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California System Architecture Study: Architecture for Action: A Strategy for Facilitating Near-term Deployment

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Publication Date

1999-02-01

CALIFORNIA PATH PROGRAM
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**California System Architecture Study:
Architecture for Action: A Strategy for
Facilitating Near-term Deployment**

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Christopher Hoene, Randolph Hall,
Christopher Intihar, Ronald Ice**

**California PATH Research Report
UCB-ITS-PRR-99-3**

This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the United States Department of Transportation, Federal Highway Administration.

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.

Report for MOU 338

February 1999

ISSN 1055-1425

FINAL REPORT

California Systems Architecture Study

**ARCHITECTURE FOR ACTION:
A STRATEGY FOR FACILITATING
NEAR-TERM DEPLOYMENT**

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ABSTRACT

Intelligent Transportation Systems (ITS), ushered in by ISTEA in 1991 and advanced under TEA-21 in 1998, fundamentally alter transportation planning and implementation in the United States. ITS shifts emphasis away from new construction and capacity to more efficient management of existing systems, in the process requiring increased coordination and integration of standards, systems, and policies. The National ITS Architecture provides a framework for integration, but leaves the majority of the implementation decisions to the state, regional, and local levels. California is well-positioned to take a leadership role in ITS implementation. Therefore, the purpose of this report is to identify the challenges to ITS deployment in California and to offer a set of recommendations for overcoming these challenges. The analysis is based upon an extensive literature review, interviews and focus groups conducted with over seventy-five transportation professionals from around the State, and a statewide *Deployment Symposium* held in September 1997. The report is organized around three layers of analysis, drawn from the National Architecture: Standards, System Management, and Policy. We conclude that the challenges to ITS deployment and development of the Architecture can best be overcome by first focusing on integration at the regional and local levels. At the same time, we identify the need for a more service-oriented public sector, whose role is to provide ITS information, education and training. We subsequently recommend a decentralized, evolutionary strategy – decentralized through an emphasis on increased regional and local authority, and evolutionary in its focus on developing the Architecture around near-term deployment – ‘Architecture for Action.’

Keywords: Intelligent Transportation Systems, systems architecture, institutional issues, policy, standards

EXECUTIVE SUMMARY

Overview

The establishment of an Intelligent Transportation Systems (ITS) Program in the Intermodal Surface Transportation and Efficiency Act (ISTEA) of 1991 signaled a paradigm shift for transportation systems. The role of ITS in today's transportation system is to promote efficient management and operations.

Fundamentally, the goal of ITS is to make current systems run more smoothly and safely by linking systems and jurisdictions. The end-state of ITS would therefore be to create one integrated and efficient transportation system, in contrast to the loosely-connected networks of transportation systems that exist today. The framework for creating this system is the National ITS Architecture, which provides a guide for integrating and implementing efficient networks. Yet, the National Architecture is really a conceptual and technical *framework* for establishing efficient linkages between these networks. Essentially all of the decisions about how to develop and implement ITS are left to sub-national levels of government – particularly individual states and local agencies – as well as private companies in the ITS marketplace.

Of the states, California presents a unique case study of ITS and the evolution of the Architecture. Recognized as a leader in the development and testing of ITS products and projects, California is therefore well-positioned to take a leadership role in defining how the National Architecture can best guide the implementation of ITS across the state. This should be done via a California Architecture that will further define how and where the National Architecture applies between systems and jurisdictions across the state. At the same time, it must encourage near-term deployment of ITS solutions to transportation problems.

This study therefore looks at the challenges to developing a California Architecture and, more generally, to effective ITS deployment statewide. The analysis is conducted from three vantage points, corresponding to the three layers of the National Architecture: (1) Standards, (2) System Management, and (3) Policy.

Purpose and Methodology

The purpose of this study is two-fold:

- (1) to identify the implications of the National Architecture for ITS projects in California,
- (2) to develop recommendations on how Caltrans can encourage effective deployment of ITS projects consistent with the National Architecture.

The study was conducted in three parts. The objective of Part I was to identify the dominant issues from each of the three perspectives listed above. Part I methodology consisted of two tasks: (1) *Literature Review* - Analyzing a number of Architecture reports plus various documents related to California ITS policies and programs, and (2) *Interviews* - Individual and group interviews of several dozen key California stakeholders. Both tasks focused upon the identification of dominant ITS deployment issues in California, which are described in this report. The objective of Part II was to explore the issues identified in Part I through a series of interviews and focus groups, culminating in a statewide *Deployment Symposium* held in September 1997 at which preliminary recommendations were presented. The objective of Part III was to examine in detail these preliminary recommendations, then to refine these recommendations into a State implementation strategy and present them in a Final Report.

Objective and Strategy

Two objectives for the Architecture are forwarded in this report. The first objective is to **implement efficient networks**, and the second is to **facilitate near-term ITS deployment**. The first is predicated on the idea that the role of ITS is to help manage existing transportation systems more efficiently. The second objective argues that the Architecture must emphasize near-term deployment of ITS products and projects. The two objectives are not mutually exclusive. Together, the message is to implement efficient networks as ITS technologies are deployed. – “Architecture for Action.”

The strategy for achieving these objectives also takes two forms. First, the overriding strategic recommendation is that **implementing efficient networks and facilitating near-term deployment must occur from the bottom up**. From a standards perspective, this strategy means that standardization should begin at the interface level. From a system management perspective, the implication is that systems must be integrated at local levels first, and built up from there to the regional and State levels. From a policy perspective, a bottom-up strategy means that deployment and the development of the Architecture must begin with local and regional policymakers and implementors. Secondly, **there is a need for a more service-oriented public sector, whose role is to provide ITS information, education and training**. From the standards, system-management, and policy perspectives, this strategy would have the public sector take a strong role in facilitating rather than directing ITS deployments across the state.

Summary of Recommendations

A series of recommendations have developed in coordination with the objectives outlined above. These recommendations represent the research team’s attempts to construct a longer-term, system-wide strategy for facilitating near-term deployment. A **decentralized evolutionary strategy** is subsequently recommended for developing an Architecture in the near-term. The strategy has several components. First, it emphasizes building the Architecture and deploying ITS beginning with local regional levels – from the bottom up. Second, it calls upon the public sector to become more service oriented in terms of the provision of information and ITS services. This strategy, and its specific recommendations for standards, system management and policy are summarized below.

Standards Recommendations

- **Develop a State Interoperability Plan**

The National Architecture is a consensus framework that should be tailored and incorporated into a State interoperability plan that will assist in connecting ITS activities in the State within the context of national and international standardization efforts that are underway. The interoperability plan would identify the timing and influence of national standards and early deployments on a broader architecture framework within the State. It would identify the links between the various local and regional architectures in the State and explicitly identify any uniformity requirements needed to tie the various architectures in the State together.

- **Maintain Leadership Position in National ITS Architecture**

Maintaining a leadership position in the application of the National Architecture will continue to pay dividends for the State of California. The most tangible reason for maintaining this expertise is USDOT’s continued support for the National Architecture, and emerging federal policies that will require conformance with the National Architecture and applicable ITS Standards. Specific recommendations for maintaining a leadership position include:

- (1) formulating a statewide position on standards
- (2) establishing a limited set of performance requirements to improve ITS consistency

- (3) a mid-course assessment of State representation on national Standards activities
- (4) bolstering the State's representation in NTCIP Center-to-Center Activities.

- ***Deploy Standards Incrementally & Capitalize on Standards Testing***

As a result of substantial schedule pressure, many ITS standards-development activities are proceeding in parallel, with schedules that are accelerated ahead of the traditional three to five year standards development timeline. This approach will likely result in the release of many early standards products, few of which will have undergone substantial testing at the time of initial release to the public. USDOT has recognized the potential for the immaturity of initial standards products in its tentative policy for standards consistency. A cautious approach should therefore be considered in California so that premature standards mandates do not lock the State into solutions that are later found to be inferior. Additionally, the approaching wave of untested, but balloted interoperability standards may be an opportunity for the Caltrans Test Center for Interoperability, which is well positioned to do some of the required testing.

System Management Recommendations

- ***Develop Model Agreements and Policies***

Model agreements provide “boiler plate” language that can be adopted within any multi-jurisdictional project of a given type, or any universal policy that governs all activities of a given type. They can be developed in much the same way as a standard. An ad hoc committee is formed under the auspices of a recognized organization, such as Institute of Transportation Engineers or perhaps Caltrans, with a single objective of developing a specific type of model agreement. A negotiation and working group process is set to develop the agreement within a set schedule, after which the agreement is submitted to balloting by involved parties.

Negotiating specific agreements is key to the success of model agreements. The model agreement has no force until it is adopted by a multi-jurisdictional project. Organizations entering into an agreement would use the model agreement as a starting point, keeping the portions that are relevant and changing or striking others. Specific terms are added to localize the agreement. Once the agreement is finalized at the staff level, it is submitted to higher levels of the organization for formal approval. The negotiated agreement provides the structure for how the system is operated on a day-to-day basis. The agreement is only meaningful if all involved parties adhere to its terms, and use it to improve their coordination of system-management functions.

Areas where model agreements are needed include: incident management (using a fire district model), plus flow management during incidents and real-time network interfaces (modeled after the electrical power industry). Caltrans Headquarters should play the lead role in developing model agreements through Traffic Operations.

- ***Implement a ‘Client/Server’ Model, With ITS as Mechanism***

ITS should be the mechanism used to implement a “client/server” model for delivering transportation services. In the future, planning organizations will provide funding for transportation and, for this reason, they will increasingly become the voice of the transportation customer (i.e., client).

Transportation operating agencies (Caltrans, cities, and transit agencies) will therefore need to concentrate on delivering transportation services that meet the needs defined by planning organizations.

Under the client/server model, we recommend that individual planning organizations establish ITS-based reporting requirements for the agencies that they fund. This would entail uniform reporting that tracks

critical transportation statistics, such as congestion, accidents, and traffic volume. ITS would provide a mechanism for data collection and reporting. Transportation agencies would be required to track the performance of the transportation system, and to utilize performance tracking as a continuous improvement mechanism. Demonstrated success in improving performance would be a factor in project funding.

Policy Recommendations

• *Emphasize Regional and Local Level Coordination*

To reassert a commitment to ITS deployment, a strategy should be employed that emphasizes district/regional and local level coordination and authority. First, Caltrans district staff should play a facilitator role with MPO's. Second, Caltrans headquarters should consider allocating additional funding to districts or MPO's for ITS projects that serve specific objectives.

Regional and local integration in California can use the lessons from the Southern California Priority Corridor (SCPC) and TravInfo as models for future efforts. These two models provide a point of departure for creating similar organizations and both are based upon the creation of a new ad hoc coordinating body. This is not to say that either of these models necessarily represent the exact form in which regional integration should occur. Obviously, because they were early examples of ITS and regional integration, problems were encountered (e.g. the length of time it took to reach agreement among the different jurisdictions). Nevertheless, the successes and failures of the two models should be useful lessons for future interjurisdictional deployments.

• *Adopt a Public Sector Service-Orientation*

Caltrans is uniquely positioned to offer a range of services to local and regional implementors that can aid in facilitating near-term deployment and the development of the Architecture. For this reason, the recommendation at the State level is for Caltrans to become the primary ITS service provider. Services that need to be provided include ITS information, education and training, as well as the tracking and monitoring of ITS deployment efforts throughout the State.

Caltrans role as primary service provider should take two forms. First, Caltrans should serve as a clearinghouse for information on ITS technologies, deployments, and training. Second, Caltrans should establish a peer assistance and referral network within the State through which experienced and knowledgeable ITS implementors could be made available for consultation with newcomers to ITS deployment, especially during planning and design phases.

• *Use A Stratified, Market-Driven Approach to Forming Public-Private Partnerships*

With regard to the private sector, it must be recognized that it is not one homogenous entity. Rather, the private sector is quite diverse. Participation by the private sector, as outlined in later sections, can take many forms. Characteristics and business practices can therefore vary greatly. For this reason, a single strategy to increase private involvement will not be effective. Therefore, the recommendation is to develop a stratified approach to recognize the diversity of the private sector.

Participation of the private sector relies strongly upon the ability of the public sector to provide a stable, committed, and business-friendly environment for private investment. Specific concerns include the costs of accessing public data, lack of public sector funding for systems, and contracting laws and regulations which slow the deployment process and make partnering less cost-effective for the private sector. In many ways, the gist of these concerns is that the public sector, in order to enable more public-private partnerships, must become more market-driven. A market environment in the public sector could

improve the likelihood of partnerships by offering a streamlined, shorter, and more flexible contracting process. Efforts should also be made to create technically consistent, common public policies to encourage entrepreneurial consistency.

About This Report

The report is presented in four chapters. Chapter 1 summarizes the research findings for the entire report with an emphasis on recommendations. The chapter identifies key ITS implementors, analyzes the major challenges to ITS deployment faced by each of the implementors, and concludes with a series of recommendations. Chapters 2-4 then present the detailed findings in each of the three areas respectively -- standards, system management, and policy. To make best use of this report, readers are encouraged to first peruse Chapter 1, then proceed directly to any (or all) of the following three chapters that are individually relevant.

CHAPTER 1: SUMMARY FINDINGS AND RECOMMENDATIONS

1.1 Introduction

1.1.1 Overview

The establishment of an Intelligent Transportation Systems (ITS) Program in the Intermodal Surface Transportation and Efficiency Act of 1991 (ISTEA) signaled a paradigm shift for transportation systems. During the prior era, in which the Interstate Highway System was developed, transportation systems emphasized new construction and increasing capacity to solve transportation problems. Recognizing the end of that era, the role of ITS in today's transportation system is to shift emphasis away from building new capacity and new systems to efficient management and operations of existing systems. Fundamentally, the goal of ITS is to make current systems run more smoothly and safely by linking systems and jurisdictions. The end-state of ITS would therefore be to create one integrated and efficient transportation system, in contrast to the loosely connected networks of transportation systems that exist today.

The objective is therefore large, and the change required is dramatic. A host of systems, standards, policies and jurisdictions must be integrated across national, state and local levels if the objective is to be realized. The sheer size of the task makes management at the national level impossible. Instead, the focus at the national level is to facilitate integration by providing a framework for standardization, system management and policy coordination. That framework is the National Architecture, which provides a guide for integrating and implementing efficient networks of systems.

These networks come in various forms. A *technical network* exists which includes the interfaces and standards used, or needed, to physically link systems within and between jurisdictions. In this respect, the technical network is perhaps the most pivotal for achieving a National Architecture. Similarly, a *transportation operations and services network* also exists, which includes the various systems that must be integrated to encourage cross-system communication. As example, traffic management centers (TMC) must be able to communicate with each other to more-efficiently manage the day to day traffic. Their systems must therefore be compatible. Lastly, a *policy network* must be developed to build the institutional capacity for interjurisdictional coordination and cooperation. While it is the least technical of the three networks, institutional arrangements and agreements between jurisdictions are necessary to take advantage of technical integration and advances. Without integrated policy, technical advances are unlikely to be implemented.

Thus, the challenge for the National Architecture is to facilitate the development and integration of the three networks simultaneously. Yet, the National Architecture is only a conceptual framework for establishing linkages between these networks. Essentially all of the decisions about how to develop and implement standardization, system management, and consistent policy are left to sub-national levels of government, particularly individual states and local agencies.

Of the states, California presents a unique case study of ITS and the evolution of the Architecture. Recognized as a leader in the development and testing of ITS products and projects, California is

therefore well-positioned to take a leadership role in defining how the National Architecture can best guide the implementation of ITS across the state. This could be achieved via a California Architecture. As discussed in later sections, California's leadership role gives it the opportunity to define the standards, systems, and policies even at the national level. Yet, California's transportation system is also particularly large and complex. Given the size and scope of transportation in the State, the task of defining an ITS Architecture for California is superceded in difficulty perhaps only by the national level.

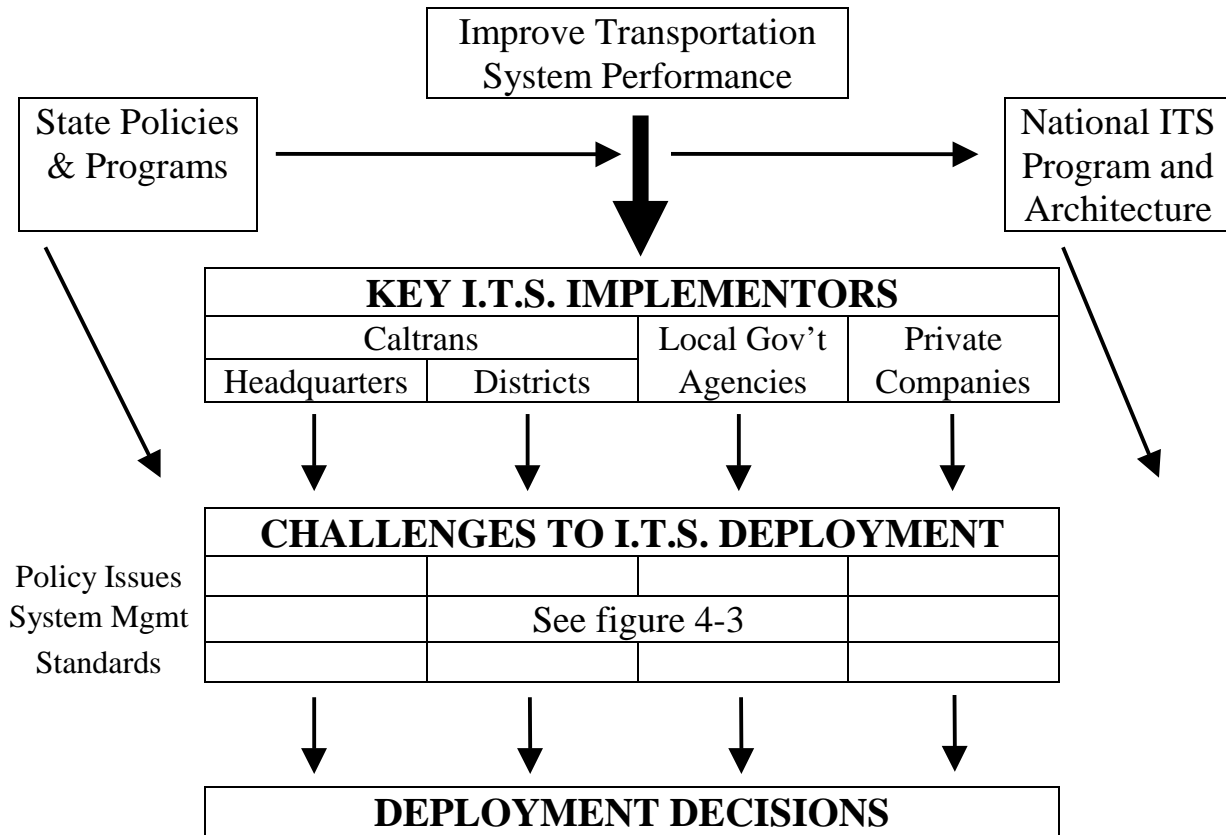
The subsequent challenge in California is to manage the integration of standards, system-management, and policy across its own diverse landscape. A California Architecture, like the National Architecture, must provide a framework for seamless integration. At the same time, it must encourage near-term deployment of ITS solutions to transportation problems. The evolution of the Architecture and ITS deployment must occur together to achieve the goal of implementing efficient networks.

This study therefore looks at the challenges to developing a California Architecture and to effective ITS deployment. The analysis is conducted from three vantage points, corresponding with the three networks discussed above: (1) Standards (technical network), (2) System Management (transportation operations and services network, and (3) Policy (institutional network). We lead with standards throughout, recognizing that without technical integration the need for system management and policy integration is rendered moot.

1.1.2 About this Report

This report is presented in four chapters. Chapter 1 summarizes the research findings for the entire report with an emphasis on recommendations. Intended as an overview, Chapter 1 is structured according to the conceptual model shown in Figure 1, which graphically portrays the ITS decision-making process. The model is presented to help identify the ways in which Caltrans may undertake actions to encourage best ITS deployment. The chapter analyzes the major challenges to ITS deployment faced by each of the implementors, stratified by the three perspectives listed above (standards, system management, and policy), and then concludes with a series of recommendations for near-term deployment. Chapters 2-4 present standards, system management, and policy level findings respectively. To use this report most effectively, readers are encouraged to first peruse Chapter 1, then proceed directly to any or all of the following three chapters that are most individually relevant.

Figure 1-1. Conceptual Model of ITS Deployment Decisionmaking



1.1.3 Purpose and Methodology

Background: From ISTEA to TEA-21

In 1991, the federal Intermodal Surface Transportation Efficiency Act (ISTEA) established a program to encourage implementation of Intelligent Transportation Systems (ITS). Toward this objective, the National ITS Architecture has been devised and is now being disseminated to guide transportation professionals in identification, design and deployment of ITS projects. The National Architecture provides a conceptual framework for understanding ITS and its relationship to other transportation activities; it encourages standardization of elements, interfaces and system behavior; and it facilitates both technical and institutional integration. Federal and State funding for ITS projects requires conformance with the National Architecture.

ITS continues to be a key component of the successor to ISTEA, the Transportation Equity Act for the 21st Century (TEA-21). TEA-21's reinforcement of the federal commitment to ITS makes the continued evolution of the National Architecture in California increasingly imperative. Additionally, USDOT is now in the process of defining *conformance requirements* to insure that federally-funded ITS projects are consistent with the National ITS Architecture. The preliminary requirements have been presented at a nationwide series of "Outreach and Listening Sessions" and Interim Guidelines are expected before the end of 1998 that will define the conformance requirements. These will be followed by "Final"

Guidelines. The continuing federal commitment to the National Architecture is therefore evident in the evolution from ISTEA to TEA-21 and the emerging *conformance requirements*.

Purpose of This Study

The purpose of this study is two-fold: (1) to identify the implications of the National Architecture for ITS projects in California, (2) to develop recommendations on how Caltrans can encourage effective deployment of ITS projects consistent with the Architecture. As will be seen throughout this report, this second purpose often generates issues that do not arise entirely out of the National Architecture but are more inherent to ITS generally. The study, as mentioned above, was conducted from three perspectives: (1) State and local policymakers, (2) State and local system operators, and (3) the standards for system interfaces and functionality that are required to enable cooperation between the many public and private implementors.

Study Organization and Methodology

The study was conducted in three parts. The objective of Part I was to identify the dominant issues from each of the three perspectives listed above. Part I methodology consisted of two tasks: (1) Literature Review - Analyzing a number of Architecture reports plus various documents related to California ITS policies and programs, and (2) Interviews - Individual and group interviews of several dozen key California stakeholders. Both tasks focused upon the identification of dominant ITS deployment issues in California, which are described in this report. The objective of Part II was to investigate the issues identified in Part I through a series of interviews and focus groups, culminating in a statewide *Deployment Symposium* held in September 1997 at which preliminary study recommendations were presented and discussed. The Deployment Symposium was attended by more than fifty public and private sector transportation professionals from across California and was intended to provide further refinement of the issues identified in Part I, as well as a review of the project's initial recommendations for facilitating near-term ITS deployment. The objective of Part III was to examine in detail the suggested recommendations, then to refine them into a State implementation strategy and present them in this Final Report.

1.1.4 Objective and Strategy: Recurring Themes

A number of recurring themes run throughout this report. These themes refer both to the objectives, as we suggest here, for a California Architecture, and a strategy for increasing the likelihood that the objectives are met.

Two objectives for the Architecture are forwarded in this report. The first objective is to ***implement efficient networks***, and the second is to ***facilitate near-term ITS deployment***. The first is predicated on the idea that the role of ITS is to help manage existing transportation systems more efficiently. Efficiency is achieved through improved communication using ITS technologies. These technologies required that networks and systems are implemented and connected. The second objective argues that the Architecture must emphasize near-term deployment of ITS products and projects. The challenge is not to impede ITS deployment by requiring implementors to wait for architectural direction. Instead, the focus should be placed upon constructing the Architecture around evolutionary ITS deployment. The two objectives are not mutually exclusive. Together, the message is to implement efficient networks as ITS technologies are deployed. – “Architecture for Action.”

Of course a strategy is needed for achieving these objectives. The strategy recommended in this report also takes two forms. ***The first overriding strategic recommendation of the report is that implementing efficient networks and facilitating near-term deployment must occur from the bottom up.*** California's

transportation systems are too complex and diverse to achieve the aforementioned objectives using a top-down strategy. From a standards perspective, this strategy means that standardization should occur from the interface up. From a system management perspective, the implication is that systems must be integrated at the local levels first, and built up from there to the regional and State levels. Lastly, from a policy perspective, a bottom-up strategy means that deployment and the development of the Architecture must begin with local and regional policymakers and implementors. Policies and institutional capacity must be built between local-local, local-regional, and regional-regional levels first. Too much supra-level direction simply won't be relevant to many of California's jurisdictions, which vary widely in size, scope and capacity.

However, a bottom-up strategy does not signal a reduced role at the State level. On the contrary, no organization in the State is better equipped to monitor, track, and oversee the development of the Architecture than Caltrans. Yet, ITS has fundamentally altered State roles from that of primary implementors to that of primary service providers. Therefore, ***the theme of service provision is the second recommended strategy in this report.*** Examples of services that need to be provided include information, education and training on ITS technologies and solutions, as well as the tracking and dissemination of information on ITS deployment. These services need to be provided at all levels, but should be led by Caltrans as the only organization capable of overseeing the development of the Architecture statewide.

The themes of implementing efficient networks, facilitating near-term deployment, integrating standards, systems, and policies from the bottom up, and service provision appear throughout the report.

1.1.5 FORCES AFFECTING ITS IMPLEMENTATION

General Transportation Needs and the Role of ITS

Government transportation agencies throughout California are facing diverse and growing transportation problems, often with resources that are static or diminishing. Increasing congestion on freeways and major arterial roadways is perhaps the most visible of these problems, and ITS does offer a number of measures to address traffic congestion. However, many other transportation needs demand attention and compete for scarce resources. Thus, ITS will be seen by most transportation professionals not as an end in itself, but as another tool for responding to a range of transportation needs. Where ITS solutions are available, transportation professionals most need information, education and the ability to deploy in the near term. These needs must be met if ITS projects are to be viewed as more valuable for solving transportation problems.

National ITS Programs and System Architecture

Several national-level influences are affecting transportation professionals:

- Conformance Requirements: TEA-21 requires that federally funded projects that contain ITS elements conform to the National Architecture and all applicable ITS standards. The USDOT is now developing guidelines. Interim Guidelines are expected before the end of 1998, with "final" Guidelines in 1999.
- Federal funding programs (e.g. FOT's, Priority Corridors, MDI) - The availability of federal funds designated for ITS projects has catalyzed focused deployment actions in California and other states.
- Conferences & Publications (e.g. ITSA, ITE, TRB) - Professional organizations are devoting substantial attention to ITS. This is a major source of information for transportation professionals.
- Education & Awareness Programs (e.g. USDOT, CAATS, Universities) - A broad range of ITS education efforts target decision-makers at all levels, including elected officials, agency administrators, planners, engineers and technicians.

The National Architecture will play a substantial role in all the above efforts. More specifically, it will influence transportation professionals in a number of ways. The Architecture provides a conceptual framework and vocabulary to help them both understand ITS generally and how their specific ITS projects should interact with other transportation projects. It also identifies beneficiaries, in terms of the users served by “user services” and the markets served by “market packages.” The Architecture further encourages standardization of major elements (subsystems) within an ITS project, standardization of interfaces between subsystems and between connected ITS projects, and standardized behavior of certain ITS components to yield consistency to travelers nationwide. Of perhaps greatest importance, the Architecture encourages “integration” in the technical sense described above but also in an institutional sense. That is, the Architecture facilitates and encourages deployment of ITS projects spanning jurisdictional, organizational and modal boundaries to achieve regional benefits otherwise unattainable. Finally, federal and state funding for ITS projects increasingly require conformance to the Architecture.

While the Architecture provides the overall conceptual framework, it cannot define many of the details needed to deploy ITS at the state and local level. For that reason, *a “California Architecture” is needed to further define how and where the National Architecture applies between systems and jurisdictions across the state.*

California ITS Policies and Programs

Numerous State policies or programs affect -- or may affect -- ITS implementors. In the financial realm, most ITS funding from USDOT flows through Caltrans and current Caltrans policy stipulates that all new ITS investments must be Architecture-compatible. In the technical realm, Caltrans has established standards for automated vehicle identification (AVI) for the purposes of electronic toll collection. Caltrans is also developing a comprehensive set of ITS policies and programs. The Advanced Transportation Systems (ATS) Program Plan outlines proposed policy changes and program principles that would influence ITS implementors.

To achieve the goal of integration, the strategy for encouraging deployment of Architecture-conforming ITS projects should be based upon: (1) Altering the forces influencing transportation implementors, and/or (2) Reducing the barriers to ITS deployment. The following sections discuss the key ITS implementors and the barriers to ITS deployment facing each of them.

1.1.6 Key ITS Implementors in California

Following the conceptual model presented in Figure 1-1, this section enumerates and briefly describes the key organizations involved in implementing ITS in California, including their objectives and scope of interest. The purpose is to understand the range of parties that could play an important role in a California ITS Implementation Plan.

Caltrans Headquarters

Caltrans Headquarters includes a number of divisions, which have different ITS-deployment responsibilities but a consistently statewide scope of interest. Their level of knowledge of the Architecture is high compared to other key implementors.

Caltrans District Offices

Caltrans District Offices vary in size and technical sophistication. While there are 12 district offices, most ITS implementation activities involve six districts: 3 (Sacramento), 4 (Bay Area), 7 (Los Angeles), 8 (San Bernardino/Riverside), 11 (San Diego) and 12 (Orange County). The district office's

objective is to improve performance of the State-maintained roadways within their jurisdiction, which is regional or sub-regional in scope. Their general level of Architecture and ITS knowledge appears to be low-to-medium, relatively, with the exception of some individual staff members.

