program.

Recommendation 1: JPO should describe more explicitly and in greater detail the relationship between the National ITS Architecture and the standards that have been included in the ITS Standards Program. JPO should state more clearly its criteria for deter-

mining in the future which proposed standards warrant federal support for their development and deployment. While the potential for contributing to functional interoperability is certainly a key criterion, contributions to safety, security, technological leadership, international trade, and other valid federal concerns are also justifiable bases for providing federal support.

As JPO undertakes to shift the program emphasis from defining standards to implementing those standards through outreach, education, and rulemaking, it remains to be seen whether the published standards will be incorporated effectively into functional ITS applications. The committee notes that there are standards being published and even considered for formalization through federal rulemaking that have not been demonstrated in practice. Demonstration or field testing is essential for many ITS standards, as JPO has recognized, and the committee appreciates the scope of the standards testing program that has recently been initiated. However, the committee believes on balance that some standards being developed under the JPO program may be promulgated before they have been adequately demonstrated in practice. The committee is concerned that JPO might in some cases consider standards development completed after balloting by the responsible SDO and therefore ready for rulemaking without first having undergone testing and, if necessary, revision. In addition, the committee is concerned that differences among the policies and procedures of the several participating SDOs, particularly AASHTO's limitations on private-sector participation, could be the basis for some stakeholders to question the standards' value. It might be argued, for example, that government agencies are less likely to recognize either the full private and public costs of implementing particular standards or the opportunities for technological innovation presented by emerging new technologies.

Recommendation 2: Each ITS standard in the JPO program should undergo an open development and adoption process in which all stakeholders may fully participate, regardless of which SDO provides leadership for the standard's development. This process should include appropriate validation or demonstration prior to final adoption of a proposed standard. To ensure an open process

and adequate validation, as well as to ensure that U.S. standards are given full standing in international markets, standards developed with JPO support should meet criteria for approval by ANSI as American National Standards, including the criterion that at least one of the organizations responsible for a standard's development be ANSI accredited.

FUTURE DEVELOPMENT AND LONG-TERM SUPPORT OF STANDARDS

Despite the shift of emphasis in the JPO program toward encouraging the implementation of developed standards, it is clear that needs for new standards will be recognized as ITS development and applications progress. The committee believes it is appropriate for JPO's support for ITS standards development activities to continue. It is then important for the future of the program to resolve issues noted above concerning the criteria and procedures for determining which standards warrant federal support for their development and to state clearly the national interests that warrant this support.

Recommendation 3: In the future, JPO should devote federal funds to developing only those standards for which there is a clearly stated national need for government support. The statement of need should identify explicitly the standard's role in the realization of the National ITS Architecture.

Development is only the first stage of the life of a standard, however. ITS brings together technologies and professionals from telecommunications, information systems, and transportation system management, diverse disciplinary fields that have not traditionally worked closely together but that must do so in almost all aspects of ITS development and deployment. Much ITS technology is evolving rapidly; this evolution raises the prospect that obsolescence could compromise the effectiveness of fixed standards and of the National ITS Architecture itself. The committee concludes that the JPO program has given too little attention to the task of long-term updating and support of the architecture and standards developed under the program's auspices to ensure that they do not become obsolete or hinder innovation.

The committee observes that the National ITS Architecture was developed before the rapid and continuing expansion of Internet applications, digital wireless technologies, and broadband communications. DOT's efforts to update the architecture, while laudable, appear to the committee to be inadequate to address the potentially fundamental differences between the assumptions made by the architecture's developers and the assumptions they might make if they were starting their work today. The committee notes also that some portions of the architecture are not being actively used and may be unnecessary to achieve the goal of national ITS interoperability.

Recommendation 4: JPO should undertake to have the National ITS Architecture reviewed by an independent organization to ensure that technological advances have not rendered underlying assumptions or resulting portions of the architecture obsolete. If portions of the architecture are no longer useful for achieving national interoperability, they should be appropriately modified or deleted.

As with standards, the architecture's life extends beyond its development. The committee notes that current updating activities appear to be effective in adding new services and revising relationships among existing components of the architecture. The committee is nevertheless concerned that fundamental changes in enabling technologies could render the architecture technically obsolete.

Recommendation 5: JPO should devise and implement a mechanism to ensure that the National ITS Architecture as a whole is reviewed and updated periodically. This process should entail significant private-sector participation.

