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ITS Standards: A System Management Perspective

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ITS STANDARDS

A SYSTEM MANAGEMENT PERSPECTIVE

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ABSTRACT

This working paper is part of a larger project examining how the State of California should respond to the National System Architecture (NSA) for Intelligent Transportation Systems. The specific focus of this paper is on the role of standardization in managing and controlling the transportation system. The paper reviews activities and processes used by standards setting organization in transportation. We conclude that national and international standards will continue to address the needs for defining common interfaces for communication with field devices and communication between TMCs. As these standards evolves, transportation agencies will attain greater flexibility in installing systems and sharing information with each other. However, standardization has not addressed the need to develop protocols and procedures for responding to transportation events and managing the transportation system, nor is standardization likely to address this need.

Keywords: Standardization
System Architecture
System Management

EXECUTIVE SUMMARY

Transportation standards are created by a variety of organizations. The main purpose of standardization is to minimize the amount of incompatibility that arises when merging technologies that were created independently. Standards also allow government agencies purchasing transportation equipment to compare prices across a range of vendors. This working paper summarizes standards organizations' roles and processes in the creation of transportation standards.

Ideas for standards come from many places. The standard creating organizations may see an opportunity to standardize a new technology and draft a standard creation proposal. Industry personnel may work through their employer or professional organizations to create standards. As discussed below, each organization has a niche within the transportation field. Therefore, once a need is created, the appropriate organization can easily be identified. Formal and informal systems are used to coordinate the standard creation efforts among organizations. Informally, many active committee members participate on multiple organizations. They interact at meetings and on projects. On a formal level, the Jet Propulsion Laboratory (JPL) has cataloged the existing and emerging standards for the Federal Highway Administration (Barrett, 1996).

This document provides an overview of organizations that create transportation standards. It supplements prior work under this contract (Appendix C of Horan et al, 1997, prepared by Ron Ice), which examines the relationship between transportation standards and the National System Architecture.

Overview of the Standards Creation Organizations

Transportation standards are being created by many private and public organizations across a range of domains. The major efforts are listed below:

- *Roadway and Infrastructure Standards:* The American Association of State Highway and Transportation Officials (**AASHTO**) focuses on the design, construction, and maintenance of highways, and it is composed of state officials. The Institute of Transportation Engineers (**ITE**) overlaps somewhat with AASHTO. ITE facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development and management for any mode of transportation. In contrast to AASHTO, ITE is composed of academics and professionals in the transportation planning, mobility, and safety fields.

- *Electronics:* The Institute of Electrical and Electronics Engineers (**IEEE**) focuses on the theory and practice of electrical, electronics, and computer engineering, and computer science. IEEE is composed of technical professionals. The National Electrical Manufacturers Association (**NEMA**) is similar to IEEE. They focus on the generation, transmission,

distribution, control, and end-use of electricity. In contrast to IEEE, NEMA represents companies that manufacture products for the electronics industry.

- *Umbrella Organizations:* Intelligent Transportation Systems - America (**ITSA**) is the only national public/private organization established to coordinate the development and deployment of ITS in the United States. They integrate information processing, communications, control, and electronics technologies to improve the overall transportation system. While ITSA integrates transportation technologies and organizations, the National Transportation Communications for ITS Protocol (**NTCIP**) provides a communications standard for all devices. This standard ensures the interoperability and interchangeability of traffic control and Intelligent Transportation devices. Finally, the US Department of Transportation's (**US DOT**) ITS Joint Program Office is also supporting and existing ITS standard processes. This organization has partnered with many other standards development organizations to reinforce existing standards. The interactivity is discussed in the following section.

- *Material Testing:* The American Society for Testing and Materials (**ASTM**) publishes standard test methods, specifications, practices, guides, classifications, and terminology. ASTM is involved in a wide range of industries, including transportation. These standards enable end-users to compare various products using an acceptable test method.

- *International Standardization:* The International Organization for Standardization (**ISO**) is a worldwide federation of national standards bodies. They compile national standards in order to create international consistency, which will promote trade and cooperation across the world.

- *Vehicle Standards:* The Society of Automotive Engineers (**SAE**) creates standards used in designing, building, maintaining, and operating vehicles on land or sea, in air or space. SAE's intelligent transportation systems (ITS) division is developing standards which improve the methods of operating vehicles.

Relationships Among Organizations

Many of the standards needs overlap many organizations and, therefore, the same agencies work together frequently. Those organizations that interact are listed below:

- *International Cooperation:* IEEE has a relationship with IEC and ISO. The IEC stands for the International Electrotechnical Commission. It's an organization of 50 countries that was created "to promote international cooperation on all questions of standardization and related matters, such as the verification of conformity to standards, in the fields of electricity, electronics and related technologies and thus promote international understanding." IEC does this by issuing publications, including international standards. IEC's scope is specifically

electrotechnology. ISO and IEC do work together on information technology standards, such as computer communications, ISO and IEC have formed a Joint Technical Committee Number One, JTC1. Other areas of cooperation include the environment, safety, and electromagnetic radiation.

- *Multiple Organization Steering Committee:* In 1996, the National Electrical Manufacturers Association (NEMA) teamed with the Institute of Transportation Engineers (ITE) and the American Association of State Highway and Transportation Officials (AASHTO) under a Federal Highway Administration (FHWA) contract to obtain more direct user input in the standards development process. The NTCIP Steering Group has been reorganized as the NTCIP Joint Standards Committee, an official Steering Committee of the FHWA-funded project. The Steering Committee includes members from the various standards organizations and industry personnel.

- *Reinforcing existing standards:* US DOT has chosen to support, guide, and reinforce the existing consensus standards efforts in the US by providing funding to five existing Standards Development Organizations (SDOs). This "bottoms-up" approach will allow US DOT to leverage significant volunteer resources and to foster public-private partnerships in the deployment of ITS. The five SDOs chosen for funding are: SAE, ASTM, IEEE, AASHTO, ITE. By utilizing the talents of all 5 SDOs, the US DOT program builds on expertise from the multiple disciplines of ITS. The US DOT program provides an important aspect of coordination and overall planning. Many of the standards identified for US DOT funding are being developed by several of the SDOs. The US DOT program is encouraging and facilitating increased coordination in US national standards efforts for ITS. The US DOT has also considered input from ITS America in choosing the most appropriate standards for near term funding. The overall goal of the program is to accelerate ITS deployment and promote national interoperability through robust non-proprietary, consensus-based national standards.