Regional and Local Government Agencies

Local government agencies of several types will (or may) play a major role in ITS deployment. ***Metropolitan Planning Organizations (MPOs)***, have a regional scope, a longer-range vision, and very broad objectives that address all forms of transportation plus other regional planning issues. As discussed later, MPOs are the gatekeepers to integrating ITS into the regional planning process (“mainstreaming”), as identified in both ISTEA and TEA-21. ***Transit agencies*** are usually sub-regional in scope, with the primary objective of operating the public transit and paratransit services within their jurisdiction. Some transit agencies (e.g. OCTA, LACMTA) are part of a larger organization with other transportation responsibilities related to ITS deployment. ***Municipal Transportation Departments*** have a comparatively narrow geographic scope and a shorter planning horizon, with a primary objective of maintaining safe and efficient traffic operations on surface streets within their city. The level of ITS and Architecture knowledge among staff at all of these local agencies is generally low-to-medium, with a few notable exceptions that are high.

Private Companies

Private Companies offering ITS products/services can be divided into at least two categories, depending upon the roles they may play in ITS deployment.

1. **Vendors to government** include two sometimes-overlapping categories:
 - a. consultants offering professional services (e.g. ITS design or integration studies)
 - b. manufacturers of technology products (e.g. signal control systems) sold to governments
2. **Mass Marketers** include the companies offering products/services to the public (e.g. in-vehicle navigation systems, traffic information).

A key objective of both types of companies is to make a profit (of course) and their scope of interest varies from regionwide to nationwide or worldwide. As discussed later, vendors to government are (or will be) strongly influenced by the Architecture and collaborate with public-sector ITS deployment efforts, while mass marketers appear to be moving on a path sometimes independent of government efforts. The level of Architecture knowledge among these private companies varies widely.

Other ITS Implementors

Two additional interest groups could exert substantial influence upon the implementation of ITS in California, but will not be addressed in this study: Commercial Vehicle Operators (CVO’s) and the California Air Resources Board (ARB). Future studies may want to analyze the roles of these two groups in particular.

1.2 Challenges to ITS Deployment in California

This section continues the explanation of the conceptual model of ITS deployment in California (see Figure 1-1), focusing on perhaps the most important element -- challenges to full and effective ITS deployment conforming with the Architecture. The section begins with an overview of key elements of the Architecture, followed by deployment challenges from three perspectives (Policy/Institutional,

Systems Management, and Standards) that parallel the three “layers” of the Architecture. The identified challenges represent the findings from earlier phases of the research that included a series of interviews and focus groups with transportation professionals.

1.2.1 Key Elements of the National Architecture

The Architecture Implementation Strategy (Rockwell, 1996) states that:

The National Architecture provides a general framework that may be adapted and elaborated into a broad range of regional transportation system designs. A regional architecture is a key product of this process that begins to overlay major technology and interface choices that are appropriate for the region onto the more general National Architecture definition. A regional architecture is a concise formal statement of the architecture choices made by the region. It documents the selected interface standards, regional configuration, and consensus technology choice that will support competitive procurement of systems within the region.

The Architecture leaves essentially all of the critical implementation decisions to regional implementors. Nevertheless, the Architecture provides a framework and vocabulary that can provide greater compatibility across regions, and also focus regional deployment efforts. Fundamentally, however, the Architecture defines a set of questions to be answered at the regional or perhaps local level. With the completion of the National Architecture, California agencies must now decide whether or not they should create (or participate in) a regional architecture (or architectures) and what form that architecture should take. This section discusses the challenges to successful ITS implementation in California in the three issue areas: Policy, System Management, and Standards (see figure 2-1 for a summary), as identified in a series of interviews and focus groups.

Figure 2-1 Challenges to Deployment

	Caltrans Headquarters	Caltrans Districts	Local Government Agencies	Private Companies
Standard Issues	Need For Internal Standards	Communications: - TMC↔TMC - TMC↔ISP - TMC↔Vehicle	Need For Open Systems Specifications	Mass Market Vendors: - TMC↔ISP communication - ISP↔Vehicle communication Vendors to Government: - Open System specifications.
System Management Issues	Education: - Need for System Design Manual Headquarters↔District Coordination Need for Field-device standards	Education: - Need for Design Manual Caltrans↔City Coordination - incident mgmt. - ramp metering - “smart corridor” Need For Operations and Maintenance standards & funding	Education: - Knowledge of ITS Benefits - Need for Design Manual Caltrans↔City Coordination - incident mgmt. - ramp metering - “smart corridor”	Mass Market Vendors: - TMC↔ISP Coordination Vendors to Government: - ITS Education - Need for Standards (specifications, and maintenance)
Policy Issues	Slow Procurement Process Headquarters↔District Coordination, Leadership Lack of Incentives to Private Sector	Education on ITS and the Architecture Arch. not specific (esp. Stds.) Caltrans↔Private Sector Coordination	Commitments to Legacy Systems Mainstreaming ITS into Planning Processes Incurring Local Costs for Regional Benefits Funding Uncertain	Market Definition (pub/pvt) Slow Procurement Process Public Sector Commitment Uncertain Incentives To Partner with Public Sectors Market Acceptance of ITS Products

1.2.2 Standards Issues

Standards are fundamental to the establishment of compatible and interoperable ITS deployments in the State of California. As ITS deployments continue in the State, diverse systems are being put into place that address the special needs of urban, suburban and rural transportation in California. Standards can provide interoperability across these implementations without impeding innovation as technology advances and new approaches evolve.

Potential Benefits and Attendant Risks

Well chosen, well timed, and broadly accepted standards can provide the following frequently cited benefits:

- *Cost-effective interoperability between diverse systems.* This benefit facilitates area-wide implementations that ultimately provide enhanced service to the consumer.
- *Preservation of investment.* Timely standards can reduce investments in multiple incompatible approaches, some of which will become casualties of natural selection in the market place.
- *Technology insertion.* Systems can be incrementally improved to take advantage of new technologies.
- *Creation of broader markets.* Interoperability standards set the stage for national and/or international markets.
- *Interchangeability.* Interchangeable equipment reduces capital costs through increased competition and reduces maintenance costs through smaller spares inventories of less expensive replacement parts.

Unfortunately, standardization is not a panacea. In particular, accelerating standards ahead of tangible markets or proven technologies, promulgating standards for interfaces independent of need, or heavy handed standards adoption policies which undermine market forces will inevitably have negative repercussions. Standards can also have the following undesirable affects:

- *Hinder development of new and innovative solutions.* Once a standard is developed and adopted, superior non-compatible solutions may neither be vigorously pursued nor marketable once achieved. This problem is accentuated if conditional funding or regulation is tied to adoption of the standard. An order of magnitude improvement may be required to overcome the inertia surrounding the standard.
- *Jeopardize investments by early adopter's of incompatible approaches.* Advanced ITS implementations are several years ahead of the supporting standards. Incompatible equipment may be rendered obsolete overnight and require costly retrofit or replacement. This issue is particularly pronounced in electronic toll collection, where multiple entrenched systems have stymied attempts for a national DSRC standard to date.
- *Inhibit Market Competition.* The market is an extremely efficient selective force. Standards which are accelerated ahead of the market will not benefit from lesson's learned during initial, competitive efforts to satisfy the market and may miss the market that finally does materialize or result in sub-optimal solutions.

The absence of standards will not prevent entry into markets with perceived profit potential. Such entry or positioning by several different competitors is a harbinger for timely standardization.

Addressing the Issues

Taking all factors into consideration, most agree that identification, development, and adoption of standards for intelligent transportation systems is an important step. This support is evident in the number of parallel ITS standards activities that are underway today. The breadth of activities is itself an issue since each should be monitored and leveraged within the State's own interoperability plan.

In parallel with these standards activities, ITS deployments continue at a rapid rate. These deployments provide valuable input to the formative transportation standards development process by making real-world data available to the standards development activities. More directly, achieving consistency between several deployments provides considerable momentum behind a particular approach that can result in a de facto standard that can later be formalized through the more rigorous (and time consuming) open standards development process. This approach offers a quick alternative for those interfaces where the formal process is making little headway or has not been initiated.

Interoperability in California

A general framework identifying the interoperability requirements for California could be an early product in an interoperability plan for the State. The National Architecture provides a natural starting point for developing such an interoperability framework. Chapter 2 provides a focused view of the interoperability requirements from the National Architecture that are associated with regional transportation management in California with special emphasis on connectivity.

The provided framework identifies all direct system interfaces to the Caltrans/CHP Transportation Management Center as well as many of the secondary interfaces at a level defined by the National Architecture. The framework establishes interoperability ratings for each of the interfaces as follows:

National Interoperability: Interfaces to mobile systems support national interoperability since the same mobile system should be able to roam the nation and use the local infrastructure to support ITS services. Failure to achieve national interoperability will limit the value of the service the interface supports. Examples of interfaces with a national interoperability rating include all interfaces to consumer products and the interfaces to private and commercial vehicles. These interfaces tend to be the focus of the national standards organizations and are subject to powerful market influences. It is particularly important that the State keep abreast of the national standards and international standards activities in these areas and support these standards within California as they become available.

Regional Interoperability: Regional interoperability is specified for center to center communications where the underlying coordination issues are regional, rather than national, in scope. National standards do mitigate issues that may arise as boundaries change and new requirements for information sharing develop over time. Early de facto standards adoption for these regional interfaces before national consensus is reached may be appropriate for California. Where there is standards activity on the national level (e.g., current activities within NTCIP for center to center communications), these activities should be supported and the evolving approach factored into current deployments to facilitate future convergence to the national standard once consensus is reached. For California, the impact of adopting a de facto standard for these regional interfaces before national consensus is reached would not be great enough to warrant postponing deployment.

Product Interoperability: Interfaces between systems that are operated and maintained by a single stakeholder do not require standardization to achieve national interoperability. The data formats and communications mechanisms that are used for these interfaces are largely transparent to the remainder of the Architecture. In some cases, national standards are still very beneficial since they may consolidate a market to achieve economy of scale efficiencies (e.g. NTCIP Center to Roadside). If multiple agencies adopt the same Product Interoperability standards within a region, future implementation of various

shared resource and cooperative control strategies will be facilitated. While there are notable exceptions, the State may choose to provide guidance for these interfaces but allow some latitude to the procuring agency to choose the best solution.

1.2.3 System Management Issues

Overall, the prevailing mood toward architecture in California is optimistic. Many of the coordination issues in Southern California are being resolved or are on the path to resolution, quite independent of the existence of the Architecture. Ongoing consultant contracts for TMC upgrades are accomplishing greater standardization in software. And most of the interfaces identified in the Architecture do not have to be addressed at all in California, at least not in the short run. Nevertheless, major issues remain:

- Gaining efficiency in procurement, maintenance and operation of field devices, with Caltrans HQ facilitating the development of internal standards.
- Developing an architecture for communication and shared operation for city TMC to Caltrans TMC and city TMC to city TMC interfaces, which can be used in "smart corridor" projects, signal coordination projects and meter/signal coordination projects, as well as incident response and management.

Reflecting the second issue, we found that one of the biggest challenges in developing the Los Angeles Smart Corridor was creating the policies for jointly operating the facility under the cooperation of the City of Los Angeles, Caltrans and other agencies. These policies are documented in "Operation Planning Element" of the project (JHK, 1993). As general themes, the document identifies which department has authority over decision making and use of equipment under well-defined circumstances, and defines action steps required for possible events. The Smart Corridor System acts like a third party that integrates information between agencies, rather than providing direct access to another agency's systems. Other key features are as follows:

- The Agency in which the incident is first reported is appointed the incident manager. The incident manager agency remains the incident manager agency for the life of the incident. (For example, if a highway incident is almost cleared and causes backup problems on surface streets, the Caltrans incident manager remains in charge.)
- The owner of a CCTV camera should be the top priority user. Other agencies who wish to use the other agency's camera must make certain that it is idle
- An operating agreement is recommended to "allow the use of each Agency's CMS for management of congestion and incidents on a facility within Smart Corridor irrespective of which agency has jurisdiction over the facility."
- Agencies can input information regarding planned events at their discretion.

Separate from this document, LA DOT and Caltrans have agreed that certain routine actions could be taken by within another agency's jurisdiction when the other agency's TMC is closed down. This might include changing a CMS message or choosing a pre-programmed signal plan. However, this concept does not appear to have been executed.

We found that similar approaches have been successful in other areas, including fire agencies and electrical power distribution. There is longstanding precedent for fire departments to provide aid to each other in case of emergency. Today, these agreements take the form of “Mutual Aid” and “Automatic Aid”, which formalize in advance the conditions under which one department will aid another, and the nature of the aid provided. Such agreements are commonplace today in California, in large measure in response to the large brush fires that occur in the State.

Electric utilities have established a hierarchical set of agreements to coordinate the generation and transmission of electricity among inter-connected networks.

- Purchase agreements
- OASIS
- Mutual Assistance Agreements.
- Inadvertent flow restoration.

Purchase agreements are pre-planned and long-term; OASIS is pre-planned but short-term; mutual assistance agreements are pre-planned responses to network incidents, and are executed in real-time; flow restoration occurs on a continuous basis.

As an illustration of how these agreements are established, the Federal Energy Regulatory Commission proposed that public utilities set up information networks to give wholesale sellers and purchasers of electricity equal access to information on transmission availability and prices in 1995. These are known by several names: “real-time information networks” (RINs), “Open Access Same-time Information System” (OASIS) or “Transmission Systems Information Networks” (TSINs)”. Two working groups came about to create a consensus on the “How” and “What” of the Information Networks. NERC facilitated the efforts of the “What” Working Group, as it came to be called. It was their job to reach consensus on the information that should be included on a TSIN in order to fulfill FERC's purpose. The effort resulted in a report, submitted to FERC on behalf of the industry. A sister to the “What” Working Group is the “How” Working Group. Facilitated by Electric Power Research Institute (EPRI), the how group focused on the technical details of developing a TSIN and providing for the functionality described by FERC. The “How” Working Group efforts also resulted in a report submitted to FERC.

This process is in some ways similar to standards creation. ITS standards have been 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 Architecture 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. We found that few of the ITS standards efforts directly impact management, though quite a few are directed at control.

1.2.4 Policy Challenges

Caltrans Headquarters

While California – and Caltrans – is widely recognized as having perhaps the most aggressive ITS deployment program, several policy issues are perceived to be preventing Caltrans Headquarters from fully implementing ITS projects consistent with the Architecture. The most significant issue is the Caltrans procurement process, which is widely seen by ITS implementors as too lengthy. Another important constraint is that Caltrans' role and scope of responsibility in ITS deployment is seen as not having been clearly defined by top management, and the vision of longer-term implementation has not been made clear to Caltrans staff. There is also a lack of confidence about Caltrans' commitment in providing reasonable incentives to the private sector for public-private partnerships.

Caltrans Districts

Some challenges related to Caltrans Districts are similar to those affecting Caltrans Headquarters. Further, most Caltrans district staff have limited knowledge about the Architecture and are subsequently not prepared to embrace Architecture recommendations. Where there is extensive knowledge of the Architecture, it is viewed as having limited use to Caltrans field staff because Architecture recommendations are not specific enough or do not answer their most important questions (e.g. communications standards). Finally, limited coordination between the private sector and Caltrans District offices hinders the deployment of ITS, in part because there are insufficient structures in place that would enable both parties to benefit from the relationship.

Local Government Agencies

Several policy issues affecting local governments relate strongly to their limited budgets. One such factor affecting their conformance with the Architecture is their pre-existing “legacy” systems. Some local governments have a great deal invested in proprietary systems, which may require extensive retrofitting to be compatible with the Architecture's open systems. A related issue affecting local governments is their reluctance to invest local money in certain ITS projects where part of the justification is based upon regional benefits. Similarly, local governments are hesitant to invest in those regional ITS projects in which they may lose some local control. They also may be less likely to invest in regional projects because they have competing local priorities, for which the local benefits are often more clearly defined. Finally, local governments' implementation of the Architecture is affected by funding issues, including predictability, duration and flexibility of federal/state grants; plus the adequacy, stability and predictability of continued local funding to support ongoing operations and maintenance.

Perhaps the major policy issue affecting local governments is the lack of assimilation of ITS into the planning processes of MPOs and other planning agencies. Several interviewees stated that most regional planners were not well-educated about the vision or benefits of ITS projects. For this reason, ITS projects are not currently “mainstreamed” in the planning process and are thus much less likely to be included into the regional plans that yield ongoing funding.

Private Sector

An important issue affecting the private sector is the delineation of markets. There is ambiguity over which potential markets the public sector will or will not serve. In some collaborative efforts, where the private sector will depend upon the public sector, there is excessive ambiguity about the timing, or even the certainty, of the government's participation. Consequently, some private sector mass marketers are moving ahead, independently of the public sector, with the development of ITS products which may not be consistent with the Architecture. Without resolution of these issues, the private sector is reluctant to make investments in developing products and services that may be mutually beneficial to the public and private sectors.

A second policy issue limiting the private sector's role is the State's procurement process, which does not foster public-private partnerships for the following stated reasons:

- insufficient rewards for risk-sharing when developing new technologies
- restrictions on using a "design/build" approach
- process timing can be long and unpredictable
- restrictions on granting a private company patent rights when development costs are shared.

Finally, an obvious issue affecting the private sector's role is market acceptance of ITS products and services.

The major challenges to efficient and full deployment of ITS in California can perhaps be best understood and addressed when considered in terms of three categories: **Organizational Capacity, Regional Integration, and Private-Sector Participation**. These categories embrace a number of institutional "barriers" to ITS deployment, as summarized below and presented in detail in Chapter 4.

Organizational Capacity

ITS deployment involves a broad spectrum of organizations cutting across all levels of government agencies, political jurisdictions, and modal responsibilities, plus emergency-response functions and private companies that sell products and/or services to government or to the public directly. Three related areas have been identified in which organizations in California appear to be lacking in the capacity to implement ITS fully and efficiently:

- **Commitment:** Although Caltrans is a recognized leader in certain areas of ITS, interviews found that Caltrans and MPOs were identified as not yet having made a commitment to deployment of ITS in California.
- **Education:** Many staff-level technicians and planners are not knowledgeable about the elements of ITS and Architecture and the potential benefits attainable from ITS projects.
- **Funding:** While federal and State funding have supported research, testing and demonstration deployments, it was repeatedly stated that full deployment of ITS will not be possible unless it can compete successfully with other transportation needs in the regional planning process.

Regional Integration

The integration and coordination of ITS products and services throughout a region is a major issue affecting deployment of ITS. Two barriers to regional integration have been identified:

- **Inter-jurisdictional coordination:** ITS implementors reported that successful ITS deployment is hindered by limited coordination between local entities and appears to result from insufficient incentives and institutional structure.
- **Costs versus benefits:** ITS implementors reported that the cost of most ITS projects must be borne by local governmental agencies but that because some of the benefits may be region-wide, local planners may be hesitant to fund ITS projects. Moreover, the regional benefits of ITS projects are not always fully apparent.

Private-Sector Participation

Private sector participation and partnership are vital to the implementation of ITS (Horan, 1996). However, private-sector investment thus far is below expectations, and major questions remain regarding the method in which the public and private sectors can cooperate in the most productive manner. The participation on the part of the private sector also relies strongly upon the ability of the public sector being able to provide a stable, committed, and business-friendly environment in which to invest. This requires public budget stability, streamlined contractual processes, and again, interjurisdictional cooperation. The public sector may set minimum standards, but should be aware that without incentives to develop beyond these initial standards, advances and improvements may occur at a slower pace.

1.3 Recommendations

This section summarizes recommendations drawn from more than seventy-five transportation officials from around the State. The recommendations represent the research team's attempts to construct a longer-term system-wide strategy for facilitating near-term deployment. That strategy, as discussed in earlier, emphasizes developing the Architecture from the bottom up and public-sector service provision as the means for achieving the goals of implementing efficient networks and facilitating near-term ITS deployment. The section begins with an outline of the strategy, followed by specific recommendations related in the three project areas: Standards, Systems Management and Policy. The implications of the strategy and recommendations are then discussed with respect to each level of jurisdiction within the State (see Figure 1-1).

1.3.1 A Decentralized Evolutionary Strategy: “Bottom-Up” and “Service-Oriented”

The major challenge to building the Architecture is that transportation is made up of dynamic systems in multiple arenas with a host of actors. Coordinating the efforts of these actors, across arenas and systems, particularly in a State as large and diverse as California, becomes the great difficulty. Various approaches to facilitating coordination include both top-down and bottom-up strategies. Building upon the findings and recommendations in this report, a *decentralized evolutionary strategy* is recommended for developing an Architecture in the near-term. The strategy has several components. First, it emphasizes building the Architecture and deploying ITS beginning with local and regional levels – from the bottom up. Second, it calls upon the public sector to become more service oriented in terms of the provision of information and ITS services. To overcome the identified challenges and potential for further delays in deployment, the strategy would therefore provide more regional/local control over ITS decision making and would provide the means for the ‘fastest’ implementors to deploy. At the same time, the strategy would encourage other implementors to begin planning and programming ITS projects, building off of lessons from earlier deployment and targeted educational efforts directed from the State level. A California Architecture could then be structured around these activities as they occur and evolve.

This strategy, its specific recommendations, and its implications for the various jurisdictional levels in the State are the subject of the sections to follow.

1.3.2 Standards Recommendations

Many efforts that address ITS integration and interoperability are underway, taking slightly different routes towards essentially the same objective. The question we are all trying to answer is: “What must be put into place to ensure that future ITS systems will efficiently and effectively work together?” The solutions vary, but tend to include initiatives and activities that establish and encourage the use of standards for ITS projects. This section provides several recommendations relevant to ITS standards that have been developed over the course of the project. These recommendations are intended to guide the evolving relationship between the National Architecture, ITS standards, and ITS activities within the State of California. More detailed information supporting several of the recommendations is available in Chapter 2.

Recommendation: Develop a State Interoperability Plan

The National Architecture is a consensus framework that can be amended and incorporated into a State interoperability plan that can assist in connecting ITS activities in the State within the context of national and international standardization efforts that are underway. The interoperability plan would identify the timing and influence of national standards and early deployments on a broader architecture framework within the State. It would identify the links between the various local and regional architectures in the State and explicitly identify any uniformity requirements that tie the various architectures in the State together.

In addition to associating State projects with standards activities, the architecture framework in the interoperability plan will clarify the relationships between various ITS projects in the State. As a specific example, within the Southern California Showcase project, the focus has been on center-to-center interfaces. There are many surrounding interfaces (e.g., those that connect the traveler to ITS) that must also be implemented, and possibly standardized, to realize ITS services. As each project, like Showcase, focuses on its particular interface, it is helpful to have an overarching framework, derived from the National Architecture, which connects the programs together and aids in the examination of their inter-relationships. California should bring this broad view forward in managing its ITS deployments and participation in ITS standardization.

The architecture framework in the interoperability plan would be an ideal index for an information clearinghouse that would enable State ITS activities to be well connected with corresponding national initiatives. The information associated with each piece of the framework would include a point of contact within the State for associated standards efforts, a short list of associated projects and points of contact, current standards schedules, and key references (e.g., URLs) for more information. To be most effective, this information should be kept up-to-date and maintained on-line. The ITS America web site and Standards Development Organizations web sites already provide a broad range of excellent programmatic and technical information on ITS-related standards. The California site should use links to these sites for access to standards information that is not specific to California, thereby limiting the effort associated with maintaining the accuracy of the California-specific site. Project-specific web sites, which are increasingly common, could also be connected.

Recommendation: Maintain Leadership Position in National ITS Architecture

Maintaining a leadership position in the application of the National Architecture will continue to pay dividends for the State of California. The most tangible reason for maintaining this expertise is US DOT’s continued support for the Architecture and emerging policies that require its use. Perhaps just as significant, the National Architecture is being used to scope, monitor, and manage the current ITS standards efforts. This use of the Architecture as a standards-development tool over the last year has created a host of new products that may also be useful to the State in managing its own quest for ITS interoperability. Application of the National Architecture by the State will facilitate integration of future ITS standards into California Projects.

It is also an appropriate time for mid-course assessment and tuning of the representation from the State in on-going ITS Standards activities at the national level. Frankly, many participants do not have the technical background that is necessary to make a strong contribution to the standards. This is an issue that spans committees and is certainly not unique to California representatives. The perfect candidate for these standards committees combines a strong technical background with domain knowledge in the application area. Committee membership is often composed of a dichotomy of technologists who can understand the standard but have little real-world experience in the application area and domain experts who clearly understand the user requirements but can't directly verify that the draft standard satisfies these requirements. The unique individuals that combine these skills can bridge this gap and have their interests best represented in the standard. Admittedly, finding an individual that satisfies these criteria and also has time to support standards activities is a difficult task. Recognize that additional time will be required by the representative outside the committee meetings to build the skills necessary to be effective on the committee. For instance, some familiarity with data dictionary and message set standards, and the ASN.1 syntax will help committee representatives to be more effective in representing their interests in many of the ITS standards committees.

One way for California to sustain and improve its leadership in the development of the National Architecture is to formulate statewide positions on standards. A quick census of the current standards development committees reveals broad participation by California residents, usually representing the interests of their direct employer (local agencies, MPOs, Caltrans, and contractors). Unfortunately, these representatives usually can't represent the broader interests of the State, primarily because a tangible "state-wide" position has not been formulated for many of the interfaces that are addressed by the standards. The State could convene a focused working group, or better yet use one of the on-going regional and statewide strategic planning efforts to formulate such a position. If a consensus position can be reached within the State, this can be a powerful incentive towards building consensus around the approach within a standards committee.

Another way in which California can lead in ITS deployment is to prioritize sound systems engineering. There is no replacement for good systems engineering practice when developing large scale, high technology systems like some of the ITS systems contemplated for California. Standards must always be applied within the larger context of a tailored system design. It has been demonstrated that the Architecture can be used to "rapid prototype" some of the early systems engineering products for ITS systems. These products feed, rather than replace, the fundamental systems engineering process steps. Application of a sound systems engineering process will continue to be the best way to reduce risk and increase the likelihood of developing the right system the first time. The requirement for the use of sound, traceable processes is perhaps the most important mandate for the systems integration contractors in the State.

The State should also consider whether a limited set of performance requirements should be established to improve the consistency of ITS services within the State. The ITS interfaces that are important to California were identified and compared with current and planned standards activities as part of this project. In general, the coverage of the interoperability standards is quite good since they address most of the State's near-term interfacing needs. The few exceptions, like standards for Highway-Rail Intersections, are currently being considered for new standards activities. One significant gap that was highlighted is in the specification of performance requirements such as data quality, timeliness, accuracy, etc. These performance requirements are generally not being addressed by the current standards activities, but they can be critical to ultimate user acceptance.

Finally, the State should consider bolstering its representation in NTCIP Center-to-Center Activities. In parallel with the California System Architecture project, an interesting case study for standards participation has emerged in the NTCIP Center-to-Center committee. Early contributions from technical representatives from the Southern California Showcase program clearly influenced the direction of this committee towards support for a CORBA-based approach, consistent with the approach selected for Southern California. As 1997 came to a close, the committee planned to develop two standards, one based on CORBA and another based on DATEX and ASN.1. In 1998, the volunteer efforts of the Showcase representatives have diminished as other business pressures have taken precedence over committee work. At the same time, the partially subsidized work on the DATEX/ASN Center to Center standard has continued to progress. These events highlight the difficulty of “competing” within the subsidized standards committees based solely on volunteer efforts. If California continues to believe that CORBA is the right approach for center-to-center interoperability, modest funding should be considered to offset the costs associated with the necessary support from key experts so that the approach is adequately supported.

Recommendation: Deploy Standards Incrementally & Capitalize on Standards Testing

As a result of substantial schedule pressure, many ITS standards development activities are proceeding in parallel with schedules that are accelerated ahead of the traditional three to five year standards development timeline. This approach will likely result in the release of many early standards products, few of which will have undergone substantial testing at the time of initial release to the public. California ITS project implementers will be faced with many new standards that will continue to evolve, perhaps markedly, after their initial release. US DOT has recognized the potential for the immaturity of initial standards products in its tentative policy for standards consistency. Based on preliminary information, US DOT’s policy will not require use of a particular standard until after two to three years of practical experience with the standard is accrued in the field. This cautious approach should be considered and perhaps replicated in California policy, so that premature standards mandates do not lock the State into solutions that are later found to be inferior.

The schedule-driven charge towards ITS standards is a potential benefit to the State from one perspective. The approaching wave of untested, but balloted interoperability standards may be an opportunity for the Caltrans Test Center for Interoperability, which is well positioned to do some of the required testing. Some expansion of this testbed, to include projects in major metropolitan areas within the State, could complement an expanded State role in the testing and evaluation of these formative standards. Although the funding mechanism for these standards testing is uncertain, various strategies for expanding the role of the Test Center for Interoperability should be pursued in the near-term.

1.3.3 System Management Recommendations

Two general recommendations are forwarded in the area of system management.

- Develop Model Agreements and Policies
- Implement a ‘Client/Server’ Model, With ITS as the Mechanism

Recommendation: Develop Model Agreements and Policies

A model agreement provides “boiler plate” language that could be adopted within any multi-jurisdictional project of a given type, or any universal policy that governs all activities of a given type. They can be developed in much the same way as a standard. An ad hoc committee is formed under the auspices of a recognized organization, such as Institute of Transportation Engineers or perhaps Caltrans, with a single objective of developing a specific type of model agreement. A negotiation and working

group process is set to develop the agreement within a set schedule, after which the agreement is submitted to balloting by involved parties.

Negotiating specific agreements is key to the success of model agreements. The model agreement has no force until it is adopted by a multi-jurisdictional project. Organizations entering into an agreement use the model agreement as a starting point, keeping the portions that are relevant and striking others. Specific terms are added to localize the agreement. Once the agreement is finalized at the staff level, it is submitted to higher levels of the organization for formal approval. The negotiated agreement provides the structure for how the system is operated on a day-to-day basis. The agreement is only meaningful if all involved parties adhere to its terms, and use it to improve their coordination.