The architecture is fundamental to interoperability, but the standards are the ongoing means of realizing interoperability. The committee believes that JPO's program plans have given too little attention to ensuring that standards developed under the program's auspices will be kept up to date. The same peculiarities of the ITS marketplace that justify federal government involvement in developing standards—such as limited market scale and public safety concerns—make it unlikely that SDOs will view the necessary updating of those standards as a commercially attractive proposition without continuing government support. Funds the SDOs might receive from the sale of ITS infrastructure standards will not defray much of the cost of maintenance and updating. Particularly in those cases in which public-sector employees are expected to travel to attend standards review meetings, funding for maintenance may be difficult to find without direct federal support. Therefore, JPO's implicit assumption that the SDOs will maintain the standards they develop may be faulty.

Recommendation 6: JPO should develop explicit plans to ensure long-term support and updating of the ITS standards within its program. Long-term support might encompass training and other activities designed to enhance technical proficiency among users of the standards, as well as periodic review and revision to ensure the effectiveness of standards that are implemented.

The committee notes that JPO's training and outreach activities aimed at standards implementation may be expanded to address updating. However, JPO's activities in these areas were only beginning at the time of the committee's deliberations, and thus the committee could not evaluate their efficacy. Even so, the committee is concerned that effort will be needed to ensure appropriate private-sector participation.

Recommendation 7: JPO should continue to seek to attract broader private-sector involvement, particularly from such fields as broadband wireless telecommunications and data management. To this end, a technically qualified and independent advisory group should be designated and assigned responsibility for ensuring that the standards are reviewed and updated periodically as appropriate.

RULEMAKING TO ENCOURAGE USE OF STANDARDS

The committee agrees with the principle that ITS standards should be voluntary and is therefore troubled by the prospect of such standards being enforced through the federal rulemaking process as a basis for judging the eligibility of ITS projects for federal funding. The committee acknowledges that use of the federal rulemaking process may be necessary and appropriate in certain circumstances (e.g., functions related to regulation of the motor carrier industry) but believes such rulemaking could easily subvert the underlying objective of having common standards applied throughout the United States. Agencies with adequate funds may simply choose not to use federal standards or funds for their ITS projects. Others may be forced to acquire technology that could quickly become obsolete if the standards are not kept current. The committee notes that JPO is formulating criteria and procedures for judging the readiness of standards for rulemaking and emphasizes that readiness should include adequate demonstration and experience with use. On the whole, the committee concludes that the risks of using the rulemaking process to impose individual standards currently included in the JPO program outweigh the potential benefits of adopting those standards as criteria for federal funding eligibility.

Recommendation 8: JPO and DOT as a whole should use rulemaking sparingly and only when there is a demonstrable need to enforce particular standards to achieve national objectives of ITS interoperability. JPO's assessment of the readiness of any standard for rulemaking should include completion of adequate validation and/or demonstration to ensure that the standard performs as desired. The committee recommends further that rulemaking be undertaken only for standards for which there are clearly established procedures for periodic review and updating to prevent these rules from hindering continued technological innovation.

U.S. ITS STANDARDS IN A GLOBAL CONTEXT

DOT's ITS Standards Program appropriately focuses primarily on domestic applications of ITS technology. The committee notes, however, that ITS development and application are a global phenomenon, and the ITS market is global as well. Committee members' experience gives strong evidence that ITS equipment and standards developed overseas, particularly in Western Europe, can compete effectively in the U.S. market, and foreign producers of software and hardware are likely to undertake such competition. U.S. producers will face difficult competition in foreign markets, but their success in those markets can yield efficiencies of scale for domestic ITS users.

The committee notes that JPO provides some support for participation in ISO by U.S. professionals and applauds that effort. Yet even greater effort is warranted. Aggressive U.S. participation in international ITS standards-setting organizations is not only appropriate, but absolutely essential to advancing U.S. commercial interests. While other government agencies may share some responsibility for representing U.S. commercial interests overseas, JPO is an appropriate nexus for the particular interests of the ITS marketplace.

Recommendation 9: JPO should continue to participate and support U.S. involvement in appropriate ISO technical committee activities. In addition, greater attention should be given to other opportunities for influencing international standards, for example, through organizations operating under the auspices of the North American Free Trade Agreement or the Asia-Pacific Economic Council.