Implications

We conclude that national and international standards will continue to address the needs for defining common interfaces for communication with field devices and communication between TMCs. As these standards evolves, transportation agencies will attain greater flexibility in installing systems and sharing information with each other. However, standardization has not addressed the need to develop protocols and procedures for responding to transportation events and managing the transportation system, nor is standardization likely to address this need.

1. ORGANIZATIONAL BACKGROUNDS

This section describes the processes by which standards are set in organizations involved in transportation. The section is based on a review of documents from these organizations and interviews with the people who are charged with developing the relevant standards (Table 1).

1.1 American Association of State Highway and Transportation Officials (AASHTO)

Organization and Mission

Established in 1914, the American Association of State Highway and Transportation Officials (AASHTO) has for decades been the preeminate source of technical information on the design, construction, and maintenance of highways, and other transportation facilities. AASHTO is the only national organization whose interests include all five transportation modes: aviation, highways, public transportation, rail, and water transportation.

The highway committee develops all major engineering standards, guides, and policies for the highway program and either as a unit or through its subcommittees, investigates, studies and reports on all engineering activities and developments, including all phases of road and bridge design, construction, maintenance, traffic requirements, roadside development, aesthetics, tests and investigations of materials, protection of the environment; makes recommendations regarding needed research, promotes and encourages technology transfer by member states and related research agencies; and is responsible for providing the full range of highway engineering publications for the Association. It identifies and receives reports from its subcommittees and task forces as to federal regulatory mandates of national concern, and provides reports thereon.

Role in Standardization

AASHTO publishes manuals, guides and specifications in the areas of administration and economics, bridges and structures, construction and right-of-way, design and traffic, highway transport and safety, maintenance, materials and planning and environment. The voluntary guidelines and specifications which are contained in the more than 100 AASHTO technical publications are developed through the expertise of member departments, working together through AASHTO's many technical committees.

AASHTO standards and specifications are approved by a ballot of member departments, requiring a two-thirds vote of all members for publication.

Standardization Process

AASHTO's technical committees develop their standards. The areas in which the groups will focus are determined at AASHTO's annual meetings. The technical committees then divide the standards, and develop standards specifications. These specifications are then balloted by the

Table 1. Standards Setting Organizations in Transportation

1. AASHTO	http://www.aashto.org Amy Steiner or Linda Graves (AASHTO): (202) 624-5800
2. ASTM	http://www.astm.org Dan Smith (ASTM): (610) 832-9500 (General) or (610) 832-9727 (direct) dsmith@astm.org Joe Wilkinson (Chaparrel Systems): Weigh in Motion Subcommittee Chair (505) 988-5594
3. IEEE	http://www.ieee.org/about.html Rosemary Tennis (IEEE): (800) 678-4333 Luigi Napoli (IEEE): (908) 562-3812 IEEE Standards Companion
4. ISO	http://www.iso.org Arlan Stehney (SAE): (412) 772-7157 arlan@sae.org
5. ITE	http://www.ite.org Thomas Kurihara (ITE): (202) 554-8050 ext. 143
6. ITSA	http://www.itsa.org Ray Starsman (ITSA): (202) 484-2897 Roy Courtney (ITSA): (202) 484-2905
7. NEMA	http://www.nema.org Crawley Perris (NEMA) (703) 841-3200
8. NTCIP	http://www.ntcip.org Edward Seymour (Texas A&M): (972) 994-0433 eseymour@tamu.edu Ian Mulholland (NTCIP): ianmulholland@ntcip.org
9. SAE	http://www.sae.org Arlan Stehney (SAE): (412) 772-7157 arlan@sae.org Valerie Shuman (SAE): (847) 699-7594 vshuman@sei-it.com
10. USDOT	http://www.utsa.org/standards

committee and must receive a 2/3 majority for approval. Additionally, any later changes to the specifications must also receive a 2/3 majority vote to be approved, and the technical committee chairperson must also sign off on all changes.

Current Standards Under Development

1. NTCIP dynamic message signs
2. NTCIP highway advisory radio
3. NTCIP environment sensor stations & TWIS
4. NTCIP video camera control
5. NTCIP TMC to TMC
6. NTCIP ramp meters
7. NTCIP weigh in motion
8. NTCIP video detection devices
9. NTCIP vehicle classification devices
10. NTCIP automatic vehicle identification

1.2 American Society for Testing and Materials (ASTM)

Organization and Mission

Organized in 1898, ASTM (the American Society for Testing and Materials) has grown into one of the largest voluntary standards development systems in the world. ASTM is a not-for-profit organization that provides a forum for producers, users, ultimate consumers, and those having a general interest (representatives of government and academia) to meet on common ground and write standards for materials, products, systems, and services. From the work of 132 standards-writing committees, ASTM publishes standard test methods, specifications, practices, guides, classifications, and terminology. ASTM's standards development activities encompass metals, paints, plastics, textiles, petroleum, construction, energy, the environment, consumer products, medical services and devices, computerized systems, electronics, and many other areas. ASTM Headquarters has no technical research or testing facilities; such work is done voluntarily by 35,000 technically qualified ASTM members located throughout the world. More than 9,100 ASTM standards are published each year in the 71 volumes of the Annual Book of ASTM Standards.

ASTM creates standards for a wide variety of disciplines, including the transportation industry. A listing of recently published Special Technical Publications, Manuals, and other publications distributed by ASTM is as follows:

- Construction Materials and Engineering: Buildings, Cement and Concrete, Fire and Flammability, Geotechnical Engineering, Masonry, Paints and Related Coatings, Plastic Pipe, Road and Paving, Roofing

- Environment and Safety: Atmospheric Analysis, Environmental Assessment, Environmental Toxicology, Hazardous Materials, Waste Management
- Petroleum Products: Analysis and Testing, Coolants, Crude, Fuels, Lubricants
- Quality Control: Quality Control
- Sensory Sciences: Sensory Sciences

Role in Standardization

ASTM develops six principal types of full consensus standards. They are:

1. Standard Test Method--a definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.

2. Standard Specification--a precise statement of a set of requirements to be satisfied by a material, product, system, or service that also indicates the procedures for determining whether each of the requirements is satisfied.

3. Standard Practice--a definitive procedure for performing one or more specific operations or functions that does not produce a test result.