Areas Where Model Agreements Are Needed

The following three examples illustrate where model agreements would be beneficial:

1. Incident Management: Fire districts have a long history of providing aid across jurisdictional boundaries. They have established a simple and effective command and control structure that enables different agencies to work together toward a common objective. A fire department never loses command over incidents within its own jurisdiction (except temporarily, if units have not yet arrived), and a fire department never loses command over its own personnel. A similar command structure was eventually adopted by Caltrans and LA DOT within the Smart Corridor, and should serve as the model for future cross-jurisdictional projects in transportation. The agreement can further specify geographical areas of coverage, the types of incidents that would initiate a cross-jurisdictional response and the magnitude of the response (as has also been done in fire departments).

2. Flow Management During Incidents: The electrical power industry has a simple policy for responding to network incidents, that of sharing remaining capacity in proportion to base level capacity. Networks respond automatically by diverting the traffic of electricity. A simple guideline of this type would be highly beneficial in “Smart Corridor” type projects, where several roadways provide capacity in parallel.

3. Real-time Network Interfaces: In the future, transportation networks will become more like electrical networks, in which the system is continuously monitored and controlled from management centers. However, even the electrical power industry does not attempt to centralize management across jurisdictions. Instead, each agency manages its own network, within prescribed guidelines that prevent failures at network interfaces. The system is controlled through a combination of interface monitoring stations, real-time pricing, and safeguards that ensure that problems in one jurisdiction do not spill over into another. A similar model could and should be developed in transportation. Such an approach could begin with bilateral agreements, but may best be implemented through broader networks that ensure the stability and reliability of the network as a whole. By this approach, the transportation grid can be monitored automatically, with human intervention limited to control measures implemented by individual management centers in response to problems that are detected at interfaces.

It is also recommended that Caltrans Headquarters play the lead role in developing model agreements through Traffic Operations. Traffic Operations can also act as a facilitator and technical resource to assist Caltrans Districts and local jurisdictions in the execution of agreements that provide inter-jurisdictional coordination. However, we do not recommend enforcement of uniform agreements or completely standardized managerial interfaces across the State. To speed implementation, it is important for local jurisdictions and Caltrans districts to retain considerable autonomy. Nevertheless, through development of model agreements, Caltrans can play the leadership role of facilitating coordination.

Recommendation: Implement a ‘Client/Server’ Model, With ITS as Mechanism

Another area where coordination would be advantageous is between planning agencies and transportation departments. The need for this is accentuated by recent legislation that expands the funding authority of planning organizations.

We recommend that ITS become the mechanism to implement a “client/server” model for delivering transportation services. In the future, planning organizations will provide funding for transportation and, for this reason, they will increasingly become the voice of the transportation customer (i.e., client). Transportation operating agencies (Caltrans, cities, and transit agencies) will therefore need to concentrate on delivering transportation services that meet the needs defined by planning organizations. Transportation agencies should report to planning agencies on their performance in a manner similar to how the president of an operating division for a company reports to its board of directors.

Under the client/server model, we recommend that individual planning organizations establish ITS based reporting requirements for the agencies that they fund. This would entail uniform reporting that tracks critical transportation statistics, such as congestion, accidents, and traffic volume. ITS would provide a mechanism for data collection and reporting. Transportation agencies would be required to track the performance of the transportation system, and to utilize performance tracking as a continuous improvement mechanism. Demonstrated success in improving performance would be a factor in project funding.

1.3.4 Policy Recommendations

Institutional and policy recommendations are divided into two major areas consistent with the strategy outlined above. The first recommendation calls for greater control and authority placed in the hands of local and regional implementors. The second call a greater emphasis in the public sector on ITS service provision.

Recommendation: Emphasize Regional and Local Level Coordination

To reassert a commitment to ITS deployment, a strategy should be employed that emphasizes district/regional and local level coordination and authority. First, Caltrans district staff should play a facilitator role with MPO’s. Second, Caltrans headquarters should consider allocating additional funding to districts or MPO’s for ITS projects.

Regional integration in California can use the lessons from the Southern California Priority Corridor (SCPC) and TravInfo as models for future efforts. These two models provide a point of departure for creating similar organizations and both are based upon the creation of a new ad hoc coordinating body. Case studies of these two models should be prepared and disseminated.

This is not to say that these two models represent the ideal of how regional integration can occur. Obviously, as early examples of ITS and regional integration, problems were encountered, such as the length of time it took to reach agreement among the different jurisdictions. Nevertheless, the successes and failures of the two models should be useful to future deployment. Several recommendations for overcoming the problems associated with SCPC and TravInfo include: (1) Consider allowing for contracts between federal agencies and some MPO’s, for certain large projects, to improve efficiency. (2) Future funding agreements, especially for innovative projects and implementors, should provide flexibility for significant changes in work scope. (3) Caltrans’ procurement process should be streamlined.

Recommendation: The Public Sector Should Become More Service-Oriented

While the primary policy recommendation is to emphasize regional and local integration, we do not mean to imply that the role of the State, and Caltrans in particular should be reduced. On the contrary, Caltrans is uniquely positioned to offer a range of services to local and regional implementors that can aid in facilitating near-term deployment and the development of the Architecture. For this reason, the recommendation at the State level is for Caltrans to become the primary ITS service provider. Services that need to be provided include ITS information, education and training, as well as the tracking and monitoring of ITS deployment efforts throughout the State.

Caltrans role as primary service provider should take two forms. First, Caltrans should serve as a clearinghouse for information on ITS technologies, deployments, and training. Further outreach and educational efforts are needed to make interoperability benefits more apparent to local and regional implementors that vary greatly in size and capacity. Caltrans should therefore facilitate and/or conduct educational seminars targeted for different sizes of jurisdictions. Support for a comprehensive education effort should also include the adoption of a ‘matchmaker’ role for education programs to identify local-agency staff who could benefit from such programs and coordinate with training providers to bring the programs to various localities.

Second, Caltrans should establish a peer assistance and referral network within the State through which experienced and knowledgeable ITS implementors could be made available for consultation with newcomers to ITS deployment, especially during planning and design phases.

Recommendation: Use A Stratified, Market-Driven Approach to Forming Public-Private Partnerships

With regard to the private sector, it must be recognized that it is not one homogenous entity. Rather, the private sector is quite diverse. Participation by the private sector can take at least five distinct forms: *Vendor/Consultant*; *Shared Risk* (e.g. TravInfo), *Shared Resources*; *Joint Research and Development* (National Automated Highway System Consortium); *Mass Marketers* (in-vehicle navigation systems). Characteristics and business practices vary greatly across these five categories. For this reason, a single strategy to increase private involvement will not be effective. Therefore, the recommendation is to develop a stratified approach to recognize the diversity of the private sector. At a minimum, distinct strategies should be developed for each of the categories outlined above, with perhaps the greatest opportunities being in the Shared Risk, Shared Resources and Joint Research and Development categories.

Here again, the private sector has diverse positions regarding these roles and relationships. For example, one southern California agency wants to charge ISP’s for ATIS data produced by public infrastructure, while another agency would make it available for free. Larger companies (e.g., ISP’s), who are able to make larger investments in ITS, seek larger markets (often nationwide) and more-consistent ‘deals.’ The implication is that larger companies are unlikely to pursue small markets created by dissimilar public policies.

Participation of the private sector relies strongly upon the ability of the public sector being able to provide a stable, committed, and business-friendly environment for private investment. Additional concerns revolve around the differences between the way the private and public sectors conduct business. For example, both the public and private sectors seem to have different conceptions of their roles. Amid such complex interactions, it simply becomes easier for the private sector to just move ahead without public sector partners. Specific concerns include the costs of accessing public data, lack of public sector funding for systems, and contracting laws and regulations which slow the deployment process and make

partnering less cost-effective for the private sector. In many ways, the gist of these concerns is that the public sector, in order to enable more public-private partnerships, must become more market-driven.

A market environment in the public sector could improve the likelihood of partnerships by offering a streamlined, shorter, and more flexible contracting process, particularly in the area of proprietary rights. Efforts should also be made to create technically consistent and common public policies to encourage entrepreneurial consistency (for example, distribution of ATIS data to ISP's). These policies must also be stratified across the five categories.

1.3.5 Implications for Jurisdictions

The implications of this strategy for the key stakeholder groups are outlined below.

Caltrans Headquarters

Caltrans headquarters and its Office of New Technology should assume the role of the primary *service organization*, providing information and ITS Architecture-mapping services to other jurisdictions throughout the State. The purpose of this role would be to provide a forum for the exchange of information and standards.

Caltrans should serve in a dual capacity: (1) as an ITS information clearinghouse, and (2) as a match-making organization for regional and local implementors. As an ITS information clearinghouse its primary role would be to provide the education and training needed by various planners and implementors. Targeting different sizes and types of jurisdictions with specific educational efforts should, as recommended in the above sections, be emphasized. The peer referral network recommended above should also be a part of Caltrans' education program. As a match-making organization, Caltrans should attempt to encourage information-sharing between the similar ITS deployment efforts of local/regional organizations. Providing information about what individual organizations are doing will obviously be a major component of this process.

Other recommendations related to Caltrans' role include:

- (1) devising a set of model agreements to be circulated to regional and local implementors;
- (2) establishing (and funding) regional management groups to encourage regional planning;
- (3) providing information on ITS activities in other jurisdictions and states;
- (4) developing and maintaining databases tracking ITS activities; and
- (5) providing this information via a the internet.

All of these efforts should be designed to steer local implementors toward technical convergence and Architecture conformance.

The advantage of this strategy is that it still places Caltrans in the position of being the lead on providing information and constructing a California Architecture, while providing local implementors with the ability to deploy more quickly.

Caltrans Districts and Metropolitan Planning Organizations

The MPO and Caltrans District levels are where the most critical facilitating (and funding) of ITS projects should occur, as identified in TEA-21, its predecessor (ISTEA), and most recently in legislation at the State level (SB-45). Coordination between MPO's and Caltrans Districts is therefore pivotal to ITS deployment, and they should serve as the primary funding organizations for ITS project within the State.

For innovative local implementors, the implication of this strategy is the increased ability to deploy in the near-term. An additional implication is that implementors not currently at the forefront of ITS deployment could use earlier deployments as building blocks for their own ITS evolution. The quality of second and third-order ITS deployments could therefore be increased.

However, the major caveat here is that ITS education and training efforts will have to be redoubled to ensure that a sufficient knowledge base exists from which planning and implementation of projects can occur. The efforts recommended for Caltrans headquarters, particularly with respect to ITS training and education, should therefore first target Caltrans Districts and MPO's.

Private Sector

As stated earlier, a major frustration of private sector stakeholders is a perceived lack of commitment and activity in the public sector. Much of this frustration stems from supra-level constraints on local implementors. A shift in strategy to decentralized and near-term deployment, combined with policies to implement the strategy, would send a strong signal to the private sector that the public sector was preparing to be a more viable partner. Providing local implementors with additional freedom to establish these partnerships increases the likelihood that they will in the near-term.

1.3.6 Summary

The purpose of this project has been to identify the challenges to developing a California Architecture and deploying ITS projects, and to develop a set of recommendations for overcoming these challenges. Toward that end, numerous Architecture-related documents have been reviewed and a comprehensive set of interviews and focus groups has been conducted, including the *Deployment Symposium* in September 1997. Part I research identified a complex and diverse set of actors and issues. Part II research explored those issues more in-depth through discussions with key stakeholders, and Part III, of which this report is the product, condensed the findings into a series of recommendations. Those recommendations have been presented in the three project areas: standards, system management and policy.

The linkages between the recommendations in the three areas are obvious, whether its calls for more educational efforts, model developments or increased coordination authority at the regional level. Underlying these recommendations are the themes of a bottom-up strategy for developing the Architecture, public sector service provision, near-term deployment and implementing efficient networks.

Many of these recommendations suggest slightly altered roles for the various stakeholders involved, such as more regional coordination and vision at the MPO/Caltrans District level or a focus on service provision at Caltrans. Should these recommendations be implemented, they will undoubtedly be accompanied by growing pains and organizational discomfort. Such is the nature of the paradigm shift in transportation brought about by ITS. It is imperative for the State that the new technologies are harnessed and directed toward making the State's transportation networks operate as an efficient transportation system. An Architecture for California is the framework for achieving this goal, but it should be structured to facilitate local and regional innovation and, like conventional transportation projects, it should be built from the ground up.

The chapters to follow provide further detail on the topics discussed in Chapter 1.

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CHAPTER 2: STANDARDS LEVEL

2.1 Foreword

This chapter provides the background and supporting analysis for the findings and recommendations made in Chapter 1 of the Final Report. Much of the background information that is included in this report is adapted from work developed by the National ITS Architecture joint development team. The content was assembled from interim reports, memorandums, and position papers that were developed in all three phases of this project.

As indicated by the title of this chapter, this effort began as an identification of standards issues as specified in the original proposal for this research project. In researching these issues, it immediately became apparent that there are many promising standards activities that are addressing these issues. To reflect the current dynamics in this area, this chapter provides not only a catalog of the barriers to standardization but, perhaps more importantly, a discussion of the important activities that are addressing these issues in the State of California and the rest of the nation.

It is important to note that the National Architecture activities provide only one of many inputs that must be considered in developing an Interoperability Plan for the State of California. The on-going national and international standards activities, standardization and strategic planning activities within the state, and potentially emerging defacto standards resulting from showcase regional deployments such as the priority corridors and model deployment programs will be the real drivers behind the standards that are ultimately adopted within the state.

2.2 Introduction and Overview

A central goal of the National ITS Architecture program is to support and promote beneficial standardization in ITS systems. This goal has equal application to the state of California. This chapter applies this goal to California with particular emphasis on the interfaces and standards with direct potential application for Caltrans. The chapter begins with a review of the standards requirements posed by the National Architecture and then narrows scope to those interfaces with direct application for Caltrans.

With completion¹ of the National Architecture in June 1996, the US DOT focus turned towards supporting development of national standards as the next step in enabling interoperable transportation systems. Without question, one of the principal focuses in Intelligent Transportation Systems today is the identification and development of appropriate ITS interface standards. This focus is evident when reviewing the myriad federal, state, local, and private sector activities supporting transportation standards that are currently in the planning stage or are underway. Under severe pressure for early products, many of these standards activities already have standards in ballot. Perhaps a dozen different standards are in, or nearly in, ballot as of this writing in September, 1998.

¹ "Completion" is a relative term since enhancement and maintenance of the architecture products is an on-going activity. June 1996 marked the "National Architecture Review" submittal which concluded the major architecture development effort. Since 1996, a series of updates have been released culminating in version 2.0 of the National ITS Architecture which was released in September 1998.

Many of these standards are of central interest to Caltrans. Identifying and tracking these efforts will enable the right set of standards products to be applied in California. Before these activities can be coordinated, or even monitored, a time-sensitive “inventory” of these activities must be developed. This report makes a first pass at this inventory of Caltrans-relevant standards activities with specific recommendations for how this inventory can be maintained and the identified standards activities monitored by leveraging other standards management systems that are currently being put into place.

In parallel with these standards activities, ITS deployments continue at a rapid rate. These deployments provide valuable input to the formative transportation standards development process by making real-world data available to the standards development activities. More directly, achieving consistency between several deployments provides considerable momentum behind a particular approach that can result in a de facto standard that can later be formalized through the more rigorous (and time consuming) open standards development process. This approach offers a quick alternative for those interfaces where the formal process is making little headway or has not been initiated. There are several key ITS deployments in California that may be used in this way. In addition to these California projects, several other on-going projects outside the state warrant consideration as early inputs to state standards. In particular, the current Model Deployment Initiative (MDI) sites are receiving considerable focus from US DOT with respect to showcasing compatibility. The approaches for these MDI sites are also compared with similar California programs. The interrelationship between these deployments, the national architecture interface definitions, and the on-going standards activities are highlighted in this report.

2.3 Standards and the National ITS Architecture

2.3.1 Potential ITS Standards Sources

Three types of ITS standards are considered in this chapter: *regulatory*, *de facto*, and *voluntary*. A *regulatory standard* is established by a government agency (e.g., National Highway Transportation Safety Administration) to protect public welfare and safety. Examples would include standards ensuring consistent and safe integration of ITS capabilities into the driver’s interface with the automobile. A *de facto standard* is established by someone in industry who successfully learns how to do something (e.g., design, build, and/or establish a product or service) which then becomes an accepted industry practice. A *voluntary standard* is developed through voluntary consensus by people with common needs and interests so as to provide some degree of confidence in the marketplace for manufacturers, integrators, service providers, and consumers.

A regulatory standard can mandate degrees of interoperability and compatibility and mandate performance requirements. A voluntary standard is limited to elective compliance for interoperability and compatibility. In considering the potential options for promoting adoption of ITS standards intended to serve the public interests, a middle ground can be considered in which conditional funding is tied to adoption of the standard. In this scenario, adoption of the *voluntary* standard is incentivized providing additional impetus to the natural tendency for the market to support an accepted standard. This is the approach that has been mandated by Congress in the TEA21 legislation; USDOT is in the process of establishing policy that will establish conditional funding requirements for established standards for critical interfaces.

Almost all industry standards are voluntary standards. The majority of the standards identified by the architecture are anticipated to be of this type. In areas where there is not a strong case for standardization, a laissez-faire approach is recommended. In these areas, any standards that are ultimately adopted are likely to be de facto. At the other end of the spectrum, there are a few areas in which public safety considerations warrant development of regulatory standards. On occasion, standards

which are voluntary may be adopted as regulatory standards by the State of California where the benefits of accelerated standardization are viewed as exceeding the risks. Recent examples of this practice in California include a dedicated short range communications standard and Assembly Bill No. 3418 which requires a standard communications protocol derived from an early draft NTCIP standard for traffic signals in the state of California.

De facto standards, when sufficiently open, can be effective in reducing costs to consumers and supporting product interoperability for technologies that are relatively mature. On the other hand, a de facto standard put forward by a company with its own interests in mind, may ignore customer requirements and overall system integration considerations. Communication layer standards come mostly from communication service providers in support of all types of communication. ITS will probably adopt those existing and emerging standards except for a few special cases like DSRC where the interface is dominated by ITS requirements. Some of these may be proprietary and although the general consensus is that proprietary standards are not as good as open standards for ITS in the long term, it is better to have some working system based on proprietary standards than none at all.

Finally, if history is any guide, there will be many cases where there will not be a single unambiguous consensus standard that is universally adopted for many ITS interfaces, especially in the near term. The current practice - to use various gateway technologies to connect disparate systems - will continue to provide part of the overall interoperability solution.

2.3.2 ITS Standards: Benefits and risks

Standards are fundamental to the establishment of compatible and interoperable ITS deployments in the State of California. As ITS deployments continue in the state, diverse systems are being put into place that address the special needs of urban, suburban and rural transportation in California. Standards can provide interoperability across these implementations without impeding innovation as technology advances and new approaches evolve. Open standards will further benefit the consumer by enhancing competition for the range of products necessary to implement ITS. Larger markets for specific products will in turn reduce production costs and assure private providers a wide market over which products can be sold.

This promise is balanced by a spectrum of issues that are posed by the very rapid, parallel generation of many related ITS standards that is underway. Put in the context of even more rapid technology innovation and fundamental shifts in the way we develop large systems, and we are in an era where there is a real risk for disconnected standards, incompatible “standard” solutions, and premature obsolescence to negatively impact the systems we deploy in the next few years. While there is no single solution to these issues, the National ITS Architecture, and derivative architectures that are under development in California, provide part of the answer.

A compelling case can be made for adopting national, or even international standards rather than state-wide standards for many interfaces to fully realize these benefits. Especially important in this regard are those standards that connect the traveler to ITS. As deployment occurs, diverse systems will be developed to address the special needs of urban, suburban and rural environments. Standards must ensure interoperability across these implementations without impeding innovation as technology advances and new approaches evolve.

Potential Benefits

Well chosen, well timed, and broadly accepted standards can provide the following frequently cited benefits:

- *Cost-effective interoperability between diverse systems.* This benefit facilitates area-wide implementations that ultimately provide enhanced service to the consumer.
- *Preservation of investment.* Timely standards can reduce investments in multiple incompatible approaches, some of which will become casualties of natural selection in the market place.
- *Technology insertion.* Systems can be incrementally improved to take advantage of new technologies.
- *Creation of broader markets.* Interoperability standards set the stage for national and/or international markets.
- *Interchangeability.* Interchangeable equipment reduces capital costs through increased competition and reduces maintenance costs through smaller spares inventories of less expensive replacement parts.

Potential Risks

Unfortunately, standardization is not a panacea. In particular, accelerating standards ahead of tangible markets or proven technologies, promulgating standards for interfaces independent of need, or heavy handed standards adoption policies which undermine market forces will inevitably have negative repercussions. Standards can also have the following undesirable affects:

- *Hinder development of new and innovative solutions.* Once a standard is developed and adopted, superior non-compatible solutions may neither be vigorously pursued nor marketable once achieved. This problem is accentuated if conditional funding or regulation is tied to adoption of the standard. An order of magnitude improvement may be required to overcome the inertia surrounding the standard.
- *Jeopardize investments by early adopter's of incompatible approaches.* Advanced ITS implementations are several years ahead of the supporting standards. Incompatible equipment may be rendered obsolete overnight and require costly retrofit or replacement.
- *Inhibit Market Competition.* The market is an extremely efficient selective force. Standards which are accelerated ahead of the market will not benefit from lesson's learned during initial, competitive efforts to satisfy the market and may miss the market that finally does materialize or result in sub-optimal solutions.

The lack of a standard will not prevent entry into perceived markets with profit potential. Such entry or positioning by several different competitors is a harbinger for timely standardization.

Monitoring the risks as well as the rewards associated with standards should lead to a balanced ITS standards strategy that recognizes that adoption of ITS standards on a state-wide basis must be carefully considered.

2.3.3 National architecture standards requirements

The National Architecture provides a basis for standards that support the ITS user services. It defines the major system interfaces, the semantic content of the messages that pass across these interfaces, and provides some indication of the class of communications services suitable for each interface. In total, more than 125 distinct interfaces have been defined in this way by the architecture. This architecture definition material, while comprehensive, is not at a sufficient level of detail to transition directly into a draft standard. Providing this detail is a key component of the on-going standards activities.

This section provides only a cursory overview of the standards requirements defined by the national architecture. The interested reader may access the architecture definition from the world wide web (www.odetics.com/itsarch), through the USDOT electronic document library (EDL), or through a CD-ROM that is periodically produced for major architecture releases. The last CD-ROM generated, as of this writing, was released in September 1998.

The major driver for standardization is the quest for interoperability between systems. Each of the system interfaces that have been defined by the national architecture have been examined with respect to the anticipated breadth of the interoperability need for that interface. A four level rating has been applied to each system interface that characterizes the interoperability rationale for that interface. The interoperability rating definitions and the implications of each category for California are:

1. *National Interoperability.* Interfaces to mobile systems support national interoperability since the same mobile system should be able to roam the nation and use the local infrastructure to support ITS services. Failure to achieve national interoperability will limit the value of the service the interface supports. Examples of interfaces with a national interoperability rating include all interfaces to consumer products and the interfaces to private and commercial vehicles. These interfaces tend to be the focus of the national standards organizations and are subject to powerful market influences. It is particularly important that the state keep abreast of the national standards and international standards activities in these areas and support these standards within California as they become available.
2. *Regional Interoperability.* Interfaces connecting systems that may be operated by different agencies (interfaces that often span jurisdictional boundaries) can be standardized to facilitate the sharing of information between agencies. Regional interoperability is specified for center to center communications where the underlying coordination issues are regional, rather than national, in scope. For instance, there is no real requirement for a transportation management system in California to be able to coordinate with one in New York. Two different regional dialects for center to center communications could be implemented in the two geographically isolated systems, without significant impact to national interoperability goals. National standards do mitigate issues that may arise as boundaries change and new requirements for information sharing develop over time. Early de facto standards adoption for these regional interfaces before national consensus is reached may be appropriate for California. Where there is standards activity on the national level (e.g., current activities within NTCIP for center to center communications), these activities should be supported and the evolving approach factored into current deployments to facilitate future convergence to the national standard once consensus is reached. For California, the impact of adopting a de facto standard for these regional interfaces before national consensus is reached would not be great enough to warrant postponing deployment.
3. *Product Interoperability.* Interfaces between systems that are operated and maintained by a single stakeholder do not require standardization to achieve national interoperability. The data formats and communications mechanisms that are used for these interfaces are largely transparent to the remainder of the architecture. In some cases, national standards are still very beneficial (and hence still attainable through the consensus standard development process) since they may consolidate a market to achieve economy of scale efficiencies (e.g. NTCIP Center to Roadside). If multiple agencies adopt the same Product Interoperability standards within a region, future implementation of various shared resource and cooperative control strategies will be facilitated. While there are notable exceptions, the state may choose to provide guidance for these interfaces but allow some latitude to the procuring agency to choose the best solution.
4. *No Interoperability Requirement.* In other cases, the sheer range of application-specific interfaces precludes efficient national standardization and no standard is suggested. For instance, a national standard is not recommended for the interface between a Fleet Management system and a

Commercial Vehicle since the nature of the interface is so dependent on fleet type. From the National Architecture perspective, standardization for these interfaces is not suggested.

Note that there is a distinction between the “rationale” for standardization that is itemized above and the priority of the standard which relates to urgency (time criticality) and importance (the level of economic benefit that is anticipated from the standard by interested stakeholders). Table 2-1 lists the interoperability ratings for each of the major system interfaces defined by the National Architecture. Omitted from this table are human interfaces, physical interfaces, and environmental interfaces that are defined by the architecture.

Table 2-1: Major Subsystem Interface Interoperability Assignments

Subsystem	Interfacing Subsystem/System	Interoperability
Commercial Vehicle Administration	Commercial Vehicle Check	regional
Commercial Vehicle Administration	CVO Information Requestor	national
Commercial Vehicle Administration	DMV	national
Commercial Vehicle Administration	Enforcement Agency	regional
Commercial Vehicle Administration	Financial Institution	national
Commercial Vehicle Administration	Fleet and Freight Management	national
Commercial Vehicle Administration	Other CVAS	national
Commercial Vehicle Administration	Planning Subsystem	regional
Commercial Vehicle Check	Commercial Vehicle Administration	regional
Commercial Vehicle Check	Commercial Vehicle Subsystem	national
Commercial Vehicle Subsystem	Commercial Vehicle Check	national
Commercial Vehicle Subsystem	Fleet and Freight Management	none
Emergency Management	E911 or ETS	regional
Emergency Management	Emergency Vehicle Subsystem	regional
Emergency Management	Fleet and Freight Management	national
Emergency Management	Information Service Provider	regional
Emergency Management	Map Update Provider	national
Emergency Management	Other EM	regional
Emergency Management	Personal Information Access	national
Emergency Management	Planning Subsystem	regional
Emergency Management	Remote Traveler Support	national
Emergency Management	Traffic Management	regional
Emergency Management	Transit Management	regional
Emergency Management	Vehicle	national
Emergency Vehicle Subsystem	Emergency Management	regional
Emergency Vehicle Subsystem	Roadway Subsystem	regional
Emissions Management	Map Update Provider	national
Emissions Management	Planning Subsystem	regional
Emissions Management	Roadway Subsystem	product
Emissions Management	Traffic Management	product
Fleet and Freight Management	Commercial Vehicle Administration	national
Fleet and Freight Management	Commercial Vehicle Subsystem	none
Fleet and Freight Management	Emergency Management	national
Fleet and Freight Management	Information Service Provider	none
Fleet and Freight Management	Intermodal Freight Depot	national
Fleet and Freight Management	Intermodal Freight Shipper	regional
Information Service Provider	Emergency Management	regional
Information Service Provider	Financial Institution	national
Information Service Provider	Fleet and Freight Management	none
Information Service Provider	Intermodal Transportation Service Provider	regional
Information Service Provider	Map Update Provider	national
Information Service Provider	Media	product
Information Service Provider	Other ISP	national
Information Service Provider	Parking Management	regional
Information Service Provider	Personal Information Access	national
Information Service Provider	Planning Subsystem	regional
Information Service Provider	Remote Traveler Support	product
Information Service Provider	Toll Administration	regional

Table 2-1: Major Subsystem Interface Interoperability Assignments

Subsystem	Interfacing Subsystem/System	Interoperability
Information Service Provider	Traffic Management	regional
Information Service Provider	Transit Management	regional
Information Service Provider	Vehicle	national
Information Service Provider	Weather Service	regional
Parking Management	DMV	national
Parking Management	Enforcement Agency	regional
Parking Management	Financial Institution	national
Parking Management	Information Service Provider	regional
Parking Management	Parking Service Provider	product
Parking Management	Planning Subsystem	regional
Parking Management	Traffic Management	regional
Parking Management	Transit Management	regional
Parking Management	Vehicle	national
Personal Information Access	Emergency Management	national
Personal Information Access	Information Service Provider	national
Personal Information Access	Map Update Provider	national
Personal Information Access	Transit Management	national
Planning Subsystem	Map Update Provider	national
Planning Subsystem	Traffic Management	regional
Remote Traveler Support	Emergency Management	national
Remote Traveler Support	Information Service Provider	product
Remote Traveler Support	Map Update Provider	national
Remote Traveler Support	Transit Management	product
Roadway Subsystem	Emissions Management	product
Roadway Subsystem	Multimodal Crossings	national
Roadway Subsystem	Traffic Management	product
Roadway Subsystem	Wayside Equipment	product
Roadway Subsystem	Vehicle	national
Toll Administration	DMV	national
Toll Administration	Enforcement Agency	regional
Toll Administration	Financial Institution	national
Toll Administration	Information Service Provider	regional
Toll Administration	Planning Subsystem	regional
Toll Administration	Toll Collection	regional
Toll Administration	Traffic Management	regional
Toll Collection	Toll Administration	regional
Toll Collection	Vehicle	national
Traffic Management	DMV	national
Traffic Management	Emergency Management	regional
Traffic Management	Emissions Management	product
Traffic Management	Enforcement Agency	regional
Traffic Management	Information Service Provider	regional
Traffic Management	Map Update Provider	national
Traffic Management	Other TM	regional
Traffic Management	Parking Management	regional
Traffic Management	Planning Subsystem	regional
Traffic Management	Rail Operations	national
Traffic Management	Roadway Subsystem	product
Traffic Management	Toll Administration	regional
Traffic Management	Transit Management	regional
Traffic Management	Weather Service	regional
Transit Management	Emergency Management	regional
Transit Management	Enforcement Agency	regional
Transit Management	Financial Institution	national
Transit Management	Information Service Provider	regional
Transit Management	Intermodal Transportation Service Provider	regional
Transit Management	Map Update Provider	national
Transit Management	Other TRM	regional
Transit Management	Parking Management	regional

Table 2-1: Major Subsystem Interface Interoperability Assignments

Subsystem	Interfacing Subsystem/System	Interoperability
Transit Management	Personal Information Access	national
Transit Management	Planning Subsystem	regional
Transit Management	Remote Traveler Support	product
Transit Management	Traffic Management	regional
Transit Management	Transit Vehicle Subsystem	product
Transit Vehicle Subsystem	Roadway Subsystem	regional
Transit Vehicle Subsystem	Transit Management	product
Transit Vehicle Subsystem	Transit Vehicle	product
Vehicle	Emergency Management	national
Vehicle	Information Service Provider	national
Vehicle	Map Update Provider	national
Vehicle	Other Vehicle	national
Vehicle	Parking Management	national
Vehicle	Roadway Subsystem	national
Vehicle	Toll Collection	national

2.4 Current National Architecture Activities

Delivery of the architecture documentation in June 1996 and the National Architecture Reviews in July 1996 marked the end of the two phase, 33 month architecture development effort. A portion of the architecture development team was retained by US DOT to perform several on-going tasks related to the national architecture.