Appendix A
Speakers and Presenters

March 28–29, 2000

Overview of the U.S. Department of Transportation's ITS Standards Program

Michael Schagrin, U.S. DOT, Joint Program Office, accompanied by Gary Carver, Al Stern, and Anne Tsang of the Jet Propulsion Laboratory (JPL)

Issues of Standards-Setting Processes

Richard Weiland, Weiland Consulting Company (representing ITS America in his role as Chair of the Council of Standards Organizations) (invited guest)

Lee Armstrong, Armstrong Consulting, Inc. (invited guest)

May 17–18, 2000

Perspectives of Equipment Manufacturers

Craig Gardner, Gardner Systems (speaker)

Dawn Hardesty, ITS America, and Richard Weiland, Weiland Consulting Company (invited guests)

U.S. DOT Responses to Committee Questions
Michael Schagrin, U.S. DOT, accompanied by Gary Carver and Al Stern, JPL

July 10–11, 2000

Role of the American Association of State Highway and Transportation Officials (AASHTO) as a Standards Development Organization (SDO)
David Hensing, AASHTO

Testing Program for ITS Standards
Jerry Pittenger, Battelle Memorial Institute

U.S. DOT Responses to Committee Questions
Michael Schagrin and William Jones, U.S. DOT, accompanied by Gary Carver and Al Stern, JPL

Appendix B
ITS Standards Documents

Title	Lead SDO and Document Number	Description
A Conceptual ITS Architecture: An ATIS Perspective	SAE J1763	A description of a general reference architecture for integration of multiple advanced traveler information system (ATIS) devices. This conceptual architecture provides a general view of ITS functions and interfaces; however, the National ITS Architecture reflects a more current conceptual model in this area.
ATC Application Program Interface (API)	ITE 9603-1	Advanced transportation controller (ATC) software application program interfaces (APIs) that support ITS data flows and standards enabling the deployment of ITS functions. The APIs provide a template for API programming for specific functionality associated with equipment and market packages defined by the National ITS Architecture.

Title	Lead SDO and Document Number	Description
ATC Cabinet	ITE 9603-2	Functional physical design requirements for an ATC cabinet that supports the deployment of multiple ITS functions in a single unit.
Adaptive Cruise Control: Operating Characteristics and User Interface	SAE J2399	Minimum requirements for safety-related elements of the operating characteristics and user interface of vehicles equipped with adaptive cruise control (ACC). Also coordinates the operating characteristics and user interface with collision warning and avoidance, along with other driver systems.
Advanced Transportation Controller (ATC)	ITE 9603-3	Standard for ATC devices to support ITS data flows and standards that enable deployment of ITS. Capable of operating in the ATC cabinet and using the ATC APIs.
Advanced Traveler Information System (ATIS) Data Dictionary	SAE J2353	A minimum set of medium-independent data elements needed by potential information service providers to deploy ATIS services and provide the basis for future interoperability of ATIS devices.
Advanced Traveler Information System (ATIS) Message Set	SAE J2354	A basic message set using the data elements from the ATIS Data Dictionary needed by potential information service providers to deploy ATIS services and to provide the basis for future interoperability of ATIS devices.
Commercial Vehicle Credentials	ANSI TS286	An electronic data interchange (EDI) transaction set that can be used by owners, lessees, and drivers of commercial motor vehicles to apply electronically for credentials necessary to operate those vehicles legally. Can also be used by authorizing jurisdictions to transmit credential data electronically to applicants and other authorized entities.

Title	Lead SDO and Document Number	Description
Commercial Vehicle Safety Reports	ANSI TS285	An EDI transaction set to permit enforcement officials, government administrators, and other authorized parties to retrieve electronically information on the safety performance, regulatory compliance, and credentials status of commercial motor vehicles, carriers, and drivers.
Commercial Vehicle Safety and Credentials Information Exchange	ANSI TS285	An EDI transaction set to permit enforcement officials, government administrators, and other authorized parties to retrieve electronically information on the safety performance, regulatory compliance, and credentials status of commercial motor vehicles, carriers, and drivers.
Data Radio Channel (DARC) System	EIA/CEA EIA-794	Specification of the DARC FM subcarrier waveform for the delivery of traveler information, messages, and data services to mobile, portable, and fixed receivers.
Field Test Analysis Information Report	SAE J2372	Results of field tests on location-referencing standards.
Forward Collision Warning: Operating Characteristics and User Interface	SAE J2300	Minimum safety and human factors requirements for front collision warning (FCW) operating characteristics and driver interfaces to ensure consistency across vehicles so that drivers can quickly understand and safely use an FCW-equipped vehicle.
Guide for Microwave Communications System Development	IEEE 1404	A guide that addresses all the requirements for microwave system design, procurement, construction, maintenance, and subsequent operations.