4. Standard Terminology--a document comprising terms, definitions, description of terms, explanation of symbols, abbreviations, or acronyms.

5. Standard Guide--a series of options or instructions, that do not recommend a specific course of action.

6. Standard Classification--a systematic arrangement or division of materials, products, systems, or services into groups based on similar characteristics such as origin, composition, properties, or use.

Standardization Process

Standards development work begins when a need is recognized. Task group members prepare a draft standard, which is reviewed by its parent subcommittee through a letter ballot. After the subcommittee approves the document, it is submitted to a main committee letter ballot. Once approved at the main committee level, the document is submitted for balloting to the Society. All negative votes cast during the balloting process, which must include a written explanation of the voter's objections, must be fully considered before the document can be submitted to the next level in the process. Final approval of a standard depends on concurrence by the ASTM Committee on Standards that proper procedures were followed and due process was achieved. Only then is the ASTM standard published.

Current Standards Under Development

1. Standard for dedicated, short range, two-way vehicle to roadside communications equipment: physical layer
2. Standard for dedicated, short range, two-way vehicle to roadside communications equipment: data link layer
3. Standard for dedicated, short range two-way vehicle to roadside communications equipment
4. Standard specification for highway weigh-in-motion (WIM) systems with user requirements and test method (completed)

1.3 Institute of Electrical and Electronics Engineers (IEEE)

Organization and Mission

The Institute of Electrical and Electronics Engineers (IEEE) is the world's largest technical professional society, composed of more than 320,000 members who conduct and participate in its activities in 147 countries.

The technical objectives of the IEEE focus on advancing the theory and practice of electrical, electronics and computer engineering and computer science. To realize these objectives, the IEEE sponsors technical conferences, symposia and local meetings worldwide, publishes nearly 25% of the world's technical papers in electrical, electronics and computer engineering; provides educational programs to keep its members' knowledge and expertise state-of-the-art. The purpose of all these activities is two fold: (1) to enhance the quality of life for all people through improved public awareness of the influences and applications of its technologies; and (2) to advance the standing of the engineering profession and its members.

IEEE is responsible for coordinating, developing, and maintaining standards, recommended practices, and guidelines related to Intelligent Transportation Systems (ITS) within the scope of IEEE interests. They work with other national and international standards writing bodies to coordinate area of involvement Standardization Process. Their efforts within transportation are:

- The application of SONET communications standards network architectural options, capabilities, network management and associated equipment features to ITS voice, data and video communications network requirements.
- Guidelines for the selection, installation approach, splicing, connectorization of fiber optic cable, and test for urban, suburban, and rural communications requirements as well as operations centers and campuses are to be included.
- Research, compile, and consolidate information leading to the publication of a standard message set for Vehicle/Roadside communications.
- Work in conjunction with information sources such as the Electronic Toll and Traffic Management (ETTM) User Group, the ATA, the CVO community, the vendor community,

and other standards bodies to consolidate appropriate message sets into a single open industry standard.

Role in Standardization

IEEE's role in developing standards within transportation focus on electronic areas. Their standards also fit underneath the Intelligent Transportation Systems' umbrella. IEEE's standards are typically detailed in nature. For example, the SONET standard will address engineering practices and procedures for the location of protectors, grounding and bonding practices and site geometry considerations. Additionally, their expertise is also used to develop detailed communications standards.

Standardization Process

The staff of IEEE Standards serves the IEEE Standards Board and standards-developing groups; oversees the development and publication of IEEE standards, standards of certain Accredited Standards Committees, and related products; and promotes the use of IEEE standards around the world.

Staff Engineers are assigned to standards groups to guide them through the process of developing a standard. They attend meetings and provide current information on policies and procedures. The IEEE Standards Board support staff members oversee the process of submitting project authorization requests (PARs) and completed standards for approval, and also provide a standards balloting service. Project Editors review drafts of developing standards, work with standards developers to ensure that drafts are proceeding on the right track, and also prepare the finished documents for publication. The Standards Process Automation System® [SPAsystem®] staff create tools for on-line standards development and dissemination. IEEE has published IEEE Standards Companion, which is a guide book for developing any IEEE standard. The Standards Companion details the methods of finding a sponsor, developing a work group, documenting the processes, reaching consensus among the team, and creating an official standard or patent.

Current Standards Under Development

1. Guide for microwave communications system development: design, procurement, construction, maintenance, and operations
2. Recommended practice for the selection and installation of fiber optic cable in ITS's urban, suburban, and rural environments as well as transportation operating centers and associated campuses
3. Standard for ITS data dictionaries
4. Message set template for ITS
5. Standard for message sets for vehicle/roadside communications (ETC & CVO)
6. Message sets for incident management (EMS to TMC, E911)

1.4 International Organization for Standardization (ISO)

Organization and Mission

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies from some 100 countries, one from each country. ISO is a non-governmental organization established in 1947. The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity. ISO's work results in international agreements which are published as International Standards. The scope of ISO is not limited to any particular branch; it covers all standardization fields except electrical and electronic engineering, which is the responsibility of the International Electrotechnical Commission (IEC). The work in the field of information technology is carried out by a joint ISO/IEC technical committee (JTC 1).

Role in Standardization

Industry-wide standardization is a condition existing within a particular industrial sector when the large majority of products or services conform to the same standards. It results from consensus agreements reached between all economic players in that industrial sector - suppliers, users, and often governments. They agree on specifications and criteria to be applied consistently in the choice and classification of materials, the manufacture of products, and the provision of services. The aim is to facilitate trade, exchange and technology transfer through:

- Enhanced product quality and reliability at a reasonable price,
- Improved health, safety and environmental protection, and reduction of waste,
- Greater compatibility and interoperability of goods and services,
- Simplification for improved usability,
- Reduction in the number of models, and thus reduction in costs,
- Increased distribution efficiency, and ease of maintenance.

Users have more confidence in products and services that conform to International Standards. Assurance of conformity can be provided by manufacturers' declarations, or by audits carried out by independent bodies.

Standardization Process

ISO standards are developed according to the following principles:

1. Consensus: The views of all interests are taken into account: manufacturers, vendors and users, consumer groups, testing laboratories, governments, engineering professions and research organizations.

2. Industry-wide: Global solutions to satisfy industries and customers worldwide.

3. Voluntary: International standardization is market-driven and therefore based on voluntary involvement of all interests in the market-place.