- **Architecture Maintenance:** This activity maintains the baseline architecture definition and makes controlled changes to this baseline. The architecture was updated in January 1997 to support the Highway-Rail Intersection user service. This update added two new interfaces to the National Architecture Definition which may be of interest to Caltrans. These new interfaces are briefly described in this section. Subsequently, version 2.0 of the architecture was released in 1998. This update implemented 100 distinct changes to the existing architecture interfaces but did not represent any increase in scope or functionality.
- **Standards Support:** The National Architecture team is an active participant in each of the current standards development activities that are supported by US DOT. In addition, the National Architecture team is a liaison to the ISO international standards activities. The status of these standards activities is provided in this section.
- **Outreach:** Many different outreach, guidance, and training activities are supported:
 1. Support for the National ITS Architecture world wide web site (<http://www.odetics.com/itsarch>)
 2. Generation of CD-ROMs that include the architecture definition and all supporting documentation.
 3. Two different training courses are offered that provide comprehensive, hands-on training in the National ITS Architecture and its potential applications. One course is targeted for the public sector and covers generation of regional architecture.
 4. Serve as a consultant to US DOT and the four model deployment initiative (MDI) sites (and the deployment incentive program participants in the future) showcase some measure of compatibility in their implementation.

2.4.1 Current Standards Activities

The current National Architecture activities that have the greatest implication for ITS standards in the State of California is the support for many national standards development activities. The US DOT has already performed a series of steps intended to expedite this standards development effort. A solicitation entitled “ITS Standards Development” (DTFH61-96-R-00004) was issued and five contracts were awarded to SAE, IEEE, ITE, ASTM, and ASHTO to facilitate the standards development effort. Figure 2-1 illustrates the general structure of these standards development efforts.

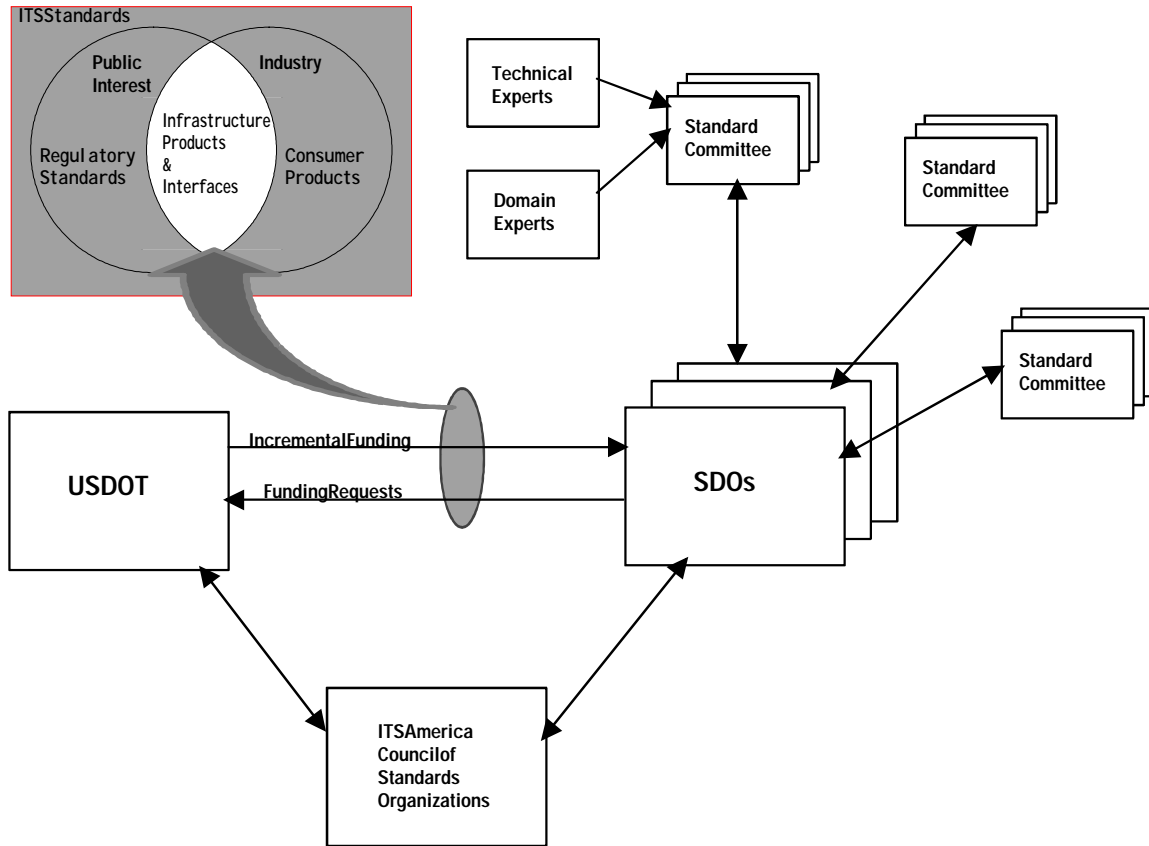


Figure 2-1: ITS Standards Development Structure Overview

This program is working through the National Architecture interfaces in an order that is largely established by the funded SDOs. The general process is that the funded SDOs present DOT with a project plan that establishes the general scope for a standards activity. USDOT evaluates the plan and determines whether funds will be made to accelerate the effort. The first standards to be addressed by the program are those considered to be foundation standards (fundamental to the standardization of many interfaces such as the data dictionary efforts and the location referencing specification), CVO standards, and key center to center standards. Many more National Architecture interface requirements have been addressed in subsequent efforts.

As of this writing in late September, 1998, 91 ITS standards and/or standards development activities are being tracked by US DOT. In addition, several supporting activities have been funded and several more proposals are under current evaluation. The National Architecture Team is a participant in many of these standards activities. A summary of the key activities is presented in table 2-2. This table is an August

1998 excerpt from the JPL database that is used by USDOT to track the key standards activities. Note that the last column (ballot date) is data that was provided to JPL by the committees. The identified schedule milestones reflect status presented by the SDOs in June 1998. In many cases, the SDOs have set very aggressive schedules that push the generally accepted limits for the schedule time required for standards to be developed through the consensus process. Some of these dates have slipped, and continued variability in the proposed schedules can be expected in the future. In many cases, the best standards status will be provided by members representing California activities who work on the committees.

Table 2-2: Current ITS Standards Program Activities

SDO	Standard Title	Ballot Date
AASHTO	NTCIP - Class B Profile	Complete
AASHTO	NTCIP - Class E Profile for Center to Center Communications	8/15/98
AASHTO	NTCIP - Global Object Definitions	12/30/96
AASHTO	NTCIP - Object Definitions for Actuated Traffic Signal Controller Units	6/15/96
AASHTO	NTCIP - Object Definitions for Dynamic Message Signs	5/1/97
AASHTO	NTCIP - Object Definitions for Environmental Sensor Stations	9/1/97
AASHTO	NTCIP - Object Definitions for Highway Advisory Radio (HAR)	11/1/99
AASHTO	NTCIP - Object Definitions for Ramp Meter Control	6/15/98
AASHTO	NTCIP - Object Definitions for Transportation Sensor Systems (formerly	11/15/98
AASHTO	NTCIP - Object Definitions for Video Camera Control	10/1/98
AASHTO	NTCIP - Simple Transportation Management Framework	Complete
AASHTO	NTCIP Automatic Vehicle Identification	1/28/99
AASHTO	NTCIP Overview	Complete
AASHTO	NTCIP Vehicle Classification Devices	1/4/99
AASHTO	NTCIP Weigh-in-Motion	3/31/98
ANSI	Commercial Vehicle Credentials	2/1/97
ANSI	Commercial Vehicle Safety and Credentials Information Exchange	6/1/96
ANSI	Commercial Vehicle Safety Reports	6/1/98
ASTM	DSRC Data Link Layer	6/1/98
ASTM	DSRC Physical Layer - 902-928 MHz	4/15/98
IEEE	A Standard for Intelligent Transportation Systems (ITS) Data Dictionaries	5/15/98
IEEE	Guide for Microwave Communications System Development	2/1/98
IEEE	ITS Data Dictionaries Guidelines	6/15/98
IEEE	Message Sets for DSRC ETTM & CVO	5/15/98
IEEE	Message Sets for Incident Management: EMS to TMS and ETS (OR E911)	11/15/98
IEEE	Recommended Practice for Selection and Installation in ITS Environments	1/4/98
IEEE	Survey of Communications Technologies	
IEEE	The Development of a Template for ITS Message Sets	7/14/98
ITE	Advanced Transportation Controller (ATC) Functionality and Interface	6/30/98
ITE	ATC Physical Cabinet Functional Design	9/30/98
ITE	ATC Software Application Interface (API)	7/31/99
ITE	ATMS Data Dictionary (TMDD) - Section 1 (Links/Nodes)	1/29/98
ITE	ATMS Data Dictionary (TMDD) - Section 2 (Incidents)	3/26/98
ITE	ATMS Data Dictionary (TMDD) - Section 3 (traffic control)	5/28/98
ITE	ATMS Data Dictionary (TMDD) - Section 4 (DMS/Video/etc)	7/15/98
ITE	External TMC Communications Scoping and Requirements Study	1/15/98

Table 2-2: Current ITS Standards Program Activities

SDO	Standard Title	Ballot Date
ITE	Message Set for External TMC Communication (MS/ETMCC) - Bundle A	7/15/98
ITE	Message Set for External TMC Communication (MS/ETMCC) - Bundle B	7/15/98
ITE	TCIP - Common Public Transportation Objects	3/1/98
ITE	TCIP - Control Center Objects	8/1/98
ITE	TCIP - Fare Collection Objects	8/1/98
ITE	TCIP - Framework	8/1/98
ITE	TCIP - Incident Management Objects	3/1/98
ITE	TCIP - Onboard Objects	8/1/98
ITE	TCIP - Passenger Information Objects	3/1/98
ITE	TCIP - Scheduling/Runcutting Objects	3/1/98
ITE	TCIP - Spatial Representation Objects	3/1/98
ITE	TCIP - Traffic Management Objects	8/1/98
NRSC	High Speed Subcarrier (HSSC) Layer 1	Disbanded
ORNL	ITS Datum Level 0 Version 1.0	3/1/98
SAE	A Conceptual ITS Architecture: An ATIS Perspective	Complete
SAE	Adaptive Cruise Control & HF: Op Characteristics & User Interface	7/30/99
SAE	Advanced Traveler Information System (ATIS) Data Dictionary	4/30/98
SAE	Advanced Traveler Information System (ATIS) Message Set	4/30/98
SAE	ATIS Message Structure for High Speed FM Subcarrier	6/30/98
SAE	Field Test Analysis Information Report	7/30/98
SAE	Front Collision Warning HF: Op Characteristics & User Interface	8/30/99
SAE	In-Vehicle Nav & ATIS Comm Device Msg Set Std - Eval Proj	1/20/98
SAE	Information Report on ITS Terms and Definitions	Complete
SAE	ISP-Vehicle Location Referencing Standard	7/30/98
SAE	ITS Data Bus Architecture Information Report	8/15/97
SAE	ITS Data Bus Conformance Testing Standard	9/30/98
SAE	ITS Data Bus Gateway Recommended Practice	9/30/98
SAE	ITS Data Bus Protocol Standard - Application Layer	5/15/98
SAE	ITS Data Bus Protocol Standard - Link Layer	5/30/98
SAE	ITS Data Bus Protocol Standard - Physical Layer	8/30/98
SAE	ITS In-Vehicle Message Priority	8/30/99
SAE	Location Reference Message Specification Information Report	7/30/98
SAE	Location Referencing Stakeholder's Workshop Information Report	5/30/98
SAE	Mayday Industry Survey Information Report	10/15/97
SAE	On-Board Land Vehicle Mayday Reporting Interface	3/30/98
SAE	Serial Data Comm. Between MicroComputer and Heavy Duty Vehicle	Complete
SAE	Std for Nav.& Route Guidance Function Accessibility while Driving	3/30/99
SAE	Std for Nav.& Route Guidance Man-Machine Interface Transactions	3/30/99
SAE	Truth in Labeling Standard for Navigable Map Databases	Complete
SAE	Visual Demand Measurement	6/30/99

Even this list is a subset of the broader set of on-going standards development activities with potential application to ITS. A range of other standards, including construction recommended practices, communications standards, video compression standards, and others could be included in an overall standards inventory with potential use for ITS in the state of California. The most comprehensive ITS

Standards inventory is contained in the ITS Standards and Protocols catalog which describes more than 300 distinct standards and standards activities in its most recent iteration. This catalog is available online through the ITS America web site.

2.5 Focus on Caltrans-Relevant Interfaces

Many of the interfaces defined by the National Architecture are secondary to the near-term focus on deployment of regional ITS systems. As part of the national architecture effort, the interfaces were prioritized in several different ways based on associated technical and non-technical issues and the necessity of the interface to near term activities like ITI and CVISN model deployments. By applying such a filter, the numerous interfaces defined in the National Architecture can be reduced to a more manageable number that can be studied in a detailed manner. This section provides similar focus on a subset of the defined interfaces. In this case, all interfaces are filtered save for those that are of central importance to Caltrans near term operations. Figure 2-2 shows the interfaces supported by a Caltrans Transportation Management Center with a mapping between these real world interfaces and the interfaces defined by the National Architecture framework.

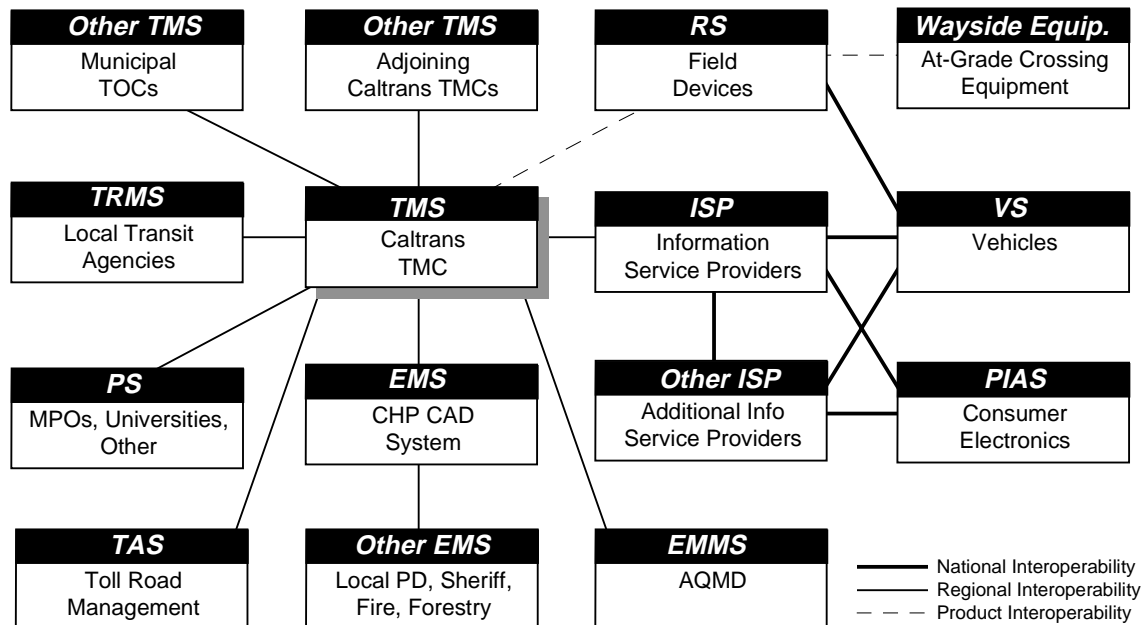


Figure 2-2: Identifying Caltrans Interfaces within the National Architecture

This figure identifies many of the interfaces that support Caltrans' role in regional transportation deployments. Each box identifies a particular system or a collective group of many systems that is relevant to Caltrans operations. The band at the top of each box provides the abbreviation for the subsystem or terminator defined in the national architecture that maps to these systems.

The figure identifies all direct system interfaces to the Caltrans Transportation Management Center as well as many of the secondary interfaces at a level defined by the physical architecture. The figure omits many interfaces (e.g., the interface between transit management and the transit vehicle fleet, the interface between the municipal TOC and associated field elements) that are present but have no direct bearing on Caltrans TMC connectivity.

The abbreviations used to reference the applicable national architecture elements are spelled out in Table 2-3. Using these names, the reader may extract the pertinent elements of the national architecture definition from the documentation, world wide web, or CD-ROM sources.

Table 2-3: Applicable National Architecture Element Names

Abbreviation	National Architecture Name
CVAS	Commercial Vehicle Administration Subsystem
CVCS	Commercial Vehicle Check Subsystem
CVS	Commercial Vehicle Subsystem
EMMS	Emissions Management Subsystem
EMS	Emergency Management Subsystem
EVS	Emergency Vehicle Subsystem
FMS	Fleet and Freight Management Subsystem
ISP	Information Service Provider
PIAS	Personal Information Access Subsystem
PMS	Parking Management Subsystem
PS	Planning Subsystem
RS	Roadway Subsystem
RTS	Remote Traveler Support
TAS	Toll Administration Subsystem
TCS	Toll Collection Subsystem
TMS	Traffic Management Subsystem
TRMS	Transit Management Subsystem
TVS	Transit Vehicle Subsystem
VS	Vehicle Subsystem
Wayside Equip.	Wayside Equipment

2.6 A Closer Look at the Relevant Interfaces

This section examines the standards activities and major deployments with implications for each of the interfaces identified earlier. An overarching review of the existing activities associated with each of the identified interfaces is an important initial step in determining the standardization approach that is appropriate for California,

- **TMS to Other TMS (Caltrans TMC - Municipal TOC Interface)**

- n Activity on several fronts promises (potentially conflicting) results for inter-TMC communication specifications. The NTCIP Center to Center standards activity is currently working towards two different standards, one based on DATEX/ASN.1 and the other on CORBA based partially on work in the Southern California Showcase Program. Continued attention in this area should result in completion of a CORBA-based center to center standard and important approaches for interoperability between the two different approaches.

- n *National Standards Activities*

- NTCIP

- Traffic Management Data Dictionary

- Message Set for External TMC Communication

- Leading State Deployments*

- Southern California Priority Corridor

- MDI Activities*

- One of the priority interfaces identified for MDI commonality

- **TMS to Other TMS (Caltrans TMC to Other Caltrans TMC)**

- n Similar to the previous entry. California has had an early focus in defining an overall approach for state DOT interoperability in defining an overall approach for state DOT interoperability. In general, there are fewer interfaces here and they are more easily bound by Caltrans than in the previous interface to municipal TOCs. Applying the evolving NTCIP standard to this interface as it becomes available should still be considered but the need may not be as compelling as in the previous entry since Caltrans owns both sides of the interface. The current TMC standardization activity in the state will focus on this interface and provide specific solutions.

- n *National Standards Activities*

- NTCIP

- Traffic Management Data Dictionary

- Message Set for External TMC Communication

- Leading State Deployments*

- Southern California Priority Corridor

- MDI Activities*

- One of the priority interfaces identified for MDI commonality

- **TMS to RS** (Caltrans TMC to Field Devices)

- n NTCIP has evolved into the major driver for this interface. Additional protocols and object definition will be made available over the next year, largely completing the standards suite for this interface. Develop plan for converging the existing regulatory standard within the state to the current standard.

- n *National Standards Activities*

- NTCIP

- Traffic Management Data Dictionary

- n *State Standards Activities*

- Assembly Bill No. 3418

- n *Leading State Deployments*

- Existing proprietary interfaces evolving towards NTCIP

- n *MDI Activities*

- Evolution over time towards NTCIP compatible approaches generally acknowledged by all four sites.

n

- **TMS to ISP**

Varied approaches have been deployed in the state with the TravInfo, YATI, and TransCal systems and the evolving Southern California Showcase/TravelTIP approach. Significant commonality between the object definitions required for this interface and the definitions required for the above TMS-TMS interfaces should be recognized and leveraged. Seattle has an operational multi-tiered implementation of this interface that uses a “Self-Describing Data” approach developed at the University of Washington to provide flexible ITS data streams to subscribing ISPs. This approach might be compared and contrasted with the CORBA/IDL-based approach being considered in California for this same interface. The approach formulated by the Northeast Consultants for TransCOM, and the TRW “object toolbox” approach being pursued in Phoenix are other potential points of comparison.

- n *National Standards Activities*

- NTCIP (Future)

- Traffic Management Data Dictionary

- Message Set for External TMC Communication

- n *Other National Activities*

- Enterprise Bearer Independent Format (BIF) specifications have provided significant guidance for this interface. Various implementations have been modeled after BIF specifications. Planned activity to coordinate the IT IS codes promulgated by Enterprise into many slightly different deployments within the SAE ATIS Standards activities.

- n *Leading State Deployments*

- TravInfo, Southern California Showcase, TravelTip

- n *MDI Activities*

US DOT/Architecture team targeted this interface for some level of commonality across the four sites. This coordination did not lead to common interfaces across the four MDI deployments, the varied implementations could be reviewed and used to inform similar efforts in the state.

- **TMS - EMMS** (Caltrans TMS to AQMD)

- n Not currently a priority interface in California. Could develop in the future, especially in the southern region. Phoenix has recently implemented the practice of warning motorists of adverse air quality on variable message signs and routing traffic around the air basin during periods of elevated air pollution levels. Such pollution sensitive demand management practices, if successful, may warrant a closer look at this interface in the future.

- n *National Standards Activities*

None

Leading State Deployments

None

MDI Activities

Phoenix has a manual notification system in place in combination with a state of the art point detection and gross violator citation system.

- **TMS to EMS** (Caltrans TMS to CHP CAD)

- n The need for this interface is highlighted by the early decision to collocate CHP and Caltrans personnel in the same facility to coordinate incident responses. Several leading edge efforts are currently underway in California including Freeway Incident Response Services Tracking (FIRST) program in Los Angeles and the InterCAD program in San Diego. Importantly, from a state defacto standard standpoint, both the InterCAD and FIRST systems share a common interface to the CAD systems. A survey of the MDI sites revealed no apparent, comparable integration efforts underway. This is a key area where the State of California appears to be ahead of the pack and could use this lead to support and influence national standards efforts (such as the proposed IEEE standards activity) as they are initiated.

- n *National Standards Activities*

IEEE Message Set for Incident Management (Future Work)

Leading State Deployments

FIRST

InterCAD

MDI Activities

Current legacy interfaces viewed as varied/difficult to achieve measure of compatibility during the MDI development effort.

n

- **TMS to TAS**

New issues and solutions have been formulated for this interface as private toll roads have began operation in the state. Evolution towards data sharing strategies could benefit both parties, but also creates special handling requirements for private toll road congestion data. The national architecture interface definition encompasses these data sharing interfaces as well as more futuristic congestion pricing coordination over this interface. The high degree of commonality between the traffic data sharing requirements for this interface and the TMS - TMS interface indicate probable leveraging of NTCIP standards for this interface. Unique congestion pricing interface support is a relatively simple technical addition if institutional issues can be resolved. While technically feasible, there is some resistance among toll operators to extend toll collection stations to also collect traffic information for external use. This particular interface is an important issue in the New York/New Jersey/Conn. MDI where a TRANSCOM server to TRANSCOM workstation interface is used that is common with the approach used for TMS - TMS interfaces in the region.

- n *National Standards Activities*

- NTCIP (Likely application of center-center standard)

- Leading State Deployments*

- None identified

- MDI Activities*

- TRANSCOM integrates the traffic management information component of the toll authorities in the North East region. Seattle has several interesting plans in this area but they are unique to the Seattle-area's geography/ferry system and are not applicable to California.

- **TMS to PS (Interface to Planners, Researchers)**

Many agencies, private companies, and other institutions are interested in compiling and using historical data that is represented by this National Architecture interface. In many cases, the information requirements for this interface are a subset of the other center to center interfaces (e.g., TMS -ISP, TMS - TMS) indicating that planners can interconnect with the regional system as an additional traffic management or information service provider system. This reuse of one of the higher priority center to center interface definitions is the approach that is likely to be taken for Southern California Priority Corridor.

- n *National Standards Activities*

- No dedicated effort. A draft version of the Archived Data User Service (ADUS) has been developed and an update to the National ITS Architecture is likely in the next year to incorporate better support for data archiving. It is likely that, following this effort, one or more focused efforts towards data archiving standardization would be initiated.

- Leading State Deployments*

- Southern California Priority Corridor.

- MDI Activities*

- San Antonio was planning to provide extended Internet support for registered users where historical data (up to 30 days old) can be accessed. The general public would only

have access to real-time information. No current information on whether this was accomplished. Washington State DOT regularly prepares (quarterly or bi-annually) a CD ROM that contains a complete set of traffic measures for the Seattle area and provides it on request.

- **TMS to TRMS**

Caltrans TMSs will increasingly share real-time information with transit fleets. Potential applications include the use of transit vehicles as probes. Most of the traffic information sharing requirements for this interface align with information sharing requirements for other center to center interfaces in preceding entries. The TCIP effort is a driver for this interface.

- n *National Standards Activities*

- TCIP. Potential leveraging of NTCIP center-center standards work.

- Leading State Deployments*

- Southern California Priority Corridor.

- MDI Activities*

- While the MDIs all connect Transit and Traffic Management systems in their top-level architectures, relatively little dedicated design work has been performed for this particular interface that has been relayed to the architecture team to date.

- **RS to Wayside Equipment**

A preliminary list of 2070 controller functions listed grade crossing equipment as one of the applicable interfaces. This is an appropriate inclusion that may evolve beyond coordination of adjacent highway-highway intersections in the future. Both Seattle and San Antonio pursuits identified under MDI activities should be monitored for potential application in California. The passive San Antonio approach might be considered an early deployment with the richer Seattle-like deployment coming into play as Positive Train Separation and Positive Train Control systems come on-line.

- n *National Standards Activities*

- National Architecture Definition available 1/97. No HRI-related standards efforts initiated to date through the ITS Standards Acceleration program.

- Leading State Deployments*

- Grade crossing enforcement system in Los Angeles has received national recognition.

- MDI Activities*

- Seattle has plans to provide train information to the regional ATMS as part of the Positive Train Separation test that is under development in the area's high-speed rail corridor. This approach promises to provide high fidelity train information to the area traffic management system but will require cooperation with the railroads. San Antonio is pursuing a non-intrusive railroad monitoring system that can provide similar information on train locations to the TransGuide center with no support from the railroads required.

- **RS to VS**

The dedicated short range communications standards area continues to be contentious. Many, including the National Architecture Team, US DOT, and automobile manufacturers have identified this ITS interface as a priority for national interoperability.

While generally considered to be desirable, achieving national standards has been difficult because of entrenched competing interests for this interface. ASTM has produced six drafts without a successful ballot to date. Two ASTM working groups are currently making progress on Layers 1 and 2 with the stated goal to “find the middle ground” between the new CEN standard and ASTM Draft 6 which basically represents the Hughes system. Once these issues are resolved on the national level, market forces will encourage adoption of the new standard as the tag inventory cycles. Interim operation with multi-protocol readers will solve transition problems.

The state of California should work through the established national standards organizations to aid in achieving these needed ITS standards.

n National Standards Activities

ASTM DSRC Protocol

IEEE DSRC Message Set

Leading State Deployments

Toll bridges, Private toll roads.

MDI Activities

One of the interesting concepts that is being pursued in the San Antonio MDI is the free distribution of tags that present popular state slogans/images (e.g., “Don’t Mess with Texas”) that are placed in cars on a voluntary basis. Tens of thousands of tags have been distributed and approximately 80 readers are beginning to provide good travel time data for the San Antonio area. It was decided that this system would not be compliant with the then most-current ASTM “draft 6” standard. The compelling issues are tag cost and the forecast high turn-over in the tag population (100% every two years) which provides San Antonio an easy migration path to a standard tag when the standard is available. Developments continue on cross compatible approaches (e.g., Recent work to converge Help Inc. and I-95 approaches).