Title	Lead SDO and Document Number	Description
ISP-Vehicle Location Referencing Message Profiles	SAE J1746	A referencing format for ISP-to-vehicle and vehicle-to-ISP references. Will reflect the cross-streets profile of the current location reference message specification (LRMS) document as expressed in the National Location Referencing Information Report (SAE J2374).
ITS Data Bus Architecture Reference Model Information Report	SAE J2355	A reference model for an in-vehicle data bus. The ITS data bus (IDB) will enable manufacturers, dealers, and vehicle owners to install a wide range of electronic equipment reliably and safely in a vehicle at any time during the vehicle's life cycle.
ITS Data Bus Conformance Test Procedure	SAE J2368	Testing procedures for physical and data link layers required to certify a device as IDB compliant. Ensures that devices support a fixed set of minimal messages. Primary categories of compliance testing are mechanical, electrical, and behavioral (plug and play).
ITS Data Bus Data Security Services Recommended Practice	SAE J1760	Specification of data security requirements between devices on the IDB and definitions of device- and message-level security. Also includes a mechanism to discourage theft of data bus modules.
ITS Data Bus Gateway Recommended Practice	SAE J2367	Requirements for the interface between the ITS systems on the IDB and the vehicle, specifically, what vehicle information will be made available to the IDB.
ITS Data Bus Protocol—Application Layer Recommended Practice	SAE J2366-7	Requirements for the application layer of the Open Systems Interconnection (OSI) model for the IDB.
ITS Data Bus Protocol—Link Layer Recommended Practice	SAE J2366-2	Requirements for the link layer of the OSI model for the IDB.

Title	Lead SDO and Document Number	Description
ITS Data Bus Protocol—Physical Layer Recommended Practice	SAE J2366-1	A physical interface device (connector) that will ensure compatibility between vehicles and after-market devices. Includes physical interface performance requirements, circuit identification and configuration, and electrical requirements for the physical layer of the IDB.
ITS Data Bus Protocol—Thin Transport Layer Recommended Practice	SAE J2366-4	Requirements for the thin transport layer (Layer 4 of the OSI model) for the IDB.
ITS Data Dictionaries Guidelines	IEEE ITSPP#6A	Key enabling guides and standards for the coordinated development of specialized ITS data dictionaries.
ITS In-Vehicle Message Priority	SAE J2395	Specification of orderly temporal and spatial presentation of ITS information to the driver.
In-Vehicle Navigation System Communication Device Message Set Information Report	SAE J2256	Definition of the form and content of the messages sent between a traffic management center (TMC) or ISP and vehicles, including traffic information, emergency service, and route guidance information.
Information Report on ITS Terms and Definitions	SAE J1761	A dictionary of terminology in the ITS field, with a focus on the vehicle and interfaces to the vehicle.
Mayday Industry Survey Information Report	SAE J2352	A summary of information obtained from a survey conducted in 1997 of Mayday system manufacturers. The information is limited to technical data as it pertains to vehicle and on-board Mayday system operations. The survey's purpose was to determine whether the general concept and architecture on which the J22313 Mayday Message Set was based are consistent with those of current Mayday system hardware manufacturers.