There are three main phases in the ISO standards development process.

1. The need for a standard is usually expressed by an industry sector, which communicates this need to a national member body. The latter proposes the new work item to ISO as a whole. Once the need for an International Standard has been recognized and formally agreed, the first phase involves definition of the technical scope of the future standard. This phase is usually carried out in working groups which comprise technical experts from countries interested in the subject matter.

2. Once agreement has been reached on which technical aspects are to be covered in the standard, a second phase is entered during which countries negotiate the detailed specifications within the standard. This is the consensus-building phase.

3. The final phase comprises the formal approval of the resulting draft International Standard (the acceptance criteria stipulate approval by two-thirds of the ISO members that have participated actively in the standards development process, and approval by 75 % of all members that vote), following which the agreed text is published as an ISO International Standard.

Most standards require periodic revision. Several factors combine to render a standard out of date: technological evolution, new methods and materials, new quality and safety requirements. To take account of these factors, ISO has established the general rule that all ISO standards should be reviewed at intervals of not more than five years. On occasion, it is necessary to revise a standard earlier.

To date, ISO's work has resulted in 9,300 International Standards, representing some 170,700 pages in English and French (terminology is often provided in other languages as well).

Current Standards Under Development

1. Glossary of standard terminologies for the Transport Information and Control Systems (TICS) sector
2. Reference model architecture(s) for the TICS sector
3. Reference model architecture for generic AVI/AEI
4. Stationary dissemination systems for traffic and traveler information
5. Automatic fee collection application interface definition for dedicated short range vehicle beacon communications

6. Test procedures for automated fee collection user equipment and automatic fee collection fixed equipment
7. Automatic fee collection requirements for dedicated short range vehicle-beacon communications
8. Locally-determined route guidance
9. Forward obstacle warning systems
10. Short range warning systems for low speed maneuvering
11. Side obstacle warning systems

1.5 Institute of Transportation Engineers (ITE)

Organization and Mission/

The Institute of Transportation Engineers (ITE) is an international educational and scientific association of transportation and traffic engineers, transportation planners and other professionals who are responsible for meeting mobility and safety needs. The Institute facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development and management for any mode of transportation by promoting professional development of members, supporting and encouraging education, stimulating research, developing public awareness, and exchanging professional information; and by maintaining a central point of reference and action.

The Institute has formed ten councils around each of the transportation topics below. The members of each council work together to produce products that will educate members, set standards, and discuss issues relevant to that discipline. This is done through sponsoring seminars, technical sessions, and briefings held in conjunction with either ITE's Annual Meeting or International Conference and by publishing informational reports, equipment standards, and recommended practices. More information on each council can be found under Information by Discipline. The website contains a wealth of information on each of these topics. It is too lengthy to add to this paper.

- Traffic Engineering
- Transportation Planning
- Transportation Safety
- Intelligent Transportation Systems
- Transportation Demand Management
- Transit
- Transportation Education
- Transportation Expert Witness
- Transportation Consultants
- Transportation Industry

Role in Standardization

ITE has recognized the need to create standard message sets for communication. They work with the device manufacturers to develop standards, which will enable operability across different devices and manufacturers. The federal government then adheres to these standards, which motivates states to also adopt the standards.

Standardization Process

The ITE standards creation process works as follows:

1. Once a need is recognized, a committee is formed to develop a standard creation proposal. The committee includes representatives from traffic, safety, ITS, and other groups as appropriate.
2. The standards council is responsible for approving the committee's proposal.
3. Once approval is obtained, a technical committee is formed to develop the detailed standard.
4. An impartial review panel (not yet involved to date) then reviews the standard over a 60 day period.
5. Finally, the ITE board approves the standard. This step is somewhat of a formality.

Current Standards Under Development

1. ATC cabinet functional description
2. ATC cabinet specification document
3. ATA 2070 - ATC controller specification document
4. ATC API functional description
5. TCIP - transit data dictionary
6. TCIP - public transit vehicle message set
7. TCIP - transit vehicle to transit management center message set
8. TCIP - remote traveler support message set
9. Traffic management data dictionary
10. ATC cabinet standard
11. ATC API specification
12. External TMC - first, second, and third MS increments

1.6 Intelligent Transportation Systems - America (ITSA)

Organization and Mission

ITS (Intelligent Transportation Systems) comprises a number of technologies, including information processing, communications, control, and electronics. Joining these technologies to our transportation system will save lives, save time, and save money.

The use of ITS in Japan, Europe, and Australia has been greatly accelerated through mutual cooperation of the public and private sectors. Similar cooperation is required in the United States. Yet, unlike the state-mandated cooperation found in many countries, the United States requires a voluntary commitment to cooperation that preserves the benefits of the free enterprise system while ensuring that the broad goals established by Congress are met. The model for this type of cooperation is the public/private partnership -- a voluntary association of public and private interests committed to the successful development and deployment of ITS in the United States. It is the mandate of the Intelligent Transportation Society of America (ITS America) to coordinate that cooperative effort. As mandated by Congress, ITS America is the only national public/private organization established to coordinate the development and deployment of ITS in the United States.

A projected $209 billion will be invested in ITS between now and the year 2011 with a full 80% of that investment coming from the private sector in the form of consumer products and services. Among other services, ITS technologies:

1. Collect and transmit information on traffic conditions and transit schedules for travelers before and during their trips. Alerted to hazards and delays, travelers can change their plans to minimize inconvenience and additional strain on the system.

2. Decrease congestion by reducing the number of traffic incidents, clearing them more quickly when they occur, rerouting traffic flow around them, and automatically collecting tolls.

3. Improve the productivity of commercial, transit, and public safety fleets by using automated tracking, dispatch and weigh-in-motion systems that speed vehicles through much of the red tape associated with interstate commerce.

4. Assist drivers in reaching a desired destination with navigation systems enhanced with pathfinding, or route guidance. These are just a few of the technologies being deployed. The complete list is lengthy and growing every day. The ITS industry in the United States is in the midst of a massive buildup.

Public agencies also stand to derive enormous benefits from the deployment of these technologies. For government agencies at all levels, the innovative application of advanced technologies means lower costs, enhanced services, and a healthier environment for the constituents these agencies serve.

Role in Standardization

ITSA develops standards for broadly scoped projects. They coordinate the standards development process with other standards creation organizations. ITSA serves as an ITS “information clearinghouse,” and they serve as the hub for other organizations for data collection and communication in developing a standard.