• EMS to Other EMS

The InterCAD system in the San Diego region was developed to provide interoperability between CHP, local police department, sheriff, forestry, and other emergency response agencies. This system is one of the front-runners for the nation for this interface based on the information that has been made available to the architecture team. The IEEE Incident Management committee views this interface as one of their next priorities once the EM to TMS interface is completed. In fact, many of the same messages that are in the P1512 standard will also apply to this interface.

n National Standards Activities

IEEE Message Set for Incident Management

Leading State Deployments

InterCAD, FIRST

MDI Activities

The fire dispatch systems in Chandler and Phoenix are in the process of being integrated using an interface based on the ANSI Health Level 7 (HL7) standard. This interface definition will be submitted to the IEEE Incident Management Committee for future consideration as CAD-CAD interface standards are addressed.

- **ISP to Other ISP**

A secondary interface for Caltrans which represents the interaction between multiple Information Service Providers. The TravInfo, TravelTip, TransCal, YATI, and Southern California Showcase programs all include Information Service Provider support. The Smart Traveler concept is intended to umbrella these efforts and assist in developing a plan for convergence for this interface as well as others. It is important that the state continue to work with the fairly active SAE ATIS efforts for this interface. Practical overlap with the TMS-ISP and TRMS-ISP interfaces identified above allow reuse of the above definitions for this interface. As an interface with substantial private sector influence, any standards will likely be voluntary and heavily influenced by the market.

- n *National Standards Activities*

- SAE Navigation and ATIS Message Set

- SAE ATIS Message Set (Proposed)

- Leading State Deployments*

- MDI Activities*

- The MDI deployments all reflect the “Regional Multi-modal Traveler Information Center” core that is referenced in the early Intelligent Transportation Infrastructure (ITI) definitions. This central repository is currently defined as follows for the four sites:

- 1. San Antonio will integrate a database server into the TransGuide architecture.
 2. Phoenix includes an AZTech Server in its design that will be developed by TRW.
 3. Seattle has the University of Washington ITS Backbone that provides information to Information Service Providers in the region.
 4. Northeast Consultants is developing a Traveler Information Center which integrates with the TRANSCOM regional server and provides data both directly to travelers and to other Information Service Providers.

- **ISP to VS/PIAS**

This interface is a priority for national interoperability and will be heavily influenced by market factors. Many different incompatible systems will be deployed as part of the MDI. It is anticipated that the market will be the ultimate selective force for these interfaces. It is suggested that Traveler Information Systems in the State of California monitor and support the SAE standards in the applicable areas.

- n *National Standards Activities*

- SAE High Speed Data Subcarrier Protocol

- SAE Message Set for Mayday Alert

- SAE ATIS Message Set

- Leading State Efforts*

TravelTIP

TravInfo

Maxwell Labs Web Site

MDI Activities

The MDIs are deploying a diverse set of traveler information systems. For example, three different incompatible FM Subcarrier systems (RBDS, STIC, and HSDS) will be included in the MDI deployments.

2.7 Critical Interfaces and Standards for California

The National ITS Architecture defines more than 300 distinct interfaces and major information flows that integrate intelligent transportation systems. As might be suspected, not all of these interfaces are critical to near-term deployment nor do they all have equal importance to California. This section briefly reviews the interfaces, their associated standards activities, and evaluates their criticality for ITS implementations in the state of California.

The motivation for this section is the desire to focus California's ITS deployment strategy on those interfaces, and standards, that will achieve the most benefit for the state. There are many ways to process through the complete list of interfaces and cull the list of possibilities: Let's consider a few approaches:

1. *Compare the National ITS Architecture interfaces with California's overall transportation needs.* California has arguably the most substantial and diverse transportation requirements in the country. Due to these needs, the interfaces that are necessary to implement ITS in the nation are also generally necessary for California. The notion that the entire National ITS Architecture has potential application in California is supported by the recent Southern California Priority Corridor Strategic Deployment Plan which found that all 56 market packages defined by the National Architecture have potential application within the Southern California Priority Corridor.
2. *Select the interfaces that are important to key stakeholders within the state and focus on these.* Each stakeholder will naturally focus on the interfaces with the greatest implications for their own systems. In our interim report, "California Systems Architecture Study – Part I: A Status Report on Work in Progress", we focused on the interfaces that are central to Caltrans Transportation Management Center operation. This focus resulted in a simplified framework depicted earlier in this chapter that omits many of the interfaces defined in the National ITS Architecture. For a particular stakeholder, a subset of the National ITS Architecture interfaces can be identified. It is not clear whether this focus on the needs of particular stakeholder(s) is appropriate for this research.
3. *Identify interfaces where market forces are not the critical driver and focus public resources in these areas.* In many of the ITS interfaces, the market will likely be the ultimate arbitrator (if the market develops as we hope). California's public funds may best be focused on other interfaces where public interest is the primary driver. This approach would entail reviewing the architecture interfaces and identifying those that are likely to be public-public, public-private, and private-private and focusing on those interfaces where at least one end of the interface is likely to be operated and maintained by a public agency in the state. This would also serve as an initial filter analysis that could be combined with any of the other analyses.
4. *Compare the current federal standards acceleration program with the state's needs and focus on those areas where the state's need is clear and there is no current federal support.* We have a complete inventory of current federally sponsored standards activities. The coverage of these activities could be reviewed for critical gaps.

5. *Focus on those interfaces that have the biggest impact on the state’s “bottom-line”.* In effect, this analysis would attempt to identify the interfaces where the cost of not standardizing is greatest. This would require insight into state spending profiles for different ITS segments and projections of how much money standards would save in each of these areas. This could be a valuable analysis, but probably cannot be credibly accomplished within the modest remaining schedule and budget of this research project.
6. *Favor standards and interfaces that support near term needs over those that support longer range deployments.* This is an obvious criteria that has been applied in earlier National ITS Architecture analyses. This analysis could be applied to assist in picking those standard interfaces that have near-term criticality for the state.

Alternatives 3, 4 and 6 are pursued further in this memo. Each analysis can be applied separately or in combination to assist in identification of interfaces of most importance to the state. Of course, this rather mechanical approach should be reviewed and the results tested to ensure that they match our intuition of what is most important to California.

2.7.1 Identify Key Near-Term Interfaces

This paragraph identifies the interfaces that are critical to early deployments using the National ITS Architecture tools available on the widely distributed CD-ROM. The National ITS Architecture databases provided on the CD-ROM contain all architecture design information that was used to develop the architecture and supporting documentation. These same Microsoft Access databases are a good starting point for custom application and analysis of the architecture. For example, the Physical.MDB Access Database identifies priority deployments (largely those that support the Metropolitan ITS Infrastructure, Rural ITS, and CVISN early deployment initiatives). Using the National ITS Architecture database and the custom “California” database created for this project, the interfaces identified in Table 2-4 were identified. Table 2-4 includes 155 distinct interfaces and information flows, about half of the system interface requirements identified in the architecture.

Table 2-4: Interfaces Critical to Early ITS Deployments in California

Source	Destination	Architecture Flow
Commercial Vehicle	Commercial Vehicle Subsystem	vehicle measures
Commercial Vehicle Administration	Commercial Vehicle Check	credentials information
Commercial Vehicle Administration	Commercial Vehicle Check	CVO Database update
Commercial Vehicle Administration	Commercial Vehicle Check	safety information
Commercial Vehicle Administration	Financial Institution	payment request
Commercial Vehicle Administration	Fleet and Freight Management	compliance review report
Commercial Vehicle Administration	Fleet and Freight Management	electronic credentials
Commercial Vehicle Administration	Other CVAS	CVAS information
Commercial Vehicle Administration	Planning Subsystem	operational data
Commercial Vehicle Check	Commercial Vehicle Administration	credentials information
Commercial Vehicle Check	Commercial Vehicle Administration	roadside log update
Commercial Vehicle Check	Commercial Vehicle Administration	safety information request
Commercial Vehicle Check	Commercial Vehicle Subsystem	border clearance event
Commercial Vehicle Check	Commercial Vehicle Subsystem	border clearance request
Commercial Vehicle Check	Commercial Vehicle Subsystem	clearance event record
Commercial Vehicle Check	Commercial Vehicle Subsystem	lock tag data request
Commercial Vehicle Check	Commercial Vehicle Subsystem	on-board safety request
Commercial Vehicle Check	Commercial Vehicle Subsystem	pass/pull-in

Table 2-4: Interfaces Critical to Early ITS Deployments in California

Source	Destination	Architecture Flow
Commercial Vehicle Check	Commercial Vehicle Subsystem	safety inspection record
Commercial Vehicle Check	Commercial Vehicle Subsystem	screening request
Commercial Vehicle Subsystem	Commercial Vehicle Check	border clearance data
Commercial Vehicle Subsystem	Commercial Vehicle Check	lock tag data
Commercial Vehicle Subsystem	Commercial Vehicle Check	on board safety data
Commercial Vehicle Subsystem	Commercial Vehicle Check	screening data
Commercial Vehicle Subsystem	Fleet and Freight Management	driver and vehicle
Commercial Vehicle Subsystem	Fleet and Freight Management	on board vehicle data
Emergency Management	Emergency Vehicle Subsystem	assigned route
Emergency Management	Emergency Vehicle Subsystem	emergency dispatch
Emergency Management	Emergency Vehicle Subsystem	hazmat information
Emergency Management	Information Service Provider	emergency vehicle route
Emergency Management	Other EM	emergency coordination
Emergency Management	Personal Information Access	emergency acknowledge
Emergency Management	Remote Traveler Support	emergency acknowledge
Emergency Management	Traffic Management	emergency vehicle
Emergency Management	Traffic Management	incident information
Emergency Management	Transit Management	transit emergency
Emergency Management	Vehicle	emergency acknowledge
Emergency Vehicle Subsystem	Emergency Management	emergency vehicle driver
Emergency Vehicle Subsystem	Emergency Management	emergency vehicle driver
Emergency Vehicle Subsystem	Roadway Subsystem	emergency vehicle
Emissions Management	Planning Subsystem	operational data
Financial Institution	Commercial Vehicle Administration	transaction status
Financial Institution	Parking Management	transaction status
Financial Institution	Toll Administration	transaction status
Financial Institution	Transit Management	transaction status
Fleet and Freight Management	Commercial Vehicle Administration	credential application
Fleet and Freight Management	Commercial Vehicle Administration	tax filing, audit data
Fleet and Freight Management	Commercial Vehicle Subsystem	fleet to driver update
Fleet and Freight Management	Emergency Management	hazmat information
Fleet and Freight Management	Information Service Provider	route request
Fleet and Freight Management	Intermodal Freight Shipper	intermod CVO coord
Fleet and Freight Management	Payment Instrument	request for payment
Information Service Provider	Emergency Management	emergency vehicle route
Information Service Provider	Fleet and Freight Management	route plan
Information Service Provider	Personal Information Access	broadcast information
Information Service Provider	Personal Information Access	traveler information
Information Service Provider	Personal Information Access	trip plan
Information Service Provider	Planning Subsystem	road network use
Information Service Provider	Remote Traveler Support	broadcast information
Information Service Provider	Remote Traveler Support	traveler information
Information Service Provider	Remote Traveler Support	trip plan
Information Service Provider	Toll Administration	toll data request
Information Service Provider	Traffic Management	request for traffic

Table 2-4: Interfaces Critical to Early ITS Deployments in California

Source	Destination	Architecture Flow
Information Service Provider	Traffic Management	road network use
Information Service Provider	Transit Management	transit information request
Information Service Provider	Vehicle	broadcast information
Information Service Provider	Vehicle	traveler information
Intermodal Freight Shipper	Fleet and Freight Management	intermod CVO coord
Intermodal Transportation Service	Transit Management	intermodal information
Location Data Source	Personal Information Access	position fix
Location Data Source	Vehicle	position fix
Map Update Provider	Personal Information Access	map updates
Map Update Provider	Vehicle	map updates
Other CVAS	Commercial Vehicle Administration	CVAS information
Other EM	Emergency Management	emergency coordination
Other TM	Traffic Management	TMC coord.
Parking Management	Enforcement Agency	violation notification
Parking Management	Financial Institution	payment request
Parking Management	Planning Subsystem	operational data
Parking Management	Vehicle	tag update
Payment Instrument	Fleet and Freight Management	payment
Payment Instrument	Remote Traveler Support	payment
Payment Instrument	Transit Vehicle Subsystem	payment
Payment Instrument	Vehicle	payment
Personal Information Access	Emergency Management	emergency notification
Personal Information Access	Information Service Provider	traveler information
Personal Information Access	Information Service Provider	trip request
Planning Subsystem	Traffic Management	planning data
Planning Subsystem	Transportation Planners	planning data
Rail Operations	Traffic Management	railroad advisories
Rail Operations	Traffic Management	railroad schedules
Remote Traveler Support	Emergency Management	emergency notification
Remote Traveler Support	Information Service Provider	traveler information
Remote Traveler Support	Information Service Provider	trip request
Remote Traveler Support	Payment Instrument	request for payment
Remote Traveler Support	Transit Management	emergency notification
Remote Traveler Support	Transit Management	transit request
Roadway Subsystem	Traffic Management	freeway control status
Roadway Subsystem	Traffic Management	HOV data
Roadway Subsystem	Traffic Management	hri status
Roadway Subsystem	Traffic Management	incident data
Roadway Subsystem	Traffic Management	local traffic flow
Roadway Subsystem	Traffic Management	request for right of way
Roadway Subsystem	Traffic Management	signal control status
Roadway Subsystem	Traffic Management	vehicle probe data
Roadway Subsystem	Wayside Equipment	hri status
Toll Administration	Enforcement Agency	violation notification
Toll Administration	Financial Institution	payment request

Table 2-4: Interfaces Critical to Early ITS Deployments in California

Source	Destination	Architecture Flow
Toll Administration	Information Service Provider	toll data
Toll Administration	Planning Subsystem	operational data
Toll Administration	Toll Collection	toll instructions
Toll Collection	Toll Administration	toll transactions
Toll Collection	Vehicle	tag update
Traffic Management	Emergency Management	incident notification
Traffic Management	Information Service Provider	traffic information
Traffic Management	Other TM	TMC coord.
Traffic Management	Parking Management	demand management price
Traffic Management	Planning Subsystem	operational data
Traffic Management	Rail Operations	hri advisories
Traffic Management	Roadway Subsystem	freeway control data
Traffic Management	Roadway Subsystem	hri control data
Traffic Management	Roadway Subsystem	hri request
Traffic Management	Roadway Subsystem	signage data
Traffic Management	Roadway Subsystem	signal control data
Traffic Management	Roadway Subsystem	surveillance control
Traffic Management	Toll Administration	demand management price
Traffic Management	Transit Management	signal priority status
Transit Management	Emergency Management	security alarms
Transit Management	Enforcement Agency	violation notification
Transit Management	Financial Institution	payment request
Transit Management	Information Service Provider	transit and fare schedules
Transit Management	Intermodal Transportation Service	intermodal information
Transit Management	Planning Subsystem	operational data
Transit Management	Remote Traveler Support	emergency acknowledge
Transit Management	Remote Traveler Support	transit and fare schedules
Transit Management	Traffic Management	request for transit signal
Transit Management	Traffic Management	transit system data
Transit Management	Transit Vehicle Subsystem	bad tag list
Transit Management	Transit Vehicle Subsystem	emergency acknowledge
Transit Vehicle Subsystem	Payment Instrument	request for payment
Transit Vehicle Subsystem	Roadway Subsystem	local signal priority request
Transit Vehicle Subsystem	Transit Management	emergency notification
Transit Vehicle Subsystem	Transit Management	fare and payment status
Transit Vehicle Subsystem	Transit Management	transit vehicle conditions
Transit Vehicle Subsystem	Transit Management	transit vehicle passenger
Transit Vehicle Subsystem	Transit Management	vehicle probe data
Vehicle	Emergency Management	emergency notification
Vehicle	Information Service Provider	traveler information
Vehicle	Information Service Provider	vehicle probe data
Vehicle	Parking Management	tag data
Vehicle	Payment Instrument	request for payment
Vehicle	Roadway Subsystem	vehicle probe data
Vehicle	Toll Collection	tag data

Table 2-4: Interfaces Critical to Early ITS Deployments in California

Source	Destination	Architecture Flow
Vehicle	Transit Vehicle Subsystem	vehicle location
Wayside Equipment	Roadway Subsystem	track status

2.7.2 Identify Interfaces that are not Supported by the National Program

The National ITS Architecture team is currently tracking the progress of standards development versus the architecture interfaces. By connecting this standards progress with the National ITS Architecture, we can get a quick snapshot of the standards progress versus the critical interfaces identified in the previous section. Table 2-5 identifies those critical interfaces from Table 2-4 that are not currently targeted by any standards organization.

A review of Table 2-5 indicates that the major standards organizations are pursuing, or planning to pursue, standards for almost all critical ITS interfaces. The interfaces that have not been targeted to date fall into two major groups: 1) Several of the interfaces to the Fleet and Freight Management Subsystem that represent the interface between the (normally private) fleet manager and his fleet and cargo, and 2) Recently added interfaces to the architecture associated with interface and management of Highway-Rail intersections. It is likely that the highway-rail intersection interfaces will be picked up in near-term proposals. The remaining interfaces don't appear to be of special significance to California and/or Caltrans. It appears that US DOT's standards acceleration program is serving California's interests.

Table 2-5: "Critical" Interfaces with No Planned Standards Activity

	Destination	Architecture Flow
Commercial Vehicle	Fleet and Freight Management	driver and vehicle information
Commercial Vehicle	Fleet and Freight Management	on board vehicle data
Fleet and Freight Management	Commercial Vehicle	fleet to driver update
Fleet and Freight Management	Intermodal Freight Shipper	intermod CVO coord
Intermodal Freight Shipper	Fleet and Freight Management	intermod CVO coord
Rail Operations	Traffic Management	railroad advisories
Rail Operations	Traffic Management	railroad schedules
Roadway Subsystem	Traffic Management	hri status
Roadway Subsystem	Wayside Equipment	hri status
Traffic Management	Rail Operations	hri advisories
Traffic Management	Roadway Subsystem	hri control data
Traffic Management	Roadway Subsystem	hri request
Vehicle	Transit Vehicle Subsystem	vehicle location
Wayside Equipment	Roadway Subsystem	track status

Table 2-6 lists the on-going standards activities that are currently developing, or are planning to develop, standards for the interfaces critical to early California ITS deployments. These critical standards activities should be supported by California stakeholders.

Table 2-6: Standards Activities Currently Developing Critical ITS Standards

	Standard Title
AASHTO1-10	Video Detection Devices
AASHTO1-11	Vehicle Classification Devices
AASHTO1-12	Automatic Vehicle Identification (within NTCIP)

	Standard Title
AASHTO1-14	Communications Profiles (for NTCIP)
AASHTO1-15	Field Management Station
AASHTO1-8	Weigh-in-Motion
AASHTO1-9	Class E Profile for Center to Center Communications
ASTM1	Dedicated Short-Range Communication (DSRC) Physical Layer - 902 - 928 MHz
ASTM2	Dedicated Short-Range Communication (DSRC) Data Link Layer
ASTM3	Dedicated Short-Range Communication (DSRC) System - Layers 3-6, Preliminary
CVO/TS284	Commercial Vehicle Safety Reports
CVO/TS285	Commercial Vehicle Safety and Credentials Information Exchange
CVO/TS286	CVO - Credential Application
IEEE7	Message Sets for Incident Management (EMS to TMC, E911)
ITE-96-02	Transit Communications Interface Protocols
ITE-96-04	Message Set for External TMC Communications
ITE-9601-1	ATMS Data Dictionary (TMDD) - Section 1 (Links/Nodes)
ITE-9601-2	ATMS Data Dictionary (TMDD) - Section 2 (Incidents)
ITE-9601-3	ATMS Data Dictionary (TMDD) - Section 3 (traffic control)
ITE-9601-4	ATMS Data Dictionary (TMDD) - Section 4 (DMS/Video/etc)
ITE-9604-1	Message Set for External TMC Communication (MS/ETMCC) - Bundle A
ITE-9604-2	Message Set for External TMC Communication (MS/ETMCC) - Bundle B
NEMA TS3.1	NTCIP Overview
NEMA TS3.2	NTCIP Simple Transportation Management Protocol
NEMA TS3.3	NTCIP Class B Profile
NEMA TS3.4	Global Object Definitions
NEMA TS3.5	Actuated Signal Controller Objects
NEMA-TS3.6	Dynamic Message Signs
P1455	Message Sets for DSRC for ETTM and CVO
SAE-J2313	On-Board Land Vehicle Mayday Reporting Interface
SAE-J2353	Advanced Traveler Information System (ATIS) Data Dictionary
SAE-J2354	Advanced Traveler Information System (ATIS)Core Message List
SAE-J2369	ATIS Message Structure for High Speed FM Subcarrier
SAE-J2374	National Location Referencing Specification

2.8 A California Interoperability Framework

Several state and national efforts are currently addressing ITS interoperability, taking slightly different routes towards essentially the same objectives. The question we are all trying to answer is: “What must be put into place to ensure that future ITS systems will efficiently and effectively work together?” This paper provides a summary of current activities and suggests ways that an “Interoperability Framework” can be productively used to guide the ITS deployments in the state of California.

2.8.1 Defining “Interoperability Framework”

What is Interoperability?

The National ITS Architecture program was originally conceived as a way to achieve nation-wide compatibility for ITS systems. This is the terminology used in the ISTEA legislation and in all initial

US DOT documentation on the National ITS Architecture program. As the architecture was developed and reviewed, more precise terminology and definitions were attached to the general goal that the next generation transportation system could be easily integrated and would provide uniform access to ITS services across the nation.

Today, the accepted usage is that “compatibility” is a broad term that includes issues such as non-interference while the term “interoperability” gets more precisely at the ability to connect systems together. While the broader issues associated with compatibility are being addressed by many of the standards activities, the National ITS Architecture requirements focus on interoperability issues.

Numerous definitions for “interoperability” exist. From the National ITS Architecture, we have:

(Standards Development Plan) Interoperability - The capability of two systems to operate with each other, exchange information efficiently, and utilize the capabilities in each of the systems effectively.

(Standards Requirements Document) Interoperability is the key to achieving many of the goals of the Architecture that are dependent on cooperating and communicating systems. The interoperability requirements were assessed on a four level scale for all interfaces defined by the National ITS Architecture. The levels are, in order of decreasing stringency:

- 1. National Interoperability*
- 2. Regional Interoperability*
- 3. Product Interoperability*
- 4. None*

Among other definitions, one that has garnered some support within the ITS community is based on a definition included in a paper submitted for the 1997 ITS World Congress entitled "Automatic Toll Collection Systems In Europe: The Requirements for Interoperability," co-authored by Dr. Zoe Ketselidou, Mr. Brian Bourne, and Dr. William Gillan of UK Department of Transport. This paper provides a broad definition of interoperability that explicitly incorporates non-technical issues, which is appropriate for this research project given its focus on institutional issues and policy emphasis:

"Interoperability is the ability of systems to provide services to and accept services from other systems and to use the services so exchanged to enable them to operate effectively together.

Three aspects of interoperability are distinguished:

- Contractual interoperability which encompasses the financial agreements and contractual relationship between operators with interoperable EFC Systems;*
- Procedural interoperability which is the adoption of common procedures and common data element definitions for the exchange of information;*
- Technical interoperability which is the capability of equipment to communicate. Technical interoperability is the most complex and potentially the most expensive aspect to implement."*

This definition has been selected and further refined by the ITS America Interoperability Subcommittee. This subcommittee is jointly administered through the ITS America System Architecture and Standards and Protocols Committees. The chairs of all three of these committees are intimately familiar with the National ITS Architecture through experience on the development team itself or as primary reviewers. Rob Jaffe is the chair of the system architecture committee, Allan Kirson leads the Standards and Protocols committee, and Bob Parsons chairs the Interoperability subcommittee.

The Interoperability subcommittee's charter is to provide guidance for the development of the overall requirements and process for achieving interoperable ITS systems. One of the first tasks of this committee was to develop a standard definition for interoperability for use by the ITS community. Many candidate definitions have been reviewed by the committee including those cited herein as well as other, more technical definitions that are grounded in the 7-layer ISO OSI communications model. At this time, it appears that the definition of choice will include the same three components (Contractual, Procedural, and Technical) originally recommended by Ketselidou, Bourne, and Gillan.

The Interoperability Subcommittee is addressing requirements beyond the information requirements specified in the National ITS Architecture, constraints with regard to performance considerations, efficiency, capacity, security, priority, service availability, and quality of service have been discussed in this forum. A key pursuit of this committee is to determine the need and structure for a certification/endorsement process for ITS products. These special requirements, especially those that have system-wide implications such as end-to-end system performance, may also be viewed as an intrinsic part of an overall interoperability framework depending on our definition and California's needs.

“Framework”

The word “framework” is itself the most commonly used synonym for the National ITS Architecture. The word is used almost every time the architecture is defined. “Framework” is used here to mean a common overall structure that connects together the many different systems and interfaces that must work together to provide an ITS user service. The framework identifies the requirements for each interface that are necessary to ensure that the many different ITS systems will work together and the supporting standards will be consistent. The National ITS Architecture “framework” focuses on the information exchanges that are required for each interface and also touches on special requirements to include performance, communications, security, etc. The necessity for such a framework, and the holistic view that it represents, is well illustrated in a recent graphic from ITS America (see Figure 2-3).

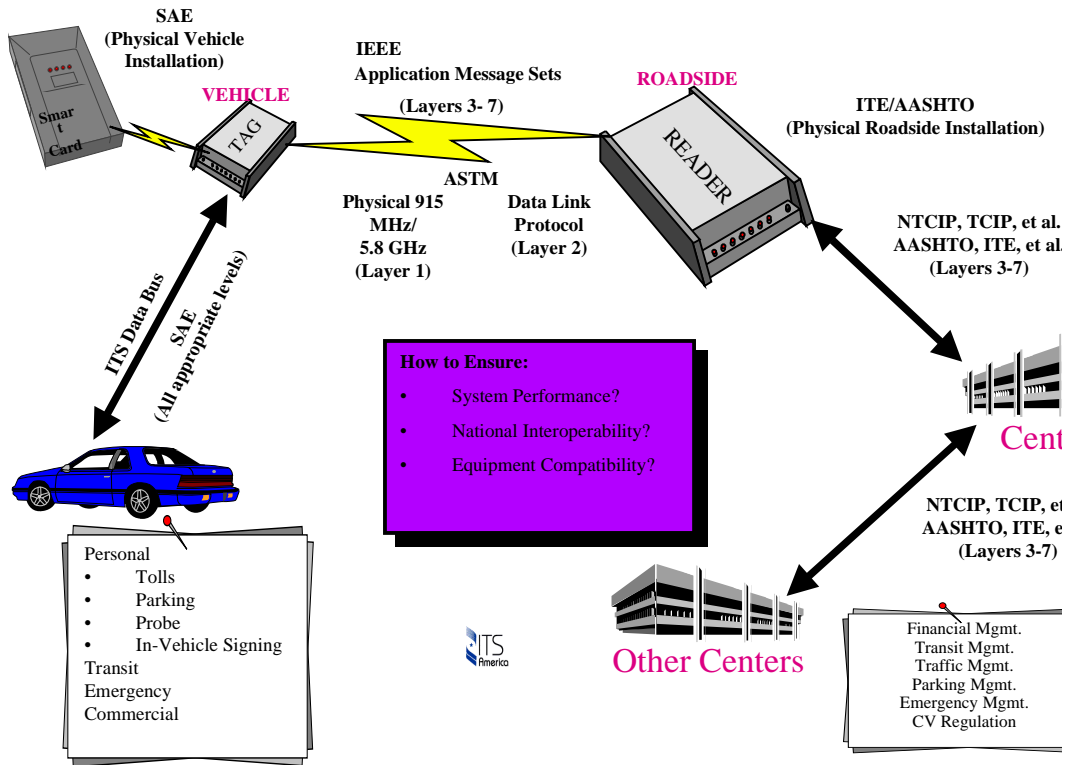


Figure 2-3: A Systems View of Interoperability Requirements for ETC

The figure illustrates that many different standards must work together to actually provide an end-to-end ITS service (like electronic toll collection). A framework is just such an end-to-end depiction of the interfaces and requirements for interoperability. It assists in the scoping, management, and evaluation of supporting standards and represents a structure into which these standards fit when they are available.

The National ITS Architecture provides a structured view of these interfaces and a baseline set of consistent requirements intended to guide their implementation. Of course, the National ITS Architecture is much broader since it also includes the interfaces required for the other user services. In many cases, the National ITS Architecture is the framework that is being used to structure and manage the ITS standards program. In other cases, the National Architecture is viewed as an overarching framework from which more specific frameworks can be created for particular services. Perhaps the best example of a more in-depth framework that is consistent and further defines the architecture framework for a particular set of services is the CVISN initiative which specifies a interconnected regional framework that supports efficient commercial vehicle credentialing and safety checks.(see <http://www.jhu.com/cvisn> for more information).

The Interoperability Framework

Based on these individual definitions, we can discuss an interoperability framework for California along two dimensions: 1) What are the interfaces that are defined by this framework, and 2) For each identified interface, what are the associated interoperability requirements that should be included in this framework. In any US ITS framework, the identified interfaces should be very close to those defined in the National ITS Architecture. In some cases, only a subset of the national interfaces will be required since not all user services will be implemented in all regions. In other cases, new interfaces will be required as new services are implemented that are not covered by the National ITS Architecture. In

either case, the basic ITS interfaces defined in the framework should coincide with those defined in the National ITS Architecture. Thus, to a large extent, the National ITS Architecture informs the interface identification portion of the framework. It also provides a key input, but not the only input, to the requirements that are identified for each interface. A more specific discussion of the National ITS Architecture and its contribution to a statewide interoperability framework is provided in the next section.

2.8.2 National Architecture Interfaces

The most familiar view of the National ITS Architecture is the sausage diagram presented in figure 2-4. It shows a number of interfaces that connect transportation centers and “roadside” elements that are distributed throughout the transportation network with travelers and their vehicles. The sausage diagram is an excellent introductory graphic that introduces some of the most important pieces of the National ITS Architecture. The graphic is approachable in part because it omits many important interfaces. It shows only the central portion of a much larger architecture.