Title	Lead SDO and Document Number	Description
Measurement of Driver Visual Behavior Using Video Based Methods (Def. & Meas.)	SAE J2396	Procedures for collecting, reducing, analyzing, and reporting on driver eye-glance data in a manner suitable for evaluating ITS systems and comparing alternative designs for a particular system in terms of visual demand. Helps ensure that systems minimize the time a driver's eyes are off the road.
Message Set for External TMC Communication (MS/ETMCC)	ITE TM 2.01	A message set standard for communication between TMCs and other ITS centers, including ISPs, emergency management systems, mission management systems, and transit management systems.
Message Sets for DSRC ETTM & CVO	IEEE 1455	Standard messages for commercial vehicle, electronic toll, and traffic management applications.
NTCIP—Application Profile for File Transfer Protocol (FTP)	AASHTO 2303	A common application profile providing connection-oriented file transfer services. (Formerly TS 3.AP-FTP-100x.)
NTCIP—Application Profile for Simple Transportation Management Framework (STMF)	AASHTO 2301	A set of application, presentation, and session layer protocols to provide simple information management services. (Formerly TS 3.AP-STMF.)
NTCIP—Application Profile for Trivial File Transfer Protocol	AASHTO 2302	Definition of how to use the Trivial File Transfer Protocol within transportation networks. A common application profile providing connectionless file transfer services. (Formerly TS 3.AP-TFTP-199x.)
NTCIP—Application Profile for Common Object Request Broker Architecture (CORBA)	AASHTO 2305	Real-time peer-to-peer exchange (including some remote control/ command capability) between TMCs and systems such as traffic operations centers, transit operations centers, emergency management centers, and traveler information systems. (Formerly TS 3.AP-CORBA.)

Title	Lead SDO and Document Number	Description
NTCIP—Applications Profile for Data Exchange ASN.1 (DATEX)	AASHTO 2304	Fulfills the need for a communications stack that supports routing, sequencing, and file transfer over point-to-point links, based on (sockets) TCP, IP, and PPP. (Formerly TS 3.AP-DATEX.)
NTCIP—Base Standard: Octet Encoding Rules (OER)	AASHTO 1102	A set of encoding/decoding rules for preparing data for transmission or decoding data before sending it to the application. Developed as a derivative of the Basic Encoding Rules (BER), as defined in ISO 8825-1. Within the NTCIP suites of protocols, OER is to be used in conjunction with NTCIP-STMF and NTCIP-DATEX ASN. (Formerly TS 3.BP-OER-1999.)
NTCIP—Class B Profile	AASHTO 2001	A general method of interconnecting ITS field equipment, such as traffic controllers and variable message signs. Includes the protocol and procedures for establishing communications between those components and the reference common data sets to be used by all such equipment. (Formerly TS 3.3.)
NTCIP—Data Collection and Monitoring Devices	AASHTO 1206	Specifies object definitions that may be supported by data collection and monitoring devices, such as roadway loop detectors. (Formerly TS 3.DCM.)
NTCIP—Data Dictionary for Closed Circuit Television (CCTV)	AASHTO 1205	A database for closed circuit television systems. The format of the database is identical to that of other NTCIP devices and uses ASN.1 representation. Targeted devices include cameras, lenses, video switches, and positioning controls for aiming identification, such as videotext overlays. The standard will support various levels of conformance. (Formerly TS 3.CCTV.)

Title	Lead SDO and Document Number	Description
NTCIP—Global Object Definition	AASHTO 1201	Definition of those pieces of data likely to be used in multiple device types, such as actuated signal controllers and dynamic message signs. Examples of these data include time, report generation, and scheduling concepts. (Formerly TS 3.4.)
NTCIP—Internet (TCP/IP and UDP/IP) Transport Profile	AASHTO 2202	A set of transport and network layer protocols to provide connectionless and connection-oriented transport services. (Formerly TS 3.TP-INTERNET.)
NTCIP—Object Definitions for Actuated Traffic Signal Controller Units	AASHTO 1202	Specifications for objects that are specific to actual signal controllers and definitions of standardized object groups that can be used for conformance statements. (Formerly TS 3.5.)
NTCIP—Object Definitions for Dynamic Message Signs	AASHTO 1203	Definition of data specific to dynamic message signs, including all types of signs that can change state, such as blank-out signs, changeable signs, and variable signs. (Formerly TS 3.6.)
NTCIP—Object Definitions for Environmental Sensor Stations & Roadside Weather Information System	AASHTO 1204	Definitions of objects that are specific to environmental sensor stations (ESSs) and object groups that can be used for conformance statements. Communication between remote entities and ESSs is accomplished by using the NTCIP application layer services to convey requests to access or modify values of ESS objects. (Formerly TS 3.7.)
NTCIP—Object Definitions for Video Switches	AASHTO 1208	Definition of the data needed to control a video switch enabling multiple monitors to view multiple video feeds.