Standardization Process

ITS America serves as the federally-mandated, international ITS information clearinghouse. As such, Access ITS America contains notices, announcements and documents issued by the United States Department of Transportation (USDOT) regarding federal ITS programs and services. Individuals and organizations active within the ITS community, and the public at large, are encouraged to make extensive use of this wealth of information provided by the USDOT and its related agencies, including:

1. Commercial Vehicle Operations

2. National ITS Architecture Documents: The National ITS Architecture provides a common structure for the design of intelligent transportation systems. The architecture defines the functions (e.g., gather traffic information or request a route) that must be performed to implement a given user service, the physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle), the interfaces/information flows between the physical subsystems, and the communication requirements for the information flows (e.g., wireline or wireless). In addition, it identifies and specifies the requirements for the standards needed to support national and regional interoperability, as well as product standards needed to support economy of scale considerations in deployment.

3. National Surface Transportation Goal for ITS

4. Program Plan: The National ITS Program Plan consists of four documents: an Executive Summary, a Synopsis, and two Volumes. The Executive Summary provides a very brief overview of the goals, objectives, and recommendations presented in the National ITS Program Plan. The Synopsis provides a fifty page encapsulation of the major subject areas within the document, with special emphasis on the area of deployment. Volume I focuses on the goals of ITS, compatibility, deployment, and program assessment. Volume II contains detailed descriptions and plans for each of the twenty nine user services.

5. Standards Catalog: Standards and protocols needed to support a nationwide ITS continue to be identified and developed as the ITS architecture and design progress. The Standards Catalog is an overall guide for exploring standards requirements and the coordination of standards development by standards developing organizations.

6. Surface Transportation Research and Development Plan: "The third edition of the Surface Transportation Research and Development Plan presents the Department's strategic plan for maximizing the effectiveness of DOT R&D activities over the next ten years toward attainment of these goals."

7. Telecommunications Documents: The ITS America Telecommunications Policy and Strategy paper reflects the present position adopted by consensus of the Telecommunications Committee. The policy statements are delineated into two categories: general guidance principles, and specific technical policies.

8. Transaction Documents: The Transaction Documents Repository provides access to legal, policy and business documents which address emerging issues relating to ITS.

9. USDOT ITS Projects Book: This resource describes ITS projects, tests, and studies initiated that have been partially or totally financed from Federal ITS funds.

Current Standards Under Development

1. Electronic toll and traffic management (ETTM) user requirements for future national interoperability (completed)

1.7 National Electrical Manufacturers Association (NEMA)

Organization and Mission

The National Electrical Manufacturers Association (NEMA) is the largest trade association in the United States representing companies that manufacture products for the electronics industry. Its member companies fall into one or more of nine NEMA divisions, each made up of sections whose companies manufacture the same or related products. Together, they manufacture a broad range of products for the generation, transmission, distribution, control, and end-use of electricity. Transportation is a small piece of their overall scope.

NEMA's involvement in transportation lies in the creation of standard electrical devices. NEMA supports the implementation new technologies by standardizing items such as control panels and controller assemblies. Product manufacturers (vendors) make up NEMA.

Role in Standardization

NEMA has developed two transportation standards:

1. Traffic Control Systems: Defines the performance of traffic signaling equipment that will ensure safety in the performance of its intended function.

2. Traffic Controller Assemblies: Covers traffic signaling equipment used to facilitate and expedite the safe movement of pedestrians and vehicular traffic.

NEMA is challenged to balance the general public's benefits of creating standards against each individual company's right to patented technology. The general public gains from standardized technology through increased competition and lower prices, but the private companies lose the technology's monopoly position when the research and development is shared with everyone. To compound problems, NEMA will develop a standard, but vendors will add features after the standard is developed. Therefore, NEMA must constantly reassess their standards through time.

Standardization Process

NEMA uses "consensus standards meetings" to develop standards. NEMA begins by drafting the standard internally, and then forwarding it for review to the product manufacturing companies and the state departments of transportation (DOTs). NEMA believes that the DOTs add to the organization's credibility. As noted in the section above, NEMA is challenged to create common protocol standards. The vendors guard their new ideas to maintain a competitive edge in the marketplace. Finally, a 2/3 majority vote is required to approve a standard.

Current Standards Under Development

1. NCTIP object definitions for actuated traffic signal controller units
2. NTCIP object set for ramp meters
3. NCTIP object set for vehicle classification devices
4. NTCIP object set for video detection devices
5. NTCIP object definitions for variable message signs

1.8 National Transportation Communications for ITS Protocol (NTCIP)

Organization and Mission

The primary objective of the National Transportation Communications for ITS Protocol (NTCIP) is to provide a communications standard that ensures the interoperability and interchangeability of traffic control and Intelligent Transportation Systems (ITS) devices. The NTCIP is the first protocol for the transportation industry that provides a communications interface between disparate hardware and software products. The NTCIP effort not only maximizes the existing infrastructure's usefulness, but it also allows for flexible expansion in the future, without reliance on specific equipment vendors or customized software.

The NTCIP will support integration of ITS technologies through the use of a standard communications protocol. In addition, vendors will produce hardware and software products that will be able to communicate effectively with other NTCIP compliant devices in the system.

Role in Standardization

Previously, each vendor of transportation control devices or software had used its own unique protocol, which required entire systems to use the same vendor for all components and upgrades. This was an obstacle to communications between systems. The NTCIP now allows for interoperability among transportation devices, and it enables different types of devices (e.g., traffic signals and variable message signs) to share a communications channel.

The NTCIP currently supports or is planning to support the following field devices:

- Traffic Signal Controllers
- Variable Message Signs
- Video Surveillance System Control
- Ramp Meters
- Highway Advisory Radio
- Transit Systems
- Automatic Vehicle Identification (reader to central)
- Transportation Management Center (TMC) to other centers (e.g., emergency management, fleet management, transit, and other TMCs)
- Weigh-In-Motion Devices
- Environmental Sensors
- Malfunction Management Units
- Other Vehicle Detection Systems

Current Standards Under Development

1. A communications standard that ensures the interoperability and interchangeability of traffic control and Intelligent Transportation Systems (ITS) devices

1.9 Society of Automotive Engineers (SAE)

Organization and Mission

The Society of Automotive Engineers is a one-stop resource for technical information and expertise used in designing, building, maintaining, and operating self-propelled vehicles for use on land or sea, in air or space. More than 70,000 engineers, business executives, educators, and students from more than 80 countries form their network of members who share information and exchange ideas for advancing the engineering of mobility systems.