The 19 interconnected subsystems identified in the sausage diagram are the central focus of the National ITS Architecture; however, the diagram does not provide a comprehensive view of the interfaces defined by the architecture. For example, the sausage diagram shows the interface between the toll tag and toll collection system beacon (vehicle subsystem to toll collection subsystem via Dedicated Short Range Communications) that was identified in Figure 2-3, but it omits many of the other important interfaces from Figure 2-3, like the interface between the toll tag and the vehicle itself and the interface into the financial infrastructure.

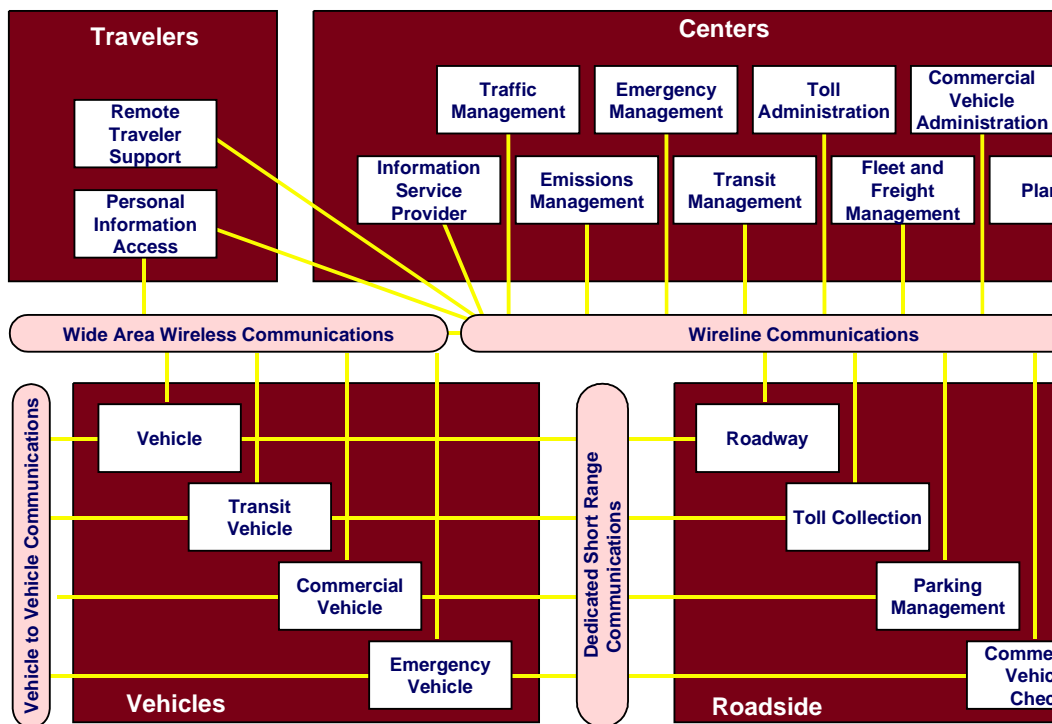


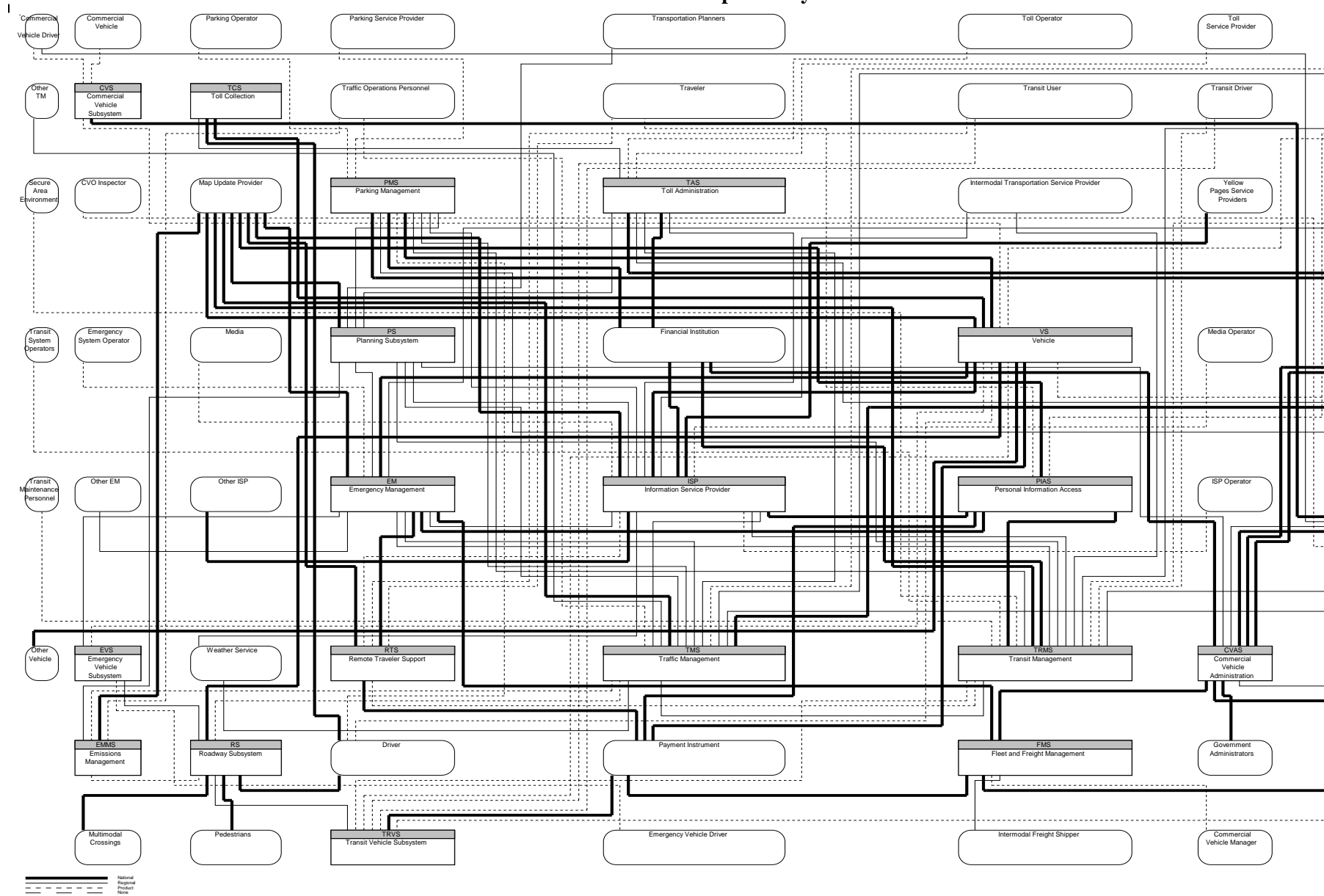
Figure 2-3: Introducing the National ITS Architecture

The National ITS Architecture actually includes these interfaces, and others, since it also defines interfaces to 57 terminators that are not displayed on the sausage diagram. The interfaces to these terminators are defined by the architecture in exactly the same way as the interfaces between subsystems that are identified in the sausage diagram. When these additional interfaces are added, the National ITS Architecture models all interfaces identified in Figure 2-3.

Figure 2-5 shows all of the interfaces that are defined by the Architecture. Each interface in the figure is encoded with the National/Regional/Product/None interoperability rating from the National ITS Architecture documentation. Note that the ITS Interoperability community (there really is one of sorts) has in general, moved beyond this four-level categorization of interoperability. This categorization still provides one useful dimension of the interoperability discussion. More importantly, the figure shows the entire scope of the Interoperability Framework defined in the National ITS Architecture.

The figure identifies all interfaces that are required to implement the 30 ITS user services in a manner consistent with the National ITS Architecture. This complex framework of interfaces is being used to scope and manage ITS standards acceleration activities that will ultimately populate the framework with open standards. Any framework that is developed by California should also be traceable to this national framework.

FIGURE 2-5: National ITS Architecture Interoperability Framework



Of course, the pursuit of interoperability did not stop with publication of the final architecture in January 1997. On-going standards activities are developing detailed specifications for many of the interfaces identified in figure 2-5. An easily accessible, but somewhat outdated version of this mapping between architecture and standards is available on the ITS America Standards web page. The web page that traces between the architecture framework and standards has not been recently reviewed or updated, but still represents a reasonable review of the scope of the current standards activities. For a more current and detailed view of the status of the standards activities in terms of the National ITS Architecture, access the mapping on the Version 2.0 CD-ROM and/or the National ITS Architecture web site at www.odetics.com/itsarch.

The national interoperability framework provided by the National ITS Architecture addresses the end-to-end information needs of ITS systems and provides each standards committee with a baseline for what is required. There are several interoperability issues that can be addressed through adherence to this top level framework and on-going coordination:

- For the system to work efficiently, standards must implement the same basic elements in the same way. Location references are an example of a basic element that will be passed across many of the interfaces depicted in Figure 2-5. The Location Referencing Message Specification is being coded into a SAE Recommended Practice which was available (in Draft form) in 1998. This interim report will be further supported by subsequent publication of Location Referencing standards that focus on particular profiles. A significant remaining issue is the means of converting from one standard Location Referencing profile to another. In many cases, these conversions will not be easy or perhaps not even possible by ITS devices with limited capabilities. These factors might lead the state to further restrict the location referencing profiles that are recommended by its framework. The first of these standard profiles will be the Cross Streets Profile that should be available as a balloted SAE standard at the end of 1998. The interoperability framework should specify such foundational definitions and standards.
- In addition to being consistent, the developed standards must also be precise. There are several examples (e.g., ATM and SONET standards) in which hastily developed and adopted standards have not included sufficient specification to guarantee interoperability between standard-compliant systems. The National ITS Architecture documentation warns of this issue but provides no guidelines for avoiding these issues in future ITS standards. Such guidelines could also be included in a framework either directly or by reference if they were available.

Through the National ITS Architecture, the standards activities, and the various ITS America Activities, a National ITS Framework is taking shape. It consists of the National ITS Architecture definition that will evolve to incorporate the results of the current standards activities, as they become available. Augmenting this information model that will evolve in detail with completion of the standards activities are the ITS America activities that will add requirements dimensions to the framework and address product certification and endorsement issues for each interface.

A set of policies must ultimately accompany this technical interoperability model. For each interface area, policies must be established with regard to encouraging standards usage, certifying standards and products for use, and managing the evolution of the standards over time. These policy issues may be regarded as an additional dimension of the framework.

2.8.3 California Interoperability Framework

Defining the Interfaces

Using our definition, we begin by identifying the interfaces that should be included in the California Interoperability framework. One might hope that by focusing on the state's needs, a more sparse set of most important interfaces might be identified that includes only a subset of the interfaces defined on the national level by the architecture.

This chapter explores in some detail the identification of "critical standards" for California. In general, the findings of that section are that California transportation requirements are so broad and the state is so diverse that the important standards for California are synonymous with those of the nation. For any particular stakeholder group (for instance, Caltrans), a subset of the interfaces could be prioritized. Viewing the state as a whole, it is not clear what differences from overall national priorities would persist. This finding is also supported by the Southern California Priority Corridor Strategic Deployment Plan which includes all 56 market packages defined by the National ITS Architecture in its vision of what will be deployed in Southern California over the next two decades.

So, the ITS interfaces that are important to the state are generally the same as those of the nation. Of course, non-technical issues are also at play here. It may be that within a state interoperability framework, hard choices can be made that would not be possible in a more general national framework. For this reason, the framework for the state may identify exactly the same interfaces as the National Framework, but each interface may provide more precise requirements that would have the net impact of improving interoperability within the state. A leading example of this additional specification at the state level may be California's specific choices for application of the NTCIP Center to Center standard. It appears likely that the national standard will support two alternative approaches: 1) a Common Object Request Broker Architecture (CORBA) based standard and, 2) a DATEX/ASN based standard. The state might decide to select between the two alternatives, and set its own more restrictive policy to only support CORBA aligned systems for future integration projects in the state. This is a choice that cannot be made on a national level at this point in time given the range of stakeholders and opinions on this issue.

While developing the state framework and making these "hard choices", we must also be sensitive to the national activities and their implications for the state. This alignment with national activities should be one of the key contributions of this project.

If one reviews 2-5 to select the interfaces that may be implemented in the state, the probable finding would be that all of them may be required in one implementation scenario or another within the state. Earlier, we focused on the interfaces that are central to Caltrans Transportation Management Center operation. This focus resulted in a simplified framework that is repeated in Figure 2-6 that omits many of the interfaces defined in the National ITS Architecture. If the framework is to be for the entire state of California, something as comprehensive as Figure 2-5 may be required. Subset frameworks that support a particular service or identify the interfaces that are important to a particular agency are easily extracted once a general framework is established.

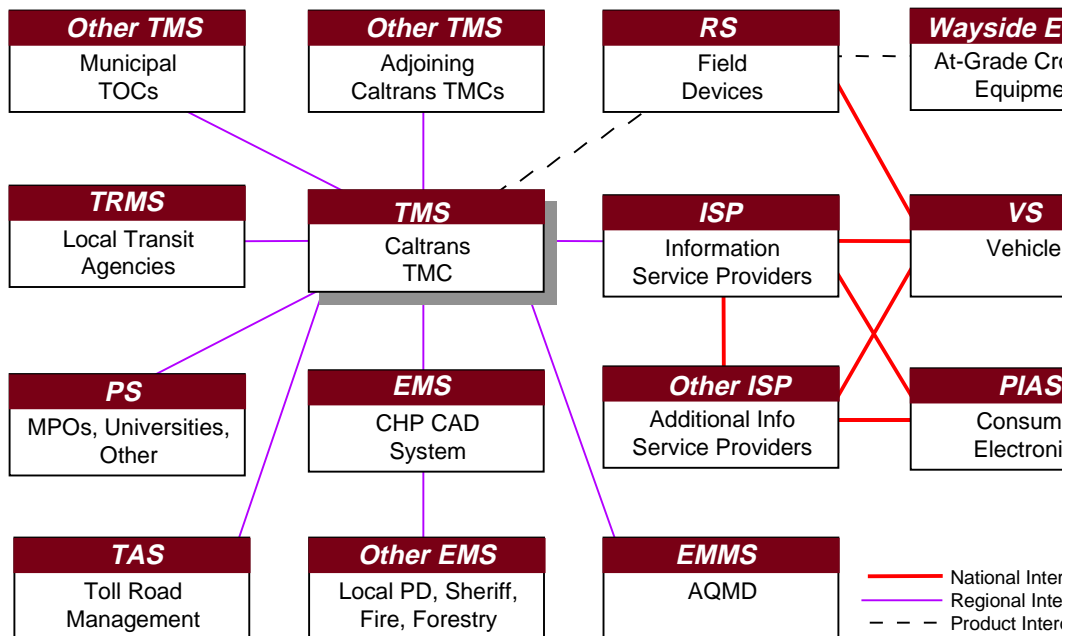


Figure 2-6: Critical Caltrans Interfaces

It is attractive to think about subset frameworks that focus on near-term, or priority interfaces. Care must be taken to avoid the risks that parsing up the framework into smaller, digestible components can raise. Broad foundational standards would have to bridge these specialized frameworks to facilitate the interoperability between frameworks that would ultimately be required. Both the previously mentioned Location Referencing example and the NTCIP Center to Center communications standards are examples of bridging standards that would impact and connect many of these partial frameworks.

Of course, these specific interfaces are addressed within the overall framework provided by the National ITS Architecture. Ultimately, the state will have to consider the broader list of interfaces as discussed in this paper. For any set of interfaces, here are some of the attributes/requirements that should be considered within an interoperability framework:

- Information requirements (Source: National Architecture. Basic conformance a requirement for Title 29/Title 43 federal funds. More detailed information requirements that are an elaboration of the architecture interface definitions could be specified by the state in situations where it is beneficial.)
- Communications Requirements (Source: National Architecture (High Level))
- Communications Media Choices (State/Regional/Local Choice)
- Communications Make/Buy Policy for various interfaces
- Special requirements (Security, Availability, Reliability,...)
- Performance requirements (Where these requirements have been derived)
- Applicable standards activities/standards (Basic application of standards likely a federal requirement for Title 29 and Title 43 projects. More explicit choices between standards options may be specified by the state)
- Evaluation/Certification Approach

2.9 Architecture and Standards Conformance

Questions about “conformance” with the National ITS Architecture and ITS standards have been increasingly frequent during the California System Architecture research activities -- Will conformance be required? What projects will it apply to? How will project planning and implementation processes be impacted? How will conformance be monitored and enforced? These are all questions that have current and keen interest for state and local implementors. As a direct result of this interest, “conformance” is one of the topics that came up repeatedly in our Phase II activities and was touched on again in recent guidance from Caltrans for our Phase III activities. Unfortunately, there are no pat answers to any of these pertinent conformance questions at this point in time. US DOT is still constructing policy for conformance as of this writing. Interim policy is expected no later than October 1998 (following within a month of this report), but only the general parameters of this policy are public information at this time.

The material that has been presented previously in the course of this project still generally holds.

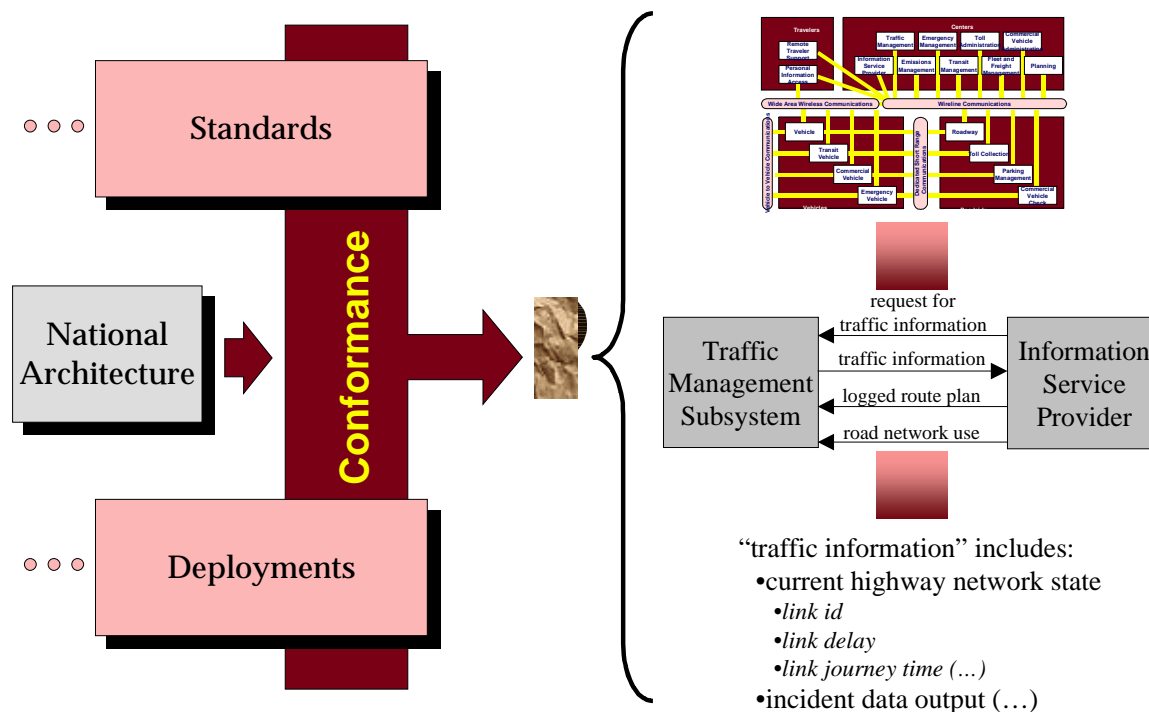


Figure 2-7: Previous Presentation Graphic Addressing Architecture Conformance

While the graphic does not provide specifics, it conveys several principals that will surely be reflected in the conformance policy:

- The National ITS Architecture must inform both the standards activities and deployment activities if it is to serve in its intended role as a bridge to interoperable systems.
- The architecture can be described, and conformed to, at several different levels. The “sausage diagram” level of conformance is easily achieved and helps to ensure that the breadth of ITS stakeholders are brought to the table in the process. Conformance with the basic connectivity requirements identified by the architecture requires little additional effort and begins to ensure a deployment (or standard) meets the most basic interface requirements specified by the architecture.

The most detailed specifications of the architecture require significantly more effort to comply with but represents the measure that brings “architecture conformance” and interoperability goals closest together.

The current best guess is that the “sausage diagram” and basic connectivity requirements (architecture flow-level) levels of conformance are the levels that are being seriously considered for the final policy. The more detailed definitions for the architecture will almost certainly not be required for conformance, but would be used on a voluntary basis in the development of regional architecture’s based on local needs.

2.9.1 Recent Developments

Enactment of the Transportation Equity Act for the 21st Century (TEA-21) in June 1998 provides the clear motivation for conformance with the architecture and standards. TEA-21 includes many passages that indicate congressional concern with interoperability and compatibility in federally funded transportation systems. The section that is most pertinent to architecture and standards conformance is section 5206 which requires architecture and standards conformance for federally funded projects (see section 5206 (e)). US DOT is currently establishing a policy that supports this legislation; interim policy should be available in October, 1998 and final policy available 12 months later.

Months before TEA-21 enactment, US DOT began the process of determining an appropriate policy that will implement the proposed requirement for conformance from congress. Formation of small multiple agency groups including Washington office and field representatives from operations and planning offices, from both FHWA and FTA, were formed to determine how best to implement the proposed legislative provision. Guided by objectives to encourage efficient integration of systems while retaining maximum local choice, the preliminary policy suggested by these groups suggested development of an ITS Element within the Transportation Plan that documents integration activities including a regional architecture. At the project stage, the proposed projects would be evaluated for consistency with the ITS element of the Transportation Plan. The federal role was proposed to be generally the same as the existing federal role in planning and oversight of federal-aid projects. The general approach also included several features (gradual phase in over several years, grandfathering of existing projects, and largely a self-policing approach to ensuring conformance, that were intended to address the anticipated concerns of local implementors.

The next step was to review these preliminary ideas with the broader transportation community in a series of ten “Listening Sessions” that were held across the U.S. in February – May, 1998, including one in Anaheim, CA on March 18-19. Volpe developed a summary of findings from these sessions that was published in July 1998¹. Several general issues with the proposed approach were flagged in the report to US DOT, including:

1. Some attendees were concerned that a separate ITS Planning Element could be a lightning rod for criticism and was counter to the general approach of mainstreaming ITS; a separate element should not be mandated.
2. Many attendees stressed that flexibility was important and that USDOT should establish policy that encouraged good practice without mandating a rigid process or architectural structure.

¹ National ITS Architecture Consistency Outreach Meetings: Summary Findings, John A Volpe National Transportation Systems Center, July 1998.

3. The need for more precise definitions of “ITS Project” and other terms were requested so that the applicability of the policy to particular projects would be clear.
4. There was some consensus that the appropriate federal role includes funding, technical assistance, guidance, and training, as well as serving as an information clearing house.

2.9.2 Architecture Conformance

The architecture conformance policy will likely reflect much of what was presented in the listening sessions as amended by the comments that were received at these sessions. The interim architecture conformance policy that will be released soon will probably be quite general and will be focused on “regionally significant” projects. The forthcoming policy could be accurately thought of as “Integration Policy” rather than “Architecture Conformance Policy” since the thrust of the policy will be to encourage beneficial integration with lesser emphasis on consistency with the framework provided by the National Architecture. If this expectation is met, California will be well positioned to satisfy the interim policy that is released due to its sustained interest in ITS integration within the state.

USDOT Policy

TEA21 - Section 5206
 ... the Secretary shall ensure that intelligent transportation system projects carried out using funds made available from the Highway Trust Fund, including funds made available under this subtitle to deploy intelligent transportation system technologies, conform to the national architecture, applicable standards or provisional standards, and protocols ...

- ◆ **Conceptual Approach**
 - ◆ **Planning**
 - ◆ Requires development of an ITS element of the transportation plan
 - ◆ Includes development of a regional architecture
 - ◆ Embedded in existing processes
 - ◆ **Project Definition**
 - ◆ Requires architecture documentation
 - ◆ Grandfathering existing projects
 - ◆ Embedded in existing federal oversight role
- ◆ **Phased in over time**

Figure 2-8: US DOT Policy Supports Underlying TEA-21 Legislation

The final policy to follow in 1999 will broaden the applicability to other types of projects and will more specifically address phasing requirements. It is expected that the policy and supporting guidance will still identify separate planning and project phases with a focus on regional architecture development in the planning phase and project consistency assessment in the project phase. Within this general structure, it will continue to undergo refinement based on the ten listening sessions and additional (formal and informal) “listening” that will occur over the next year as we work under the interim policy. Based on history, it can be expected that changes will continue to move the policy towards one that permits maximum local flexibility while still allowing US DOT to motivate beneficial integration of intelligent transportation systems.

2.9.3 Standards Conformance

While there have been disagreements on the details, the general consensus appears to be that US DOT's architecture conformance policy will encourage good practice and not prove to be an excessive burden. The standards conformance issues are somewhat different, and additional concerns have been raised.

For standards conformance, TEA-21 provides a few interesting stipulations:

- It requires that a report be submitted to Congress by June 1, 1999 that identifies standards that are critical to national interoperability or critical to the development of other standards and specifies the status of each standard identified.
- It empowers US DOT to select provisional standards for these critical areas if the "development or balloting of an intelligent transportation system standard jeopardizes the timely achievement of the objectives identified in subsection A".
- If the critical standards are not in place by January 1st, 2001, US DOT is required to select a provisional standard. A waiver provision is included in the legislation for this particular requirement.

In other words, a key motivator for industry to agree on voluntary ITS standards is that US DOT will select a regulatory standard if industry cannot reach agreement.

There has been some criticism from the standards community of this relatively heavy-handed approach. The standards community points out that standards development is an on-going process that will not end by January, 2001. Standards are continually undergoing revisions and improvements and new standards are developed as new opportunities to apply new technology are created. US DOT has heard this criticism and has included several elements in the strawman policy that address these issues and other standards issues raised elsewhere in this chapter (e.g., the expected immaturity of some of the early ITS standards.)

The general parameters of the approach are:

Continue with the Current "Industry Standard" Approach. All indications are that the selection of provisional standards is viewed as a last resort. US DOT will continue to encourage and accelerate standards as it has in the past.

Use ITS America to develop consensus on "critical standards". Dr. Christine Johnson, US DOT Joint Program Office in a presentation to an ITS America symposium on September 16, 1998, suggests that ITS America will be used as the forum to develop consensus on critical standards for national interoperability and regional/statewide interoperability. Undoubtedly, the critical national and regional interoperability interfaces and standards will be similar, but not the same as, the critical national and regional interoperability interfaces identified by the National ITS Architecture and listed in this chapter. ITS America has already provided an initial input to US DOT addressing critical standards, but it is likely that more comprehensive, consensus inputs will follow. ITS America is the forum to represent any state interests in establishing the critical standards.

Allow a One to Three Year Maturation Process before Requiring a Critical Standard. Standards will not be required by US DOT immediately after they pass balloting and are endorsed by the sponsoring SDO. It is intended that one to three additional years will pass to allow field testing and actual application of the standard to ensure that it is a good standard (and relatively well supported) before its use will be tied to federal funds.

California should consider this general policy direction as it considers potential standards requirements for projects in the state.

Appendix A contains key comments regarding standards issues from focus groups and interviews conducted in the study.

CHAPTER 3: SYSTEMS MANAGEMENT LEVEL

Background

The National System Architecture (NSA) program was one of the most prominent and ambitious elements of the Federal Highway Administration's Intelligent-Vehicle-Highway-System program (IVHS, later renamed intelligent-transportation-systems or ITS). As defined by FHWA, a system architecture "is the framework that describes how system components interact and work together to achieve total system goals and objectives." FHWA's goal was to "ensure that the deployment of IVHS user services occurs within the most sensible system framework. It will also ensure that a nationally compatible system emerges, instead of local or regional pockets of IVHS that will not accommodate intercity travel or cross-country goods movements." (FHWA, 1994)

The NSA program was completed in two phases. In Phase I, Hughes Aircraft, Rockwell, IBM (later Loral) and Westinghouse were selected to lead parallel design teams (each of these teams included numerous sub-contractors). Each team was encouraged to develop its own unique architectural concept and vision, as summarized below (from FHWA, 1994):

Hughes: "a balancing of intelligence and cost between the vehicle and infrastructure. A range of price/performance products and services provides route selection and guidance to the traveler, and traffic congestion an incident detection data to the traffic management center."

IBM (Loral): "The physical IVHS system will consist of advanced, centralized, regional Traffic Management Centers (TMCs) linked to each other by high speed wide area networks (WANs). Operationally, the regional TMCs will provide human and automated traffic management services, as well as seamless user services, both within a region and across multiple regions as necessary."

Rockwell: "an accommodative, open framework to support user service functionality while meeting the requirements of the service developers/implementers, operators/maintainers, and users. User service functionality is distributed across modular subsystems."

Westinghouse: "increase the people and traffic throughputs to solve the near and mid-term transportation problems while laying out the necessary foundation for advanced technology applications in the far term"

At the end of Phase I, the four teams competed for the opportunity to continue into detailed design in Phase II. The teams were judged both on their architecture and on their performance as a contractor. Hence, the best ideas and talents would be selected to complete the architecture. Rockwell and Loral (formerly IBM) were picked and charged to work together in Phase II, capturing the best features of all four teams in producing the final NSA. NASA's Jet Propulsion Laboratory and MITRE Corporation provided technical input throughout the project. The project was completed in early 1996.

At the present, the US Department of Transportation is working to implement the National System Architecture. This is being accomplished with a standardization program, and through requirements that local agencies are consistent with the National System Architecture in their plans. Consistency is in the

process of being defined, but the following “conceptual approach” has been proposed by the US DOT (US DOT, 1998):

“Simply stated, the conceptual approach for ensuring architecture consistency is to require the development of an ITS element of the transportation plan. The ITS element would contain a regional architecture developed using portions of the National ITS Architecture that are applicable in meeting local needs.”