Title	Lead SDO and Document Number	Description
NTCIP—Point to Multi-Point Protocol Using RS-232 Subnetwork Profile	AASHTO 2101	A set of data link and physical layer protocols applicable to roadside devices. (Formerly TS 3.SP-PMPP232-1998.)
NTCIP—Profiles—Framework and Classification of Profiles	AASHTO 8003	A framework and classification scheme for developing combinations and/or sets of protocols related to communication in an ITS environment. (Formerly TS 3.PRO.)
NTCIP—Ramp Meter Controller Objects	AASHTO 1207	Specifications for objects that are specific to ramp metering controller operations. (Formerly TS 3.RMC.)
NTCIP—Simple Transportation Management Framework (STMF)	AASHTO 1101	A set of rules and protocols for organizing, describing, and exchanging transportation management information between transportation management applications and transportation equipment such that they interoperate with each other. (Formerly TS 3.2.)
NTCIP—Simple Transportation Management Protocol (STMP)	AASHTO 1103	A set of rules and procedures for exchanging information with a minimum of overhead to provide an interoperability standard for transportation-related devices that operate over bandwidth-limited communication links. (Currently part of TS 3.2.)
NTCIP—Subnet Profile for Point-to-Point Protocol Using RS 232	AASHTO 2103	A subnetwork profile that defines requirements for the data link and physical layers of a communications stack. Specifies the rules and procedures for using the point-to-point protocol over RS-232 related circuits. The intent is to provide an interoperability standard for transportation-related devices that communicate over dial-up circuits. (Formerly TS 3.SP-PPP/RS232.)

Title	Lead SDO and Document Number	Description
NTCIP—Subnetwork Profile for Ethernet	AASHTO 2104	A subnetwork profile that defines requirements for the data link and physical layers of a communications stack. Specifies the rules and procedures for using the Institute of Electrical and Electronics Engineers (IEEE) Link Layer Control (802.2) and Media Access Control (802.3) protocols over coaxial, twisted pair, or fiber-optic media. The intent is to provide an interoperability standard for transportation-related devices that communicate over local area network (LAN) interfaces. (Formerly TS 3.SP-Ethernet.)
NTCIP—Transportation System Sensor Objects	AASHTO 1209	Object definitions that are specific to and guide the data exchange content between advanced sensors and other devices in an NTCIP network. Advanced sensors include video-based detection sensors, inductive loop detectors, sonic detectors, infrared detectors, and microwave/radar detectors. (Formerly TS 3.EP-TSS.)
National Location Referencing Information Report	SAE J2374	A basis for location referencing standardization activities by various application communities and SDOs.
On-Board Land Vehicle Mayday Reporting Interface	SAE J2313	A general specification prescribing protocol methods that enable vendors with different communication methods to communicate with response agencies in a standard format.
Recommended Practice for the Selection and Installation of Fiber Optic Cable	IEEE P1454	Guidelines for the installation, splicing, and connection of fiber-optic cable, and testing for urban, suburban, and rural communication requirements, as well as for transportation operations centers.

Title	Lead SDO and Document Number	Description
Serial Data Comm. Between MicroComputer Systems in Heavy-Duty Vehicle Applications	SAE J1708	A recommended practice for implementing a bidirectional, serial communications link among modules containing microcomputers. Defines those parameters of the serial link that relate primarily to hardware and basic software compatibility, such as interface requirements, system protocol, and message format.
Stakeholder's Workshop Information Report	SAE J2373	Results of workshops held to solicit and discuss stakeholder requirements for location referencing standardization.
Standard Specification for DSRC—Data Link Layer	ASTM Draft Z7633Z	Specification for the protocol (data link) communications. Supports both synchronous and asynchronous modes of operation.
Standard Specification for DSRC—Physical Layer 902–928 MHz	ASTM PS 111-98	Specification for the radio frequency (RF) characteristics (physical layer) for DSRC operating in the range of 902 to 928 MHz. Supports both active and backscatter transponders.
Standard for ATIS Message Sets Delivered Over Bandwidth Restricted Media	SAE J2369	A general framework allowing transmission of traveler information via bandwidth reduced media, such as those found in wireless applications. Creates a uniform coding and message structure for link travel times, incident text, weather, and transit for broadcast delivery.
Standard for Common Incident Management Message Sets (IMMS) for use by EMCs	IEEE P1512	Standards describing the form and content of the incident management message sets from emergency management systems (EMSs) to traffic management systems (TMSs) and from EMSs to the emergency telephone system (ETS) or E911.