At SAE, the ITS Program Office and the ITS Division are working together to develop solutions to the challenges of developing advanced vehicle systems for the movement of people and goods and providing services in the 21st century. Most of ITS is aimed at vehicle operators, so a significant effort is required to develop standards for use in vehicles. SAE is experienced in this area and is the natural candidate to lead these developments. To address the specific standards needs of ITS technology, the ITS Division is composed of separate and well-functioning

activities. These various units are generating standards to expedite an operational system that will increase safety, provide greater driver convenience, conserve energy and lower automotive pollution.

Role in Standardization

In January, 1996, the SAE ITS Division made a proposal to the Federal Highway Administration (FHWA) reflecting the vision and direction of the SAE ITS committees over the next five years. As a result of this action, the FHWA awarded $4 million to SAE for standards development. SAE has formally submitted a number of plans to the FHWA for approval and funding.

One standard with a critical priority will make it possible for drivers to receive up-to-the-minute information about traffic conditions from a variety of sources. Sponsored by the Map Database Committee, this standard will help in establishing a system that will tell drivers where traffic bottlenecks are happening and guide them around these obstacles with the least delay in travel time.

Another SAE standard under development deals with sending emergency messages about highway breakdowns to national, state, and local 911 response agencies. The In-Vehicle Systems Interface Committee is responsible for this standard, which will make it possible for drivers to send "mayday" messages via cellular phones or other in-vehicle communications devices.

The Safety and Human Factors Committee is pursuing a standard that will determine how drivers can best use in-vehicle navigation and route guidance systems.

One of the proposed ITS standards is now being field tested in the Boston metropolitan area. It provides for two-way vehicle-to-roadside ITS communications that includes traffic information, emergency services, routing information, vehicle location, and points of interest. The expected completion date for this test is mid-1997.

Due to differences in the design cycles of automobiles (3-5 years) and electronics (9-15 months), a car bought today is always equipped with old electronics technology. SAE is working on a convenient, economical, and technically feasible approach to enable any electronics manufacturer to build a product that plugs simply and easily into a vehicle's ITS system.

Standardization Process

All of these SAE standards are candidates for conversion to International Standards Organization (ISO) standards. SAE continues to serve as the secretariat of the international committee, ISO/TC204, which addresses the development of international ITS standards. One of the standards under development by the Advanced Travel Information System (ATIS) Committee is concentrating on creating a framework that will make ITS work on any vehicle anywhere in the world.

SAE's involvement in ITS standards will intensify in the future. SAE's vision is to lead ITS development into the 21st century through standards and programs that will enable ITS practitioners to put the technology into vehicles on a worldwide basis.

Current Standards Under Development

1. ITS data bus reference architecture model
2. Standard for navigation and route guidance function accessibility while driving
3. Location reference message specification
4. ATIS data dictionary standard
5. ATIS traveler information service message list
6. On-board land vehicle mayday reporting interface
7. Standard for ATIS message sets delivered over high speed FM subcarrier modulation
8. In-vehicle navigation and ATIS device message set
9. ITS data bus protocol
10. ITS data bus gateway reference design recommended practice
11. Standard for navigation and route guidance man-machine interface transactions

1.10 US DOT ITS Joint Program

Organization and Mission

The US Department of Transportation's (US DOT) ITS Joint Program Office is supporting an extensive, multi-year program of accelerated standards development to strengthen and facilitate the successful deployment of ITS with a specific near-term focus on the Intelligent Transportation Infrastructure. The program is supporting and accelerating the existing ITS consensus-based volunteer standards processes already underway in the US.

Role in Standardization

Program goals with respect to standards development are driven by the following direction provided in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), "The Secretary shall develop and implement standards and protocols to promote widespread use and evaluation of ITS technology. To the extent practicable, such standards and protocols shall promote compatibility among ITS technologies implemented throughout the States. The Secretary may use the services of such existing standards-setting organizations as appropriate."

In support of these goals, specific objectives of the standards program are:

1. To facilitate interoperability at interagency, inter-jurisdictional, state, and national levels. Common understanding and use of informational message transmissions will promote

coordination and interoperability among public agencies, information service providers, and travelers.

2. To provide an environment for which public sector agencies (and others) have multiple vendors from which to choose, when procuring products and services. This will create competition, resulting in lower cost and higher quality. It will also avoid the situation whereby an agency is locked into a single vendor relationship.

3. To facilitate the widespread deployment of ITS. Standards will drive efforts towards deploying integrated systems. Public agencies will be able to reference appropriate standards in their procurement packages, deploy "open" systems, and provide platforms for generating private sector interest and investments.

4. To ensure the safety of the traveling public. Establishment of human factor and operational guideline standards will ensure that ITS products and services be utilized in a safe manner.

5. To provide an environment which will promote the creation of an ITS market. Development of non-proprietary standards will make accessible the necessary technical information by which new and innovative companies can break into the ITS market to both products and services. Building to these standards will also ensure interoperability among multiple vendor products much like the integration of a home stereo system.

2. IMPLICATIONS OF STANDARDIZATION PROCESS FOR SYSTEM MANAGEMENT

The performance of transportation systems is enhanced through the application of effective management and control strategies. The National System Architecture (NSA) for intelligent transportation provides a framework for executing transportation management and control through the use of sensing, communication and information technologies. The framework can be found in a collection of three NSA documents:

- *Implementation Strategy*
- *Physical Architecture*
- *Theory of Operations*

Transportation management and control comprise processes aimed at achieving smooth and efficient traffic flow, minimal delay and safe travel. Examples include:

- Synchronization of arterial traffic signals
- Ramp metering to smooth highway traffic flow
- Dissemination of information to travelers to balance network traffic flows
- Clearance of traffic incidents
- Bus headway control to minimize passenger delay
- Continuous improvement strategies aimed at removing system bottlenecks

Each of these processes relies on the collection, communication and synthesis of information, and the subsequent formulation of protocols and strategies for acting on the information. Transportation management and control (M&C) also frequently entails coordinated action, spanning jurisdictions, modal and functional agencies, and internal organizational divisions. For example, incident clearance can require coordinated response from highway patrol, ambulance, fire, highway maintenance, HAZMAT and traffic operations.