The document goes on to propose that the ITS element may include:

General concept of operations
Roles and responsibilities for stakeholders
Linkages with capital improvement projects
Phasing considerations, both geographic and functional
Regional technology agreements

This paper presents recommendations on methodologies by which system architecture can be used to improve the deployment of transportation management projects, with emphasis on a general concept of operations and roles and responsibilities (also, see Hall et al, 1998, for concept of operations).

This paper is one component of a larger project directed at creating a California System Architecture. The project as a whole is documented in a separate report.

3.1 Management And Control Objectives

The NSA provides a framework for executing transportation management and control through the use of sensing, communication and information technologies. The framework is defined in two NSA documents:

- *Implementation Strategy* (U.S. DOT, 1996a)
- *Physical Architecture* (U.S. DOT, 1996b)

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 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 an ITS architecture could be to develop a quick and efficient mechanism that would enable jurisdictions to coordinate transportation management and control and improve system performance. The architecture would contain defined interfaces and decision-making protocols that would remove or greatly reduce the need for negotiation. Once a group of jurisdictions opt for coordinated M&C, the architecture should make implementation a routine process.

The NSA provides a step in this direction, but leaves much to be decided at the state or regional level. The following sections summarize the contents of the NSA with respect to M&C. The focus is on the *Transportation Layer* of the architecture. The Communication Layer provides the means to communicate information in support of the execution of M&C actions. The Institutional Layer defines the feasibility, practicality and acceptability of implementing M&C policies and strategies. The Transportation Layer is where M&C is executed.

The next three sections cover principal elements of coordination:

- Functional areas of responsibility
- Content of communication and information residence
- Lines of authority and resolution of decisions

These topics are followed by a discussion of issues for the State of California and findings from interviews conducted with traffic managers and technology developers. The paper concludes with recommendations for future study.

3.1.1 Functional Areas of Responsibility

The NSA identifies four key entities: subsystems, equipment packages, market packages and terminators. This section describes these four entities within the context of M&C.

The transportation layer of the NSA contains 19 subsystems, which are grouped into four categories: vehicles, roadside, centers and remote access. The categories are described as follows:

"The *center subsystems* provide management, administration, and support functions for the transportation system."

"[*Roadside subsystems* are] distributed infrastructure subsystems [that] provide the direct interface to vehicles traveling on the roadway network."

"[*Vehicle subsystems*] are all vehicle-based and share many general driver information, vehicle navigation, and advanced safety system functions."

"The *remote access subsystems* include the equipment that is used by the traveler to gather information and access other personal information services prior to a trip and while en-route."

M&C functions are largely executed through just three of the center subsystems:

- Traffic Management
- Emergency Management
- Transit Management

Nevertheless, some M&C functions may be distributed among roadside subsystems, and some M&C functions may be executed within other center subsystems (e.g., toll administration and information service provider). However, these other subsystems are more likely to play support than leadership roles in M&C.

The *Physical Architecture* further defines subsystems in terms of equipment packages and supporting processes. For example, the traffic management subsystem comprises 17 equipment packages, such as "Collect Traffic Surveillance", "TMC Advanced Signal Control", "TMC Based Freeway Control" and "TMC Based Signal Control." The *Physical Architecture* provides one or more processes to be performed by each equipment package.

Cutting across subsystems and equipment packages, the NSA defines a set of 52 *market packages* as the means for implementing ITS. Each market package specifies a cohesive set of services, which are deployed through the architectural subsystems and their equipment packages. The market packages are divided into seven groups:

- ATMS: Advanced Traffic Management Systems
- APTS: Advanced Public Transportation Systems
- ATIS: Advanced Transportation Information Systems
- AVSS: Advanced Vehicle Safety Systems
- CVO: Commercial Vehicle Operations
- EM: Emergency Management
- ITS: ITS Planning

Though the market packages are intended to span subsystems, most have a natural "home" in a single subsystem (e.g., APTS packages naturally belongs in transit management and ATMS naturally belongs in traffic management or toll administration). Market packages that are especially relevant to M&C include "Surface Street Control", "Freeway Control" and "HOV and Reversible Lane Management". These market packages are supported by surveillance oriented packages (e.g., network surveillance) and data processing oriented packages (e.g., traffic network performance evaluation).

The *Implementation Strategy* shows how each market package is supported by the NSA, and how each market package interfaces with other packages. The diagrams show which functions are performed within each subsystem and equipment package and describe (qualitatively) typical data flows between subsystems. The NSA does *not* provide specific communication protocols, file formats, or hardware specifications. The NSA also does not define functionality beyond a general level.

In addition to defining architectural subsystems, equipment packages and market packages, the NSA *Physical Architecture* defines entities "outside the architecture and how the architecture interfaces to them." These outside entities, called *terminators*, are divided into four categories

Human Entities: Employees (inspector, operator, manager, etc.) or Travelers (driver, pedestrian, etc.)

Other Systems Outside ITS: CVO Information Requester, DMV, 911, Media, etc.

Environment (Physical World): Multimodal Crossings, Potential Obstacles, Roadway, Vehicles

Peer Systems Within the Architecture (subsystems): Commercial Vehicle Administrator, Emergency Management Center, Traffic Management Center, etc.

The last category is intended more to represent the deployment of a particular system than for the architecture as a whole. That is, the NSA provides for the deployment of various subsystems, each of which may be required to interface with other architectural subsystems. Each subsystem may then view other subsystems as terminators.

From the perspective of M&C, the division of subsystems into those inside and those outside the architecture is most significant. Outside subsystems include: "CVO Information Requester", "Department of Motor Vehicles", "911 Infrastructure Enforcement Agency" and "Weather Service". Generally, the "other systems" are private entities or public entities whose primary function is not in transportation. Department of Motor Vehicles is an exception. Regional implementation of the NSA may opt to include this as a subsystem.

3.2 Content of Communication and Information Residence

The NSA provides considerable detail on data flows between subsystems. The *Physical Architecture* includes an architectural flow diagram for each subsystem, supported by descriptions of data flows between each pair of subsystems. For example the emergency management/traffic management interface includes four "logical architectural reference flows": emergency vehicle greenwave request, incident information, and incident response status. The general content of each of these data flows is described (but not specified to the point of file or packet format). Each of the specified data flows should be viewed as an optional capability. Any implementation could use all or none of the data flows and, for each data flow, the implementer can customize the content and format of messages. However, the *Implementation Strategy* does associate data flows with implementation of particular Market Packages.

The NSA provides little direction on where information should reside. Based on data flows, inferences might be drawn as to where information originates within the NSA. The *Implementation Strategy* states: "The information sharing [in the NSA] enables a variety of data replication and distribution strategies...For example, neighboring jurisdictions may want to form a centralized database which status's incidents at a regional level, but allow[s] only isolated control for dispatch at each jurisdiction."

3.3 Lines of Authority and Resolution of Decisions

The NSA does not specify lines of authority and resolution of decisions. As stated in the *Implementation Strategy*: "The National Architecture supports various approaches for coordinating traffic management systems in a given region. The control requests support a range of distributed control strategies from strict hierarchies to more general network control configurations." Diagrams are provided to show that the architecture can support hierarchical control, distributed control or completely isolated sub-systems. The NSA expects that individual jurisdictions will establish their own protocols and procedures for responding to communicated messages and for resolving decisions.

3.4 Regional Architectures

The NSA Implementation Strategy states that:

The National Architecture provides a general framework that may be adapted and elaborated into a broad range of regional transportation system designs. A regional architecture is a key product of this process that begins to overlay major technology and interface choices which are appropriate for the region onto the more general National Architecture definition. A regional architecture ... is a concise formal statement of the architecture choices made by the region. It documents the selected interface standards, regional configuration, and consensus technology choice that will support competitive procurement of systems within the region.

As stated above, the NSA leaves many (perhaps most) of the critical architectural decisions to regional implementers. Nevertheless, the NSA provides a vocabulary that can provide greater compatibility across regions, and focus regional deployment efforts. Fundamentally, however, the NSA defines a set of questions to be answered at the regional or perhaps local level.

From the standpoint of M&C, fundamental questions to address in the effort include:

Geographic Scope: Whether to create a single statewide architecture, multiple architectures divided by region, or participate in a multi-state partnership.

Functional Scope: Whether the architecture should encompass all of the subsystems identified in the NSA; Coverage of market packages and inclusion of equipment packages; Whether additional subsystem should be added and if so which. Which specific agencies will participate in the regional architecture.

Goals and Objectives: Specific aims to be accomplished through the creation of a regional architectures in terms of improvement management and control of the transportation system.

At a more detailed level, the architecture should create specificity in the three areas of coordination: (1) Functional areas of responsibility, (2) Content of communication and information residence, and, (3) Lines of authority and resolution of decisions.

Functional Areas of Responsibility: The NSA defines functions for sub-systems, equipment packages and market packages and defines terminator systems. A regional architecture should associate these generic entities with specific organizations to define spheres of responsibility. A regional architecture should select a set of market packages to support and assign responsibilities for each market package.

Content of Communication and Information Residence: The NSA defines data flows, but does not specify message formats and exact message content. The regional architecture could provide this specificity, and identify how and when messages invoke actions on the recipient. The regional architecture could also define the information to reside in each subsystem and how that information should be accessed by other subsystems.

Lines of Authority and Resolution of Decisions: The NSA is largely silent on authority and decision-making. The regional architecture could define processes and protocols to invoke M&C actions, within such market packages as Emergency Response or Regional Traffic Control. The degree to which decision-making is hierarchical versus distributed, and the role of humans in decision-making could also be resolved.

Numerous opportunities exist to enhance the coordination of M&C functions through the creation of a regional architecture. Tables 1-4 outline four such areas: (1) traffic operations, (2) incident management, (3) flow/capacity, and (4) transit. These are defined on a functional, rather than a system basis, recognizing four principal ways that organizations can be coordinated to improve the management and control of the transportation system. Each table identifies functional objectives, relevant NSA market packages, and coordination opportunities. Coordination can occur within an organization, between peer organizations (e.g., between two separate transit agencies), and across functions (e.g., between transit and traffic).

Table 3-1. Traffic Operation Coordination	
Objectives	<ul style="list-style-type: none"> Synchronization, avoidance of cyclic delays (offsets) Match capacity to demand (cycle, phase lengths) Smooth highway flow, increased capacity (metering rate) Diversion (metering rate)
NSA Market Packages	<ul style="list-style-type: none"> Regional Traffic Control Surface Street Control Freeway Control Regional Traffic Control
Internal Coordination	<ul style="list-style-type: none"> Synchronization among intersections Coordinated ramp metering
Peer Coordination	<ul style="list-style-type: none"> Signal Plans for Adjacent Jurisdictions Synchronization of Ramp Meters with Adjacent Signals
Cross-function Coordination	<ul style="list-style-type: none"> Signal interruption for emergency vehicles Changes in signal plan due to diversion, lane reversals Signal interruption for transit vehicles Signal interruption for train crossings Signal plans for special events

Table 3-2. Incident Management Coordination

Objectives	Safety and treatment for involved persons Safety for other drivers, passengers, pedestrians, etc. Safety of EM personnel Rapid detection, response, clearance Minimal delay (capacity loss) during incident Minimal damage to involved/other vehicles Effective load balancing
NSA Market Packages	Incident Management System HAZMAT Management Emergency Response Emergency Routing
Internal Coordination	Dispatching emergency response units to scene
Peer Coordination	Requesting support units (e.g., HAZMAT) Coordinating incident clearance with treatment of injured
Cross-function Coordination	Routing emergency vehicles; selecting clearance alternative Directing traffic to alternate routes Clearance strategy based on truck manifest

Table 3-3. Flow/Capacity Coordination

Objectives	System optimal assignment of traffic among network links
NSA Market Packages	HOV and Reversible Lane Management Dynamic Toll/Parking Fee Management Traveler Information (various)
Internal Coordination	Toll setting across highway segments Compatibility of roadway information on affected segments
Peer Coordination	Routing across multiple jurisdictions Fare information across multiple jurisdictions
Cross-function Coordination	Coordinated routing with signal phase/progression Routing to circumvent incidents, speed clearance Transit Prioritization

Table 3-4. Transit Coordination

Objectives	On-time schedule control Rapid replacement of failed vehicles Rapid dispatch of demand responsive vehicles and efficient routes
NSA Market Packages	Transit Fixed-Route Operations Demand Responsive Transit Operations Multi-modal Coordination
Internal Coordination	Skip-stop, "hot-spares", diversion for schedule adherence
Peer Coordination	Schedule transfer coordination among jurisdictions
Cross-function Coordination	Bus diversion during incidents

3.5 Architectural Needs in California

Interviews were conducted with managers of California Department of Transportation (Caltrans) Management Centers in six of its districts: Sacramento, San Francisco Bay Area, Los Angeles, San Bernardino, San Diego and Orange County (Horan et al, 1997). Interviews were also conducted with TMC managers in the cities of Los Angeles, San Diego and San Jose. In most cases interviews were conducted in person.

The interviews covered four general topics: awareness and participation in the NSA, awareness and participation in standards setting, ongoing projects, and vision for a regional architecture. More specific questions were posed within each category, including identification of impacts of the NSA on ongoing projects, and the geographic and functional scope of future architectures

Overall, the prevailing mood toward architecture in California is optimistic. Many of the coordination issues in Southern California are being resolved or are on the path to resolution, quite independent of the existence of NSA. Ongoing consultant contracts for TMC upgrades are accomplishing greater standardization in software. And most of the interfaces identified in the NSA do not have to be addressed at all in California, at least not in the short run. Nevertheless, major issues remain:

- Gaining efficiency in procurement, maintenance and operation of field devices, with Caltrans HQ facilitating the development of internal standards.
- Developing an architecture for communication and shared operation for city TMC to Caltrans TMC and city TMC to city TMC interfaces, which can be used in "smart corridor" projects, signal coordination projects and meter/signal coordination projects, as well as incident response and management.

3.6 Architectural Implications Of Multi-Jurisdictional Projects

To date, the most challenging projects in intelligent transportation have been those that crossed jurisdictional lines. These are challenging technically, because different organizations have installed different computing systems, hardware and software. They are challenging institutionally, because different organizations have different and conflicting objectives, and because there is no straight-forward method for resolving conflicts. In this section, we examine some of the multi-jurisdictional projects planned and underway in California. We examine the lessons learned, and we examine multi-jurisdictional models from other areas. Finally, we propose methods for managing multi-jurisdictional projects in the future.

3.6.1 Multi-Jurisdictional Projects in California

This section reviews projects in the following areas: (1) emergency response coordination, (2) integrated traffic corridors, (3) intermodal coordination, (4) probe vehicles, (4) ride-sharing projects, (5) ride-sharing, (6) projects targeted at trip generators, (7) traveler information, and (8) wide-area architecture projects. For each project, we provide major participants, an overview of the project and its objectives, architecture and data flows and procedures. In some cases, information is missing because the project is still being planned.

3.6.2 Emergency Response Coordination

These projects entail developing systems for coordinating response to transportation emergencies among police and fire departments.

Coachella Valley All-Agency Radio System

Major Participants: CVAG (lead), CHP, Riverside County, Palm Springs, and Coachella

Status: Has not been funded

Overview: Installation of a multi-agency, 2-way voice radio communications system for Coachella Valley subregion of Riverside County to provide better incident management, emergency response, emergency routing and Mayday support.

Architecture & Data flows: information useful for Mutual aid requests and during natural disasters. Voice is the primary carrier of data and aid requests.

Procedures: TAC and TAC sub committees will establish end-user protocol for priority use under CHP ownership of the system.

Inland Empire InterCAD

Major Participants: RCTC (lead), CHP, SANBAG, CT8, Riverside and San Bernardino County sheriff and fire

Status: Has not been funded

Overview: Network of interconnected public safety agencies in Riverside and San Bernardino counties to facilitate regional incident management by seeking to improve notification times and response to requests for mutual aid among law enforcement, fire and paramedic agencies through interoperability of computer aided dispatch systems.

Architecture & Data flows: Real-time CAD link (not an integration of CAD systems) independent of CAD architectures used by participating agencies. Carrier of information (incident information) will be a common message format and a common agency interface to the system.

Procedures: To be established by a multi agency Task Force.

San Diego Regional CAD Interconnect Project (INTERCAD San Diego)

Major Participants: San Diego PD, CHP, California Division of Forestry and Fire Protection, San Diego FD, Federal FD, Heartland Fire JPA, Escondido PD (and FD) and Oceanside PD (and FD).

Status: Project Phase II in progress. It involves the InterCad system integration to the Kernel. The work is currently focused on modifying the InterCad network (SMDS/PacBell) while the CAD systems are being modified. The Seed design was due in spring, 1998.

Overview: Provide a real-time link between CAD systems in San Diego County, independent of the CAD architectures used by the participating agencies. System independence is achieved through use of a common message management system, standardized message format and a common interface to the agencies. The agencies in turn will maintain translational capability between its internal representation of incident data and the common message format.

Architecture: The components of the InterCAD San Diego include the host CAD interfaces, the message servers, the regional network, an on-line management system for both the messaging system and the regional network and the means to connect the regional networks in San Diego and the Inland Empire. CAD Interconnect network will connect to the regional Transportation Management Center (TMC) through the same message server interface established for other public safety agencies. This will ensure that critical transportation network status information reaches public safety dispatchers and that selected incident data from public safety agencies can be integrated into the TMC data fusion process. The system is intended to connect systems that would otherwise not be compatible with each other.

Procedures: Each agency will receive the incident data in their message system servers through the host CAD system. The specific operational and technical problems are to be solved by a multi-agency task force that has yet to be established. The fire/EMS agencies have already stressed the need to keep track of apparatus status, move-ups, strike team formation, personnel and equipment availability, etc. to adequately manage multi-agency response operations.

Inland Empire Smart Call Box Advanced Weather Warning System and Traffic Census

Major Participants: CHP, Caltrans, CalSAFE, Riverside County Transportation Commission, SANBAG

Status: Has not been funded

Overview: The project will provide basic weather surveillance capabilities on designated highways within Inland Empire. The system will use proven technologies and existing call box infrastructure. The weather detection and reporting capability can provide a source of data dissemination that is otherwise unavailable to travelers in the region. The smart call box traffic census program can use existing call box system with integrated traffic counter devices, existing Caltrans inductive loops and various classification equipment to provide accurate, reliable and timely traffic census and classification throughout Inland Empire.

Architecture and Data Flows: Caltrans District 8 has planned to install environmental sensing units (ESU's) in the Cajon Pass on I-15, SR 138 west of I-15, and the Whitewater Summit area of I-10. These will report directly to the District 8 TMC and include forecast capability. The Smart Call Boxes are proposed to complement to the Caltrans system. These call boxes can be used in areas where full ESU's are planned but not yet deployed, as well as in areas that are not programmed for ESU's. For low visibility sensors, placement at several locations will improve their operational usefulness. The data will flow from the weather sensors (may be housed in the call boxes) and traffic loop detectors to the call boxes that will serve as transmission nodes. The information will be relayed to the Computer Aided Dispatch system of CHP via cellular signals. The system can either transmit the data at periodic intervals or the data can be downloaded in real-time. The weather hazards can then be communicated to the travelers. Commercial Vehicle Operators can also be connected to this system and schedule their fleet accordingly.

Procedures: Pre-designated thresholds for high wind and low visibility are programmed into the system and activate the call box to transmit alerts directly to CHP's CAD system. CHP will respond to the alert according to pre-determined CHP policy. The Smart Call Box Traffic Census system will use the existing call box system with integrated traffic counter devices, existing Caltrans inductive loops and various classification equipment to provide accurate, reliable and timely traffic census and classification throughout the Inland Empire. These data will be used to forecast the traffic growth and also help plan strategies for the district.

3.6.3 Integrated Traffic Corridors

This category includes coordination of traffic management activities between state highways and surrounding arterials within a corridor. Multi-modal coordination is sometimes included as part of these projects.

Fontana-Ontario ATMIS Corridor (West End Corridor)

Major Participants: Caltrans Dist. 8, CHP, Omnitrans, Cities of Fontana and Ontario, SB County, California Speedway etc.

Status: The TAC review is completed. Comments are being incorporated. The final version will be submitted to FHWA by 3/3/98.

Overview: Integrated traffic management and information corridor serving ingress and egress to several important activity centers along I-10 from Ontario to Fontana, including Ontario Airport, Ontario convention center, and Ontario Mills.

Architecture & Data Flows: Between the two TICs and other users; in the form of incident information to ensure that mobile resources flow smoothly between the ends of the corridor.

Procedures: The Fontana TMC will have capacity to monitor and modify key arterial signal patterns

IMAJINE

Major Participants: MTA, Caltrans District 7,

Status: Needs Assessment and Concept of Operations Documents have been finalized. Work is currently focused on users and systems requirements.

Overview: IMAJINE Phase I planned for synchronizing signals on arterial streets with the State Highway System. This involves integrating City and County Traffic Operations Centers with Caltrans Transportation Management Center. Transit vehicles and supervisors will be tracked through the 105 Corridor in coordination with the MTA Bus Priority Pilot Project, and signal timings will be coordinated so as to move transit vehicles through signalized intersections with minimal delay. Additionally, Phase I seeks to coordinate paratransit services with fixed transit services to minimize operating costs of the paratransit fleet. Phase II builds on the first phase by adding an operational interface to rail services in the region. Within the IMAJINE area, RED and BLUE lines as well as METROLINK operate major terminals. IMAJINE phase II will provide the necessary shuttle services between these stations to facilitate end-to-end alternate mode trips and extend the concept further to the north and west to address CVO mobility needs in the Alameda corridor.

Data Flows and Architecture: The Architecture consists of three subsystems: Paratransit/ Fixed transit coordination, Highway/Arterial Signal Synchronization and Bus/Signal priority Coordination. The Data exchanged will be Transit and paratransit schedules and routes, traffic signal timings, vehicle locations, Arterial Traffic flow information and Freeway Traffic Flow information.

Procedures: Not yet developed.

Los Angeles Smart Corridor

Major Participants: City of Los Angeles, Caltrans District 7, CHP, and LADOT

Status: Smart Corridor is operational

Overview: Joint undertaking of city of Los Angeles, CHP, LADOT, LAPD, FHWA, LACTC and MTA spanning a 5-mile wide and 12-mile long corridor between downtown LA and the San Diego Freeway. Its purpose is to provide corridor mobility by addressing recurring and non-recurring traffic congestion through route diversion, demand control, network balancing and motorist information.

Data Flows and Architecture: The Smart Corridor System/Expert System is composed of SC computer (at Caltrans TOC), Expert Systems computers, SC Workstations at LADOT ATSAC center, LADOT communications center & CHP dispatch center; Expert Systems Workstations at LADOT ATSAC center, Caltrans TOC, & Smart Corridor Computer and intertie with HP and Caltrans' SATMS Operations Center. LADOT, Caltrans, CHP and SCRTD jointly operate the System under coordination of Systems Manager.

LADOT is responsible for operation and maintenance of the data communication network for controlling 353 signals. Caltrans is responsible for operation and maintenance of the trunk network linking the SC Central to other agency control centers. The 14 Color Freeway CCTVs will be maintained by Caltrans and Operated by LADOT and Smart Corridor. 29 Color Surface Street CCTVs will be maintained by LADOT and Operated by Smart Corridor, LADOT, Caltrans and CHP jointly. A joint operation of CHP, Caltrans and LADOT will provide connection from Smart Corridor Traffic condition database to CHP media communications interface. Highway Advisory Telephone will be operated and maintained by Caltrans TOC using 20 toll free lines. Caltrans will operate Freeway entrance ramp meters, freeway connector meters and six CMS on the freeway. 103 Trailblazer and 7 Matrix CMS will be jointly operated on the surface streets by LADOT and Caltrans, with LADOT having a higher hierarchy. The freeway HAR will be jointly operated by Caltrans and Smart Corridor and Surface Street HAR will be operated by Smart Corridor and LADOT.

Procedures: The incident management system (I. M. System) receives incident information from the following sources: Smart Corridor Operators, CHP CAD system, The Smart Corridor Arterial incident detection task and SATMS incident detection algorithms. All such information is converted into Incident Reports (IRs) which are of standardized format and in case of multiple IRs, the system combines them into a IS (Incident Summary), attaches weights to information obtained from different sources and finally asks the operator to confirm the incident. The operator confirms the incident (if available, with CCTV cameras). Upon confirmation, the system suggests a Response Plan based on attributes of the incident, such as time of occurrence, duration, location and type. Each plan has four goals -- Advisory, Traffic flow control, Diversion and On-Site Traffic Management -- and each goal has an associated agency that will execute response plans. Due to the dynamic nature of IRs, the IM system monitors the incident as well as the responses and suggests changes to it. Although all agencies reported above are allowed to submit IRs, only Caltrans and LADOT are allowed to confirm incidents.

SR-91/La Palma Avenue Smart Corridor

Major Participants: City of Anaheim, Caltrans District 12

Status: Functional specifications completed in September, 1996. Under development.

Overview: Decision support system to tie Anaheim and Caltrans District 12, and assist operators during recurring and non-recurring traffic congestion conditions. CCTV, CMS/Trailblazer signs, traffic signals, traffic flow information and HAR/HAT will be used to control traffic along the SR-91 corridor from SR39 and SR 90.

Data Flows and Architecture: The agencies exchange Video (real time/archived CCTV images), data (graphics, signal timing and other real time traffic surveillance data) and audio (through a fiber optic tie). City of Anaheim obtains real-time feedback from city traffic signals and detector data from Caltrans District 12. Caltrans District 12 gets CHP dispatch information and City of Anaheim has connectivity to

the Anaheim Police Mainframe. The two agencies also exchange transit, construction, maintenance and special event schedules. The two agencies own and operate two separate TMCs. All data gathering sources are owned by one agency or the other. City of Anaheim owns/controls all traffic signals on La Palma Ave, Trailbalzers, CCTVs, HAR and other devices within city's jurisdiction and on La Palma Ave, and the ramps onto freeway 91 that have meters are operated by Caltrans District 12.

Procedures: The TMC at City of Anaheim interfaces with CMS, Trailblazer signs, CCTVs and Traveler Advisory Service and records traffic information. Hence, based on data obtained from one agency, the other agency can either vary traffic signal timings or supply information on Trailblazer signs to overcome congestion. The Decision Support System software will be integrated with pre-planned city and Caltrans activities. The two agencies will also share the use of CCTV cameras, with the highest level in the control hierarchy going to the agency responsible for operation and maintenance of the CCTV cameras. The images will be shared. The agency with lower hierarchy can use Remote Procedure Calls to request control if required. If there is a conflict of interest between agencies at any point, judgement will be used so as to benefit the motorist the most. During special events, Anaheim will give up control of the CCTV cameras under its jurisdiction to Caltrans District 12 since Caltrans operates the TMC 24 hours a day. For Trailblazer signs, an initial library of messages will be set up and the control hierarchy will be similar to CCTV cameras. Both agencies can monitor the signs but only one can operate them at a time. Agencies will request the other to place a message from the library. This will allow agencies to post signs through remote and portable terminals. A similar process is to be followed for HAR. In case of Ramp meters/Traffic signal systems, both agencies may ask the other for manual override to ease congestion on the freeway or surface streets.

SR 17/I880 Silicon Valley Smart Corridor

Major Participants: City of San Jose, Santa Clara County, Caltrans District 4, CHP, Cities of Campbell, Los Gatos, Milpitas and MTC

Status: Under construction

Overview: The Silicon Valley Smart Corridor (SVSC) seeks to coordinate traffic operations along SR-17/I-880 and parallel surface arterials in Santa Clara County by using advanced technologies and real-time system management techniques to help keep all transportation facilities within the Highway 17/I-880 operating at maximum efficiency. SVSC stresses both mode and route diversion. Route diversion will only be used in case of incident congestion such as major accidents and not for routine or recurring. To facilitate ridesharing, smart parks will provide park-and-ride along with ITS technologies and special conveniences to attract motorists, such as HAR, electric vehicle charging area, in-vehicle information, CMS, and information kiosks. Smart Parks will serve as anchor points for transit services.

Data Flows and Architecture: The corridor contains freeways, expressways, surface streets, bus routes and LRT lines that are owned and operated by several different agencies. The Smart Corridor involves cooperation between agencies that operate different transportation facilities to share collected data amongst all participating agencies. The actions of any agency are coordinated with and known to all others. This results in the traveler having a single source of information about all facilities and travel options. Information is disseminated via changeable message signs and Highway Advisory Radio and traffic signals will be synchronized. Information will be obtained from CCTV cameras which will be transmitted via fiber optic and some leased telephone lines.

Procedures: The agencies will exchange real-time data on traffic counts, facility status, incident information, equipment status, planned events and operational stages. The data exchange network will enable basic commands to be sent between agency systems as well as data. This enables, for example, the implementation of traffic responsive signal coordination across jurisdictional boundaries, involving detector data being collected from all involved signal systems and the selected timing pattern number sent back to the system for implementation,

In addition, a fiber optic network will enable agencies to view each other's closed circuit television cameras when desired. The communication network is also shared to provide maximum reach at minimum cost.

3.6.4 Intermodal Coordination

These projects focus on the coordination of transportation services among two or more transportation modes.

Integrated Railroad Crossings

Major Participants: MTA (lead), LADOT

Status: Has not been funded

Overview: MTA is proposing a three phase project to demonstrate ATMS systems and new technologies currently being deployed in cities throughout US for management of street and freeway traffic flows, at highway/rail grade crossings in an urban area LRT corridor. The first phase will implement health-monitoring systems at Metro Blue Line crossings. Health monitoring of the crossing protection and traffic control equipment at highway-railroad grade crossing is done independently for each system. Safe operation of the system is dependent on both systems functioning together in a coordinated manner. The second and third phases of the project will demonstrate two models, showing how capabilities of modern street and rail traffic control systems can be effectively brought together at grade crossings, both to improve public safety and to enhance traffic flows. Adaptive traffic preemption strategies and variable message signs will provide advance warning and motorist information.