Title	Lead SDO and Document Number	Description
Standard for Data Dictionaries for Intelligent Transportation Systems	IEEE 1489	A set of meta-entities and meta-attributes for ITS data dictionaries, as well as associated conventions and schemas, that enable describing, standardizing, and managing all ITS data.
Standard for Functional Level Traffic Management Data Dictionary (TMDD)	ITE TM 1.03	Data elements for roadway links and for incidents and traffic-disruptive roadway events. Includes data elements for traffic control, ramp metering, traffic modeling, video camera traffic control, parking management, and weather forecasting, as well as data elements related to detectors, actuated signal controllers, vehicle probes, and dynamic message signs.
Standard for Message Set Template for ITS	IEEE P1488	A standard for an ITS message set template.
Standard for Navigation and Route Guidance Function Accessibility While Driving	SAE J2364	Guidelines to help ensure ease of learning and ease of use in navigation and route guidance systems and to minimize the visual and cognitive demands associated with the use of these systems.
Subcarrier Traffic Information Channel (STIC) System	EIA/CEA EIA-795	A flexible waveform defined for the physical and data link layers for delivery of data to mobile and fixed users using a subcarrier on a broadcast FM station. Supports ATIS message sets (SAE J2369); differential Global Positioning System (GPS) message sets defined by Radio Technical Commission for Maritime Services Special Committee No. 104; emergency alert system messages defined by the Code of Federal Regulations (CFR) Title 47, Part 11; and retransmission of Radio Broadcast Data System data.

Title	Lead SDO and Document Number	Description
Survey of Communications Technologies	IEEE ITSPP#5	Survey and analysis of existing standards (and those under development) that include requirements for both wireline and wireless transmissions. The full title of this standard is "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 Communications."
TCIP—Common Public Transportation (CPT) Business Area Standard	ITE 1401	Data objects for standard data types, data elements, and messages shared by and common to other transit business areas. Includes general data concepts related to vehicle, equipment, and facility.
TCIP—Control Center (CC) Business Area Standard	ITE 1407	Data objects for transit management center functions related to providing, monitoring, and measuring real-time transit revenue service.
TCIP—Fare Collection (FC) Business Area Standard	ITE 1408	Data objects related to passenger fare collection, including cash, electronic, and nonelectronic payment. Also provides output data to the fare media, processing of financial transactions, equipment status, and planning. (Formerly TS 3.TCIP-FC.)
TCIP—Framework Document	ITE 1400	Framework document for business area object standards for transit ITS. (Formerly TS 3.TCIP-FW.)
TCIP—Incident Management (IM) Business Area Standard	ITE 1402	Data objects for detecting, verifying, prioritizing, responding to, and clearing unplanned events (accidents, weather conditions, crime, etc.), as well as information for travelers. (Formerly TS 3.TCIP-IM.)

Title	Lead SDO and Document Number	Description
TCIP—Onboard (OB) Business Area Standard	ITE 1406	Data elements for onboard transit vehicle applications. Includes all data for communications between onboard components within the vehicle and other transit applications.
TCIP—Passenger Information (PI) Business Area Standard	ITE 1403	Data objects relating to providing passengers (and potential passengers) with information for planning and making public transportation trips. Includes schedules, fares, on-line services, trip planning, and facility information.
TCIP—Scheduling/ Runcutting (SCH) Business Area Standard	ITE 1404	Data objects related to scheduling and runcutting. Includes requirements for master schedules, trip sheets, run guides, inventory files, etc., as well as output data for garage management, roadside devices, performance history. etc. (Formerly TS 3.TCIP-SCH.)
TCIP—Spatial Representation (SP) Business Area Standard	ITE 1405	Data objects for spatial representations to support other TCIP object sets. Allows for the transfer of location of transit objects and includes primitive elements and complex objects.
TCIP—Traffic Management (TM) Business Area Standard	ITE TS 3.TM	Data objects relating to traffic conditions, including planned changes in roadways and real-time traffic movement. Based on the ITE Traffic Management Data Dictionary and uses its data elements for data flowing into the transit agency.
Truth-in-Labeling Standard for Navigation Map Databases	SAE J1663	Definition of consistent terminology, metrics, and tests for describing the content and quality of navigable map databases. (Does not specify the physical format of the database or minimum performance standards.) The focus of this document is on supporting the navigation applications that automotive manufacturers and suppliers are currently developing for marketplace delivery.

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