At present, cross-organizational coordination presents the biggest challenge to M&C, both at a technical and an organizational level. At a technical level, it may be necessary to overcome differences in hardware, software, data file structures, and communication protocols. At an organizational level, it may be necessary to overcome differences in objectives, management philosophies and capabilities. Because all of these dimensions can vary enormously from organization to organization, each coordination effort traditionally requires individualized attention and protracted negotiation. Each issue must be resolved on a case-by-case basis, creating long delays and greatly increasing the cost of achieving coordination.

A key objective in creating a California System Architecture could be to develop a quick and efficient mechanism that would enable jurisdictions to coordinate transportation management and

control and improve system performance. Adopting national or international standards would be an important aspect of developing that architecture.

2.1 Interviews with Caltrans

In earlier research under the California System Architecture project (Horan et al, 1997), interviews were completed with Caltrans Traffic Operations groups around the state, to assess their involvement in the standardization process and their steps toward implementation of the NSA.

Most interviewees were familiar with standards setting activities in NTCIP, but not in other bodies, such as SAE. Some interviewees identified people within their organization who had participated in NTCIP meetings or committees. Some stated that Caltrans headquarters was representing their district, and some felt that the electrical engineers (not operations) were representing their district. Most people were aware that NTCIP is developing communication protocols for field elements, such as signal control, ramp meter control, CMS, and CATV, and all of these felt it was an important activity. A few people were critical of the pace of progress and of commercial interests, and the high overhead imposed on communication in evolving standards.

Smaller districts and agencies appeared to be the most interested in standardization. These apparently have major problems with system compatibility and maintenance, and lack the internal resources to resolve these problems. Larger districts were also interested in NTCIP, but less so, apparently because they had the resources to resolve problems internally.

2.2 Interviews with Device Manufacturers

Interviews were conducted with companies that manufacture traffic management products to assess their participation in NSA and standards setting. Four categories of products were investigated: closed-circuit-television (CCTV) cameras, loop detectors, changeable message signs, and traffic controllers. These represent the principal field elements currently being installed on California highways. Product managers at a total of 10 different companies were interviewed by telephone. Questions centered on the role of standards and system architecture in product development, as well as their input into these processes.

CCTV Camera Manufacturers

Kodak, Cohu, and Odetics manufacture CCTV cameras that are mounted over highways and other heavily traveled roads to monitor traffic conditions. These companies have had minimal involvement with NSA and NTCIP. Camera protocol standards are well established, so they focus their resources on developing and enhancing their cameras' features.

Kodak and Cohu deal primarily through a system integrator, who works with the government at a global level to develop traffic management plans. The system integrators define the government's technological requirements, and then interface with Kodak and Cohu to purchase cameras that fulfill the design's needs. In contrast to Kodak and Cohu, Odetics manufacturers cameras for a variety of industrial applications, ranging from traffic management to security systems. They rely on their distributors to stay abreast of the government initiatives. For example, Intersection Development Corporation, an Odetics distributor, is a member of the NTCIP steering committee.

None of the three camera manufactures were concerned with meeting state specifications. They do not work with their competitors to establish industry standards because California has already defined detailed camera specifications. Furthermore, they do not have direct contact with the government agencies. Instead, they focus on system integrators as a middleman to the government.

These companies compete on factors other than defining protocols, such as the amount of light needed to view a picture, resolution, or camera lifetime when exposed to weather. They are not concerned with setting protocol standards and are not involved with the government initiatives. They do not believe that a competitive advantage can be gained by assisting in standard development.

Loop Detector Manufacturers

Peek Traffic and Timemark Traffic Controllers manufacture loop detectors which measure traffic flow over fixed points in the road. Both companies are working to define standards for the industry. Peek is also working with NEMA (National Electrical Manufacturers Association) and Timemark with ASTM (the Association for Standards and Test Methods) to create specifications for loop detectors. These two groups are attempting to enhance the current standards at a more detailed level.

Peek is concerned that inferior manufacturers will win business with low-quality products at discounted prices. These companies will create a perception in the marketplace that all loop detectors are poor quality products, and that governments should select an alternative technology to measure traffic flow. Therefore, Peek is working through NEMA in the belief that it will be more difficult for low-quality products to meet stricter standards, which would ultimately enhance the industry's reputation.

Both companies have worked directly with government agencies. Their motivation has been to establish relationships with the agencies, rather than pushing for certain specifications. They feel that it is their role to assist the government in establishing standards, and it is a company's option to offer additional product features which exceed specifications. Additionally, both companies are well positioned for future contracts based on their government interaction.

Changeable Message Signs

American Electronic Signs, Cohu, and Vultron manufacture electronic, changeable message signs, which enable traffic management agencies to display information to drivers as they travel. These three companies have been involved with NTCIP to various degrees. Each company expressed concern regarding low quality, "fly by night" companies who tarnish the industry's reputation.

Vultron is on the NTCIP committee, and they are working to develop an industry standard protocol for changeable message signs. American Electronic Signs is on the NEMA technical committee to define protocols for all signs. Finally, Cohu is working indirectly through contacts on the NTCIP steering committee to learn the specifications early, but they will not contribute to defining them. Through their standard setting work, these companies are requiring all competitors to meet the state's specifications, thus eliminating inferior products. None of these companies are involved in industry groups other than the government programs.

Cohu and Vultron work primarily through systems integrators (similar to the camera manufacturers). The integrators help the government develop detailed protocols and overall traffic plans, and then engage the message sign companies to supply products.

Traffic Controllers

Dynatrol, Intersection Development, and Safetran Traffic manufacture hardware which enable traffic management centers to make changes in field equipment from a central location. For example, the 170 controller can be used to control the timing of traffic signals or collect pollution data from a central point. These companies have diverse viewpoints on the standards setting projects. Each company currently manufactures the 170 controller, and they are anticipating California's roll-out of the 2070 controller's specifications.

Intersection Development has taken a leadership role in setting the 2070 controller's standards. Their chief engineer is an NTCIP committee head, and they are also working on a subcommittee to define protocol standards. Dynatrol has taken the opposite position. They avoid interaction with the government standards setting groups. Dynatrol's strategy is to gain acceptance on the State of California's approved products list as a low cost producer once the protocol has been established. Safetran's stance is in the middle. They gain insight on upcoming trends through their involvement with the TRB (Transportation Research Board). They are also heavily involved in defining product specifications on an informal basis. Through their relationship with the state, they are one of many companies who offer input into the products during their development stages.

None of the traffic controller manufacturing companies interact with competitors. All three are confident that the state's detailed traffic controller specifications force all competitors to produce high quality goods.

Through their standards setting involvement, each of the three companies has developed different relationships with the government over time. Intersection Development works directly with the government and system integrators. They hold local information seminars and even had a demonstration trailer tour the country for two years. Conversely, Dynatrol has virtually no interaction with government standards setting agencies. They focus on providing products that meet existing specifications. Safetran has strong working relationships with the government. The government bounces ideas off their technical staff, and they provide informal input on issues such as technical feasibility of products. They are one of many companies who have this type of relationship with the government.

2.3 Issues for Systems Management

ITS standards are primarily concerned with the exchange of information through defined interfaces. Standards are being developed for information exchange between TMCs and field devices, from TMC to TMC, to and from vehicles, and so on. Standards are a way to convert the ideals and concepts expressed in the NSA into tangible results, in terms of simplified procurement, "plug and play" hardware compatibility, and software compatibility. Standards are primarily directed at simplifying the process of implementing new technology and upgrading old technology.

Standardization says very little about the content of the information that is communicated or the management strategies that this communication enables. Though standardization may help create new communication channels, the mere existence of these channels will not guarantee improved systems management. This will depend on strategies to convert information into actions, such as dynamic signal control, incident response and route diversion.

Table 2 summarizes the impacts of standards developments on six areas of transportation:

Surveillance: Principally collection of real-time information from field devices, including cameras, loops, and vehicle location systems.

Information Dissemination: Communication of transportation information to travelers

Control: Control of the transportation system, through signals and vehicle control

Toll Collection: Automatic collection of user fees.

Communication: General purpose communication to support a variety of ITS services.

Management: Higher level management functions, such as incident management.

As the table shows, relatively few of the standards efforts directly impact management, though quite a few are directed at control. This is appropriate, as management functions are the least amenable to standardization.

Table 2. Impact Areas of Standards

		IMPACT AREAS					
Organization	**Standard**	Surveillance	Info Dissem	Control	Toll Collect	Communication	Management
AASHTO	NTCIP dynamic message signs		X				
AASHTO	NTCIP highway advisory radio		X				
AASHTO	NTCIP environment sensor stations & TMS	X					
AASHTO	NTCIP video camera control	X					
AASHTO	NTCIP TMC to TMC						X
AASHTO	NTCIP ramp meters			X			
AASHTO	NTCIP weigh in motion	X					
AASHTO	NTCIP video detection devices	X					
AASHTO	NTCIP vehicle classification devices	X					
AASHTO	NTCIP automatic vehicle identification	X					
ASTM	DSR 2-way, roadside, physical	X	X			X	
ASTM	DSR 2-way, roadside, data link	X	X			X	
ASTM	DSR 2-way, roadside, roadside comm equip	X	X			X	
ASTM	WIM with user requirements and test method	X					
IEEE	MW design, procure, constr, maint, and ops					X	
IEEE	Fiber optic installation practices					X	
IEEE	Standard for ITS data dictionaries					X	
IEEE	Message set template for ITS					X	
IEEE	Message sets for vehicle/roadside (ETC & CVO)				X	X	
IEEE	Message sets for incident management (EMS - TMC, E911)					X	X
ISO	Glossary of terminologies for TICS sector					X	
ISO	Reference model architecture(s) for the TICS sector					X	
ISO	Reference model architecture for generic AVI/AEI	X				X	
ISO	Stationary dissemination for traffic and travel information		X				
ISO	Automatic fee collection DSR communications					X	
ISO	Test procedures for automated fee collection				X		
ISO	Automatic fee collection requirements for DSR				X		
ISO	Locally-determined route guidance		X				
ISO	Forward obstacle warning systems			X			
ISO	Short range warning systems for low speed maneuvering			X			
ISO	Side obstacle warning systems			X			
ITE	ATC cabinet functional description			X			
ITE	ATC cabinet specification document			X			
ITE	ATA 2070 - ATC controller specification document			X			
ITE	ATC API functional description			X			
ITE	TCIP - transit data dictionary					X	
ITE/ITSA	ETTM user reqs for future national interoperability				X	X	
ITE	TCIP - transit vehicle to TMC message set					X	
ITE	TCIP - remote traveler support message set		X			X	
ITE	Traffic management data dictionary			X			
ITE	ATC cabinet standard			X			
ITE	ATC API specification			X			
ITE	External TMC - first, second, and third MS increments						X
NEMA	NTCIP object definitions for actuated traffic signal controllers			X			
NEMA	NTCIP object set for ramp meters			X			
NEMA	NCTIP object set for vehicle classification devices	X					
NEMA	NTCIP object set for video detection devices	X					
NEMA	NTCIP object definitions for variable message signs		X				
SAE	ITS data bus reference architecture model					X	
SAE	Navigation/route guidance function access while driving		X				
SAE	Location reference message specification	X					
SAE	ATIS data dictionary standard		X				
SAE	ATIS traveler information service message list		X				
SAE	On-board land vehicle mayday reporting interface	X					
SAE	ATIS message sets delivered over high speed FM subcarrier		X				
SAE	In-vehicle navigation and ATIS device message set		X				
SAE	ITS data bus protocol					X	
SAE	ITS data bus gateway reference design practice					X	

3. CONCLUSIONS

National and international standards will continue to address the needs for defining common interfaces for communication with field devices and communication between TMCs. As these standards evolve, transportation agencies will attain greater flexibility in installing systems and sharing information with each other.

Standardization has not addressed the need to develop protocols and procedures for responding to transportation events and managing the transportation system, nor is standardization likely to address this need. To date, these procedures have been developed ad hoc, on a project by project basis. Future research will examine operational procedures that are likely to be effective in solving transportation problems, and examine ways that these procedures might be implemented in California.

REFERENCES

Barrett, R. (1996). "Standards and Protocols Catalog, Special Studies Standards Task," JPL D-12066 Revision D, Prepared for the Federal Highway Administration.

Horan, T., L.J. Glazer, K.S. Massey, A.Lohmann, R..Hall, C. Intihar and R. Ice (1997). California Systems Architecture Study -- Part I, Claremont Graduate School Technical Memorandum.