Architecture & Data Flows: Not yet defined.

Procedures: Not yet defined.

Orange County Transit Probe

Major Participants: OCTA(lead), Caltrans, Santa Ana, Anaheim

Status: Began operation in May of 1998

Overview: The project has installed GPS receivers on 15 buses, running on three lines in Anaheim and Santa Ana. Data from the buses are being used for schedule control, and to develop estimates of roadway congestion. Congestion estimates are provided to the Cities of Anaheim and Santa Ana, and to Caltrans District 12.

Data Flows and Architecture: Exception data are communicated over OCTA's radio network, indicating when a bus has fallen behind schedule or congestion is observed. These data can be viewed within the STARS software application, developed by 3M Corporation. Data are uploaded and downloaded when vehicles pull in and pull of the yard via a wireless local-area-network. These data include schedule information and more detail on schedule performance, allowing for analysis of historical schedule performance data. The STARS application is being provided to Anaheim, Santa Ana and Caltrans District 12 to view the data.

Procedures: Operational procedures are being developed.

San Diego Intermodal Transportation Management and Information System

Major Participants: Caltrans 11,SANDAG,CHP

Status: Contract has been executed, and the first monthly meeting occurred January, 1998. The project activities are divided and focused by several subgroups by function. The work will initially focus on the needs assessment and users requirements.

Overview: This project proposes improving the existing Caltrans single mode TMC operating system architecture to one that supports regional intermodal and multimodal functions, divided into two phases, including the development of user requirements, systems requirements, interface requirements and high

level design, prototype implementation, prototype operations, evaluation and final design implementation.

Data Flows and Architecture: Caltrans' Southern Districts have adopted and documented an open systems profile to ensure that all TMC systems are based on a robust architecture that complements system-to-system integration. It is proposed to have interconnection between various operating systems and the scope of the second phase of this project may include improvements in the operating systems of the other regional operators.

Procedures: Since each of the agencies involved in the project has a vision of potential intermodal and multimodal relationships, and there is no consensus, the roles and responsibilities have not been fully defined.

3.6.5 Probe Vehicles

These projects entail using vehicles to collect information on traffic conditions, and sharing that information among agencies.

Inland Empire Motorist Aid Patrol

Major Participants: SANBAG (lead), CHP

Status: Not yet funded

Overview This proposal recommends a public/private partnership funding program for a motorist aid patrol along the 110 mile stretch of I-15 between Barstow and the California/Nevada State line. Data from the patrol would support traffic data collection. This patrol area lies within San Bernardino County.

Architecture & Data Flows: Not yet defined

Procedures: Not yet defined

3.6.6 Ride-Sharing

This project entails sharing information between ride-sharing agencies to provide more complete ride-match services.

Inter-Regional Rideshare Data Base Linkage

Major Participants: CVAG (lead), CHP, Riverside County, Palm Springs, SCAG, SANDAG

Status: SCAG is incorporating the TAC comments and is pursuing SANDAG's approval on the final work plan. The final work plan was to be submitted to FHWA in spring, 1998.

Overview: This project will link the rideshare and transit databases maintained separately by SCAG and SANDAG, in order to provide rideshare information to intercounty Priority Corridor travelers and cross county commuters. Execution of this project will allow each agency to provide travelers and other organizations/employers/agencies with transit itineraries, rideshare partner matchlists, and vanpool information and coordinate the electronic exchange of transit and other rideshare information throughout Southern California - from Santa Barbara to San Diego.

Data Flow and Architecture: Not yet developed.

Procedures: Not yet developed.

3.6.7 Targeted Projects (Major Trip Generators)

These projects entail coordination of transportation to and from major trip generators, including stadiums and airports.

John Wayne Airport Area Coordinated Management

Major Participants: John Wayne Airport, CT12, Orange County
Irvine, Newport Beach

Status: Not yet funded

Overview: This project consists of a coordinated traffic management and traveler information project in the John Wayne (JWA) airport area. This area encompasses I-405 and SR-55 freeways and associated transition and exit ramps along the main street, MacArthur Blvd, Michelson drive and Campus Drive in the vicinity of the airport. The system would utilize parking availability via the real-time parking access system along with Caltrans and local monitoring of airport installed cameras. The system would disseminate the information via existing freeway CMS, New Arterial CMS and finally Travel ITP. Traffic management will include the monitoring for delays in the field.

Data Flows and Architecture: Not yet determined

Procedures: Not yet determined

San Diego Jack Murphy Stadium ATIS Project

Major Participants: City of San Diego, Caltrans

Status: Work plan approved. Contract Phase II has been executed. Under this phase, the communication links will be developed among the City's TMC, Caltrans TMC and the Stadium's TOC.

Overview: This project involves design and implementation of an ATIS project which will provide motorists with accurate and timely information about current traffic conditions on arterials and freeways. This will allow motorists to make intelligent and informed decisions regarding their route and time of travel before and during the trip.

Data Flows and Architecture: Not yet determined

Procedures: Not yet determined

3.6.8 Traveler Information

These projects entail creation of systems for disseminating information to travelers where information is collected by multiple public agencies.

Commercial Vehicle ATIS

Major Participants: CTA, Caltrans, SANBAG, SCAG

Status: The overall scope was submitted to FHWA and has received approval. The draft work plan is being reviewed by the TAC. The final will be submitted to FHWA in spring of 1998.

Overview: This project will allow commercial vehicle operators and dispatchers to receive notifications of roadway conditions and incidents so that they can manage the movement of freight more efficiently and avoid traffic congestion and delay wherever possible. Travel and route information related to CVO operation will be sent out using an FM subcarrier from the multi-regional TMC network. Drivers and dispatchers will receive a message on a vehicle or office receiver when there is unusual traffic congestion or an incident on a route in which they are interested. Depending on the level of interest and availability of information, messages could also be provided on international border crossings, port access and airport access.

Data Flows and Architecture: Not yet developed

Procedures: Not yet developed

Freeway Incident Response Services Tracking (FIRST)

Major Participants: MTA and CHP (Lead), Caltrans, LA DOT, LA County Emergency Operations Center, LA County Coroner, LAPD, LAFD,

Status: Under development.

Overview: This project plans to improve access to the proprietary CHP computer aided Dispatch (CAD) system so that freeway incident information can be distributed. It will provide an opportunity to distribute incident information to allied agencies in Los Angeles County; enable agency-to-agency transfer of traffic/incident information, offer real-time incident information to Metro Freeway Service Patrol Fleet, CHP field Officers and other MTA related bus/rail operations. It will also provide system security while improving data access and information sharing. Additionally, FIRST will attempt to improve incident reporting and tracking for statistical modeling to measure and evaluate congestion models and incident response time.

Data Flows and Architecture: FIRST is being developed by MTA and installed at CHP. The information dissemination to the other agencies will be via dedicated telephone lines, intranet web pages and to the general public through media (TV and radio).

Procedures: Not yet developed

Integrated Modal-Shift Management Tool

Major Participants: Caltrans 7(lead), MTA, SCAG, LAC Bus Operators Subcommittee, CHP, City of Los Angeles, County of Los Angeles, SCAQMD and Ventura County Transportation Committee.

Status: Work plan approved. Contract execution pending.

Overview: This project proposes integration between advanced-traffic-management-systems (ATMS) and ATIS through a real time cross jurisdictional modal shift management tool that provides travelers within Los Angeles and Ventura counties with real-time information related to incidents and potential alternate routes. These will be detailed relative to specific incident profiles and specific incident locations. It will complete an integrated system that will both combine the existing systems as well integrate traveler information services with the Caltrans District 7 ATMS. One of the key objectives of this project is to develop an integrated, distributed system that will maintain each agency's control, ownership and management of their respective data, while still allowing the sharing of the information throughout the counties and corridor.

Architecture & Data Flows: The data and information planned to be included in this system are: (a) Freeway and Surface street congestion, closures, detours and maintenance, (b) Alternate modes of transportation (bus and rail schedules) and analysis for the users on mode cost, route alternatives, timing and availability for handicapped travelers, (c) Major incident locations with alternative routes and modes to lessen both individual travel time as well as the impact of the incident overall, and (d) Additional private sector information including restaurants, hotels, gas stations, real time route guidance/navigation information in recognition that once drivers are diverted they will need landmark and services information.

Procedures: Not yet developed

Orange County TravelTip

Major Participants: OCTA (lead), Caltrans, Transit agencies (OCTA, MTA), Cities and CHP

Status: System management, integration, and outreach & marketing efforts in progress. System integration is currently focused on finalizing the system design report.

Overview: This projects provides for information dissemination through a variety of channels, along with implementation of a high bandwidth wide area network for transportation agencies in Orange County that would provide for intragency communication throughout the County without the recurring costs and incompatibility of individual point-to-point leased lines. The WAN would allow for the exchange of freeway and surface street traffic data between Caltrans, local agencies and other Corridor Showcase partners, along with TravelTIP data, ramp meter rates and status, CMS as well as traffic signal timing and status.

Data Flows & Architecture: Data will be gathered from Transit agencies, Caltrans, CHP, Transit probes, Weather Bureau, Airlines and various cities and disseminated to WWW, Bulletin Board Services, Rideshare Matching Agencies, Yellow Pages, Value Added Resellers and map vendors and directly through Community Access TV, HAR, Kiosks, Media. Since the communication systems of all the numerous agencies are heterogeneous, the National Transportation Control/ ITS Communication Protocol proposed Common Object Request Broker Architecture (CORBA). CORBA is a software architecture that establishes a four-element communication framework: Object Request Broker, Object Services, Common Service and Domain Objects. ORB is middleware that establishes the client server relationship of objects. Object Services are domain-independent services that are used to support distributed processing. Common Services are implemented as CORBA objects on top of ORB (e.g. user interface and document management). Domain Objects are the application specific interfaces defined in terms of CORBA's IDL for the domain, which in this case is the ITS domain (e.g. incident detector, incident, incident responder, congestion detector, variable message sign)

Procedures: Not yet developed

Los Angeles/Ventura Regional Advanced Traveler Information System

Major Participants: MTA (lead)

Status: The TAC review is completed. Comments are being incorporated. The final version was scheduled to be submitted to FHWA in spring of 1998.

Overview: This project proposes a partnership among various public agencies and, in the future, the private sector to deploy a sustainable ATIS for Los Angeles/Ventura region. This project uses the showcase architecture to merge information from various sources, including transportation management systems.

Architecture & Data Flows: Not yet developed

Procedures: Not yet developed

San Diego Regional Advanced Traveler Information System

Major Participants: SANDAG (lead)

Status: Has not been funded

Overview: The San Diego ATIS project proposes a partnership with the private sector to deploy a sustainable ATIS for the San Diego region. This project uses the Showcase architecture to facilitate the required merging of information from information from various sources, including transportation management systems.

Architecture and Data Flows: Not yet developed

Procedures: Not yet developed

TransCAL

Major Participants: Caltrans

Status: Operational as of 1997

Overview: TransCAL provides traveler information in the I-80 corridor between the Bay Area and Lake Tahoe. The project includes information dissemination through a traveler-advisory-telephone system, along with testing of various navigation devices and kiosks.

Architecture and Data Flows: The system was developed by TRW/ESL and is modeled after TravInfo.

Procedures: No specific Procedures are provided for responding to information. Information is provided to travelers, who choose their own responses.

TravInfo

Major Participants: MTC, Caltrans, and CHP

Status: Operational as of September, 1996. Test period continues until fall of 1998.

Overview: TravInfo integrates information from a variety of sources, and disseminates the information to travelers via a traveler-advisory-telephone-system and through links to information-service-providers. TravInfo provides real-time information on highway speeds and incidents, and static information on transit services.

Architecture and Data Flows: All information passes through the traveler-information-center housed in Caltrans District 4 and operated by Metro Networks. Operators review incident logs on the CHP computer-aided-dispatch, and enter data into the TravInfo database. Significant incidents are also voice recorded by access through the TATS. The database can be accessed by "registered participants", who can disseminate information to end-users. Currently, Etak and Maxwell Laboratories provide web page access. TATS phone callers select options from a menu, allowing them to hear the recorded messages, or allowing their calls to be routed to transit agencies or ride-sharing.

Procedures: Procedures have been developed for determining which incidents should be entered into the database. No control actions are taken by TravInfo, and information is simply made available to the public.

Real-Time Traffic Information For Truck Stops

Major Participants: Caltrans, Agencies in Inland Empire

Status: Has not been funded

Overview: This project involves installation of Traveler Information Kiosks, which will display Caltrans' real time freeway congestion maps at four trucking terminals/truck stops in Inland Empire.

Architecture & Data Flows: Not yet developed

Procedures: Not yet developed

3.6.9 Wide-area System Integration

These projects entail creation of general-purpose systems for coordination of transportation services or for sharing information among agencies.

Corridor-Wide Advanced Transportation Management System

Major Participants: Caltrans 7 (lead), CT 8,11,12

Status: The TAC review is completed. The final work plan is being prepared and will be submitted to FHWA in spring of 1998.

Overview: This project will link Regional Transportation Management Centers throughout the Southern California Priority Corridor area to coordinate regional traffic movement during recurring and non-recurring incidents, as well as to assist in disaster relief. The vision of showcase is to integrate all modes and all roads into a system of systems by leveraging the existing transportation systems infrastructure in Southern California against a number of strategic new systems initiatives.

Architecture & Data Flows: Not yet developed

Procedures: Being developed as part of individual showcase projects.

Corridor-Wide Advanced Traveler Information System

Major Participants: Caltrans

Status: The TAC review is completed. The final work plan is being prepared and will be submitted to FHWA in spring of 1998.

Overview: This project plans development of an operational framework for a comprehensive traveler information system across Southern California Priority Corridor. It will address issues such as coordinated deployment, operations, management, maintenance, upgrades for traveler information, and data availability throughout the corridor.

Architecture & Data Flows: Not yet developed

Procedures: Not yet developed

Corridor-Wide Advanced Public Transportation System

Major Participants: MTA

Status: Has not been funded

Overview: This project will provide the means to coordinate Regional Transit Agency operations throughout the Southern California Priority Corridor Area as well as the instrumentation of existing passenger/commuter rail for the purposes of tracking train arrival and departure times at Intermodal Passenger Transfer Points. Additionally, it will assist in providing real-time traveler information to the public through dissemination devices implemented under a future project.

Architecture & Data Flows: Not yet developed

Procedures: Not yet developed

Corridor-Wide System Integration

Major Participants: All showcase stakeholders

Status: The draft work plan has been prepared by NT&R and is being reviewed by the TAC. The final version will be submitted to FHWA by 3/3/98.

Overview: This project seeks integration of over fifty projects within the Southern California Priority Corridor into the Showcase "system of systems." Within these fifty projects, the corridor will deploy an architecture that is compatible with the National System Architecture guidelines, establishing 19 market packages over a corridor-wide basis. This project requires a proven systems engineering service to ensure a structured approach to integration, a consistent configuration management system, establishment of interface standards and protocols and consistency in deployments across the corridor.

Architecture & Data Flows: Not yet developed

Procedures: Not yet developed

Orange County Model Deployment Initiative

Major Participants: OCTA, Caltrans, and CHP

Status: The TAC review is completed. Comments are being incorporated. The final version will be submitted to FHWA in spring of 1998.

Overview: This project is intended to provide a mechanism for communicating information among projects and agencies in Orange County.

Architecture & Data Flows: Not yet developed

Procedures: Not yet developed

San Diego Regional Traffic Signal Integration

Major Participants: SANDAG (lead), CT 11, County of SD, and various cities

Status: The TAC review is completed. The final work plan is being prepared and will be submitted to FHWA in spring of 1998.

Overview: The project proposes initial deployment or an integrated traffic signal control system architecture. It uses showcase kernel as the tool to facilitate this integration. The regional architecture proposes the support of various traffic signal operating systems.

Architecture & Data Flows: Not yet developed

Procedures: Not yet developed

Showcase Kernel

Major Participants: Involves all Showcase members

Status: Funding in process

Overview: This initiative is designed to deliver a seamless inter-modal Transportation Management and Information System across entire Southern California Priority Corridor with the following functionality:

- Initial point of integration for the existing infrastructure and Showcase projects to start with, ensuring success of Corridor and modal wide integration of Transportation Management function.
- Initial target location for all sources of ATIS information for the purpose of consolidating traveler data, enabling migration towards one-stop shopping for multimodal trips as early as possible.
- Facilitate electronic communication for all parties interested in development of seamless ATMIS in the Corridor.
- Provide Internet capability that posts all relevant data from all modes, all roads and improvement initiatives, and provides electronic survey capability as well as allow real-time access to all Showcase initiatives.

Architecture & Data Flows: Not yet developed

Procedures: Not yet developed

3.7 Lessons Learned from Smart Corridor and TravInfo

Smart Corridor and TravInfo are the most advanced multi-jurisdictional projects in the state, and both provide lessons for the future.

3.7.1 Smart Corridor

One of the biggest challenges in developing Smart Corridor was creating the policies for jointly operating the facility under the cooperation of the City of Los Angeles, Caltrans and other agencies. These policies are documented in “Operation Planning Element” of the project (JHK, 1993). As general themes, the document identifies which department has authority over decision making and use of equipment under well defined circumstances, and defines action steps required for possible events. The Smart Corridor System acts like a third party that integrates information between agencies, rather than providing direct access to another agency’s systems. Other key features are as follows:

- The Agency in which the incident is first reported is appointed the incident manager. The incident manager agency remains the incident manager agency for the life of the incident. (For example, if a highway incident is almost cleared and causes backup problems on surface streets, the Caltrans incident manager remains in charge.)
- The owner of a CCTV camera should be the top priority user. Other agencies who wish to use the other agency’s camera must make certain that it is idle.
- An operating agreement is recommended to “allow the use of each Agency’s CMS for management of congestion and incidents on a facility within Smart Corridor irrespective of which agency has jurisdiction over the facility.”
- Agencies can input information regarding planned events at their discretion.

Separate from this document, LA DOT and Caltrans have agreed that certain routine actions could be taken by within another agency’s jurisdiction when the other agency’s TMC is closed down. This might include changing a CMS message or choosing a pre-programmed signal plan. However, this concept does not appear to have been executed.

No evaluation has been completed on the Smart Corridor project. Our conversations with Los Angeles Department of Transportation indicate that the system is used extensively for managing their signal network, and was also used for monitoring traffic and creating control responses. Our conversations with Caltrans indicated that the system was used infrequently there. The Smart Corridor system does not appear to be used extensively for the purpose of cross-jurisdictional coordination. Nevertheless, the project provides a good starting point for creating cross-jurisdictional operating agreements.

3.7.2 TravInfo

The institutional evaluation showed tremendous obstacles to creating and operating centralized information systems (Hall, 1998):

- Centralization may require a new organization, with significant time burdens
- A consensus based partnership is slow and ineffective at making critical decisions (adding to both time and cost)
- Centralization disconnects the information provider from the end user (as the owner of the information does not communicate directly with the ISP)
- A publicly funded project seems ineffective at anticipating the needs of consumers for traveler information

The institutional evaluation further concluded that (Hall, 1998):

- Government agencies should be extremely cautious in entering into system development contracts, and should first consider whether objectives can be met through other contractual vehicles, such as a service contract. This would place the contractor in a better position to integrate government data sources with private sources (especially aircraft surveillance) and to provide cost-effective synergy with radio traffic reporting.
- Information centralization projects should be initiated only when there is clear evidence that centralization provides added value to travelers or system performance. In light of available Internet technologies and the delays and costs of centralization, distributed systems, in which individual agencies retain responsibility for their own data, should be the first choice. Also, in light of the need for nationwide services, it is highly questionable whether government should take on this role.
- Information projects should stick to at least one aspect of TravInfo's concept: traveler information systems are best justified when valuable information within a government agency can be made accessible to end users through minimum public investment. Unfortunately, the high-payback/minimal investment philosophy on which TravInfo was originally founded vanished.
- In the future, it would be best to follow an information pull policy, similar to that of the California Highway Patrol. When private entities request information that has considerable public value, make cost-effective investments to simplify access. On the other hand, do not make costly investments in systems to push information on the private sector, in anticipation that the information will be desired.

3.8 Models for Coordination From Other Sectors

3.8.1 Fire Agencies

There is longstanding precedent for fire departments to provide aid to each other in case of emergency.

Today, these agreements take the form of “Mutual Aid” and “Automatic Aid”, which formalize in advance the conditions under which one department will aid another, and the nature of the aid provided. Such agreements are commonplace today in California, in large measure in response to the large brush fires that occur in the state, consuming and exceeding the fire fighting capacity of any individual jurisdiction. We use, as an example, automatic aid agreements within the Los Angeles Fire Department.

Steps The agreements between Los Angeles City Fire Department (L.A.F.D.) and fire departments of other cities take place as follows:

At first, there is a meeting with the other agency and a study is conducted of the proposed area of response of both agencies. Then, based on a sample or *Boiler Plate* draft or sample Mutual Aid Agreement, a new agreement is drafted which also depicts on a map, the area to be covered in the agreement. On approval by both the City Attorneys and review by Chief Engineer's staff, this is given to the Operations Control Division (OCD) that is the dispatching authority. The Dispatch Section is responsible for the receipt of emergency and non-emergency calls for help from the public via the 911 telephone system and the control and dispatch of all Department emergency resources. During Fiscal Year 1993-94 for example, the Dispatch Section processed over 645,993 incoming calls, of which 523,965 were emergency calls, culminating in dispatching of fire apparatus and rescue ambulances to over 309,704 emergency incidents.

On approval, the Chief presents the final document to the Commission, which then passes it forward to the City Council on recommendation by the Chief that approval be sought.

The city clerk assigns a Council File Number and, after approval is received, the City Attorney reviews changes, if any that have been made. A starting date is provided to OCD. The primary means of communication used are Telephone and Wireless Radio.

All the required signatures are obtained and copies are distributed to the affected battalions and divisions, and also to the Bureau of Emergency Services. The Bureau of Emergency Medical Services, under command of the Chief Paramedic, is responsible for the overall planning, organizing, and directing of the Department's Emergency Medical Services. The Department maintains a total of 52 Paramedic ambulances, 11 Paramedic engine companies, and 13 EMT ambulances. Uniformed EMS personnel and rescue ambulances are assigned to one of six EMS Districts under the supervision of a platoon-duty EMS District Captain. EMS Bureau resources responded to over 230,000 EMS incidents during Fiscal Year 1993-94. An additional copy is placed in the Mutual Aid Agreement Book.

Content The Agreement recognizes that it is in best mutual interest to provide the most expeditious response to suppress fires and provide other emergency assistance.

The chief components of a mutual aid agreement are (Los Angeles, no date):

1. Services to be provided by the City of Los Angeles Fire Department and the other fire agency: The limits within the cities are marked and the "agreed upon" response is defined. Each individual agency also designates which fire Stations/battalions will respond to a certain emergency call (in terms of nature of emergency and physical location). In fact, since there is public benefit, the LAFD units may respond even if it is not covered in the agreement, if personnel and equipment are available.

2. Dispatch of Services by the Fire Departments: The designated authority within the other city's fire department is identified and the procedure is documented. Usually an alarm is simultaneously conveyed to the LAFD dispatcher, who in turn dispatches the agreed-upon response.

3. Incident Command: A standard policy is inserted in all agreements:

“In those instances where the aiding Department arrives before the jurisdictional Department, the aiding Department will take the necessary action dictated by the situation. However, it is assumed that the jurisdictional Department will arrive shortly after the arrival of that aiding Department. Overall command of the incident will be assumed by the jurisdictional Department upon its arrival at the scene. The aiding Department’s personnel will remain under the command of the highest ranking officer of the aiding Fire Department at the incident. The resources of the aiding Department will be released from the scene as soon as practical by the jurisdictional Fire Department.” (Los Angeles, no date).

4. Future Revisions: Since the agreement provides mutual benefit to both parties, the fire chiefs of both cities are authorized to make changes to the agreement to provide mutual aid to both parties.

5. Administration: Details on the amount and type of assistance to be dispatched, methods of dispatching (through the dispatch center of both cities for example) and communication, training programs and procedures, methods of requesting aid, names of person authorized to send and receive such requests and lists of equipment and personnel to be utilized on both sides are enumerated.

6. Usually no compensation is involved in this agreement since the respective covenants assume a reciprocal and mutually beneficial agreement.

7. Period of Agreement: Usually there is no termination date to such agreements.

3.8.2 Electricity Generation and Distribution

Electric utilities perform two major functions: Power Generation (through Thermal, Hydro-Electric, Geo-Thermal and Nuclear Power plants) and distribution of this power to retailers and consumers over transmission lines.

The power networks in United States have been linked together in ten NERC control areas;

1. East Central Area Reliability Coordination Agreement
2. Electric Reliability Council of Texas
3. Florida Regional Coordinating Council
4. Mid-Atlantic Area Council
5. Mid-America Interconnected Network
6. Mid-Continent Area Power Pool
7. Northeast Power Coordinating Council
8. Southeastern Electric Reliability Council
9. Southwest Power Pool
10. Western Systems Coordinating Council

The WSCC, which includes California and most of Western US and Canada, has both public and private utilities as members (Table 5)

Agreements Electric utilities have established a hierarchical set of agreement to coordinate the generation and transmission of electricity among inter-connected networks.

1. Purchase agreements
2. OASIS:
3. Mutual Assistance Agreements.
4. Inadvertent flow restoration.

Purchase agreements are pre-planned and long-term; OASIS is pre-planned but short-term; mutual assistance agreements are pre-planned responses to network incidents, and are executed in real-time; flow restoration occurs on a continuous basis. These are described more fully below:

Table 3-5. Western Systems Coordinating Council Members

Arizona-New Mexico Area	
AZPS	Arizona Public Service Company
EPE	El Paso Electric Company
IID	Imperial Irrigation District
PNM	Public Service Company of New Mexico
SRP	Salt River Project
TEP	Tucson Electric Power Company
WALC	WAPA - Lower Colorado

California-Southern Nevada Power Area	
<u>PASA</u>	City of Pasadena
CFE	Comision Federal de Electricidad
LDWP	L.A. Dept. of Water & Power
NEVP	Nevada Power Company
PG&E	Pacific Gas & Electric Company
SDGE	San Diego Gas & Electric Company
SCE	Southern California Edison Company

Northwest Power Pool Area	
BPA	Bonneville Power Administration
BCHA	British Columbia Hydro & Power
CHPD	Chelan County PUD #1
DOPD	Douglas County PUD #1
GCPD	Grant County PUD #1
IPC	Idaho Power Company
MPC	Montana Power Company
PACE	PacifiCorp - East
PACW	PacifiCorp - West
PGE	Portland General Electric Company
PSE	Puget Sound Power & Light Company
SCL	Seattle City Light
SPP	Sierra Pacific Power Company
TCL	Tacoma City Light
TAUC	TransAlta Utilities Corporation

WWPC	Washington Water Power Company
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Rocky Mountain Power Area	
PSC	Public Service Company of Colorado
WAUC	WAPA - Colorado Missouri
WAUGPW	WAPA - Upper Great Plains - West

1. **Purchase agreements:** All electric utilities do not have generation capacity equal to demand. The generation costs for each utility may not be the same due to the local regulation, source of power (Thermal, Nuclear, Hydroelectric etc) and due to variable transmission losses which can vary widely, ranging from 5-12 %. Also, rates change every hour depending on power consumption. Thus it is profitable for power companies to buy from each other. The Los Angeles Department of Water and Power, for example, purchases excess Hydro-power from Bonneville Power (BPC) during the daytime under a purchase agreement. During evenings, another contract is in place between the same companies in which LADWP sells electricity to BPC. The transmission route, when it passes from several networks, is optimized for least cost (transmission cost and losses), and stability.
2. **OASIS:** OASIS is an online tool for WSCC member utility companies to pool their transmission resources so that all of a company's unused *transmission* capacity can be used by other companies on a temporary basis. OASIS is for a shorter duration, ranging from a day to a month. The transmission line availability is visible on the worldwide-web and the *reservations* can be made as late as one day in advance. In case of emergencies, the dispatcher has authority to make and execute contracts over the phone. This arrangement is seen as temporary in nature. Once deregulation is implemented, all electricity networks in California will be required to pool their transmission assets and the prices for such services will be based on the costs to the company as opposed to a wider fluctuation based on the regulated profitability requirements.
3. **Mutual Assistance Agreements:** The Utilities within a control region (WSCC for example) may have parallel transmission resources between two points. Under the Mutual Assistance agreement; *in case of a major incident all the remaining transmission capacity is to be shared by the utilities in the ratio of their holding before such event occurred.* For example, suppose that there are transmission 10 lines of transmission between two cities; out of which 6 are owned by LADWP and 4 by Southern California Edison. Due to an act of Nature, if 5 of these lines are put out of operation, the remaining lines are to be shared by the companies in the ratio of 3:2 by LADWP and SCE even if all the 5 lines knocked out were LADWP or four of SCE and one of LADWP.
4. **Inadvertent flow restoration:** All the utilities in WSCC grid generate and transmit electricity at 60 Hz. As part of the WSCC agreement, each company is required to keep a certain amount of generating capacity in reserve. The reserve takes two forms: spinning reserve and non-Spinning reserve. Spinning reserve is the reserve that is online and being continuously generated. Non-spinning reserve is offline but available for consumption on a short notice (about 10 minutes). Each company is required to maintain enough in reserve, such that the sum of which equals the largest single power generation unit. In case two companies jointly operate a power plant, they are required to maintain enough reserve that equals the largest shared power generation unit. Moreover, each utility should have at least 7% of total thermal generation online and 5 % of their hydro-resources online and take the higher of the two, out of which 50% must be spinning reserve. This brings about a loss in economy but increases reliability. At points where two networks interface, several parameters are monitored: imbalance, under voltage, over current, negative sequence protection, loss

of synchronization, etc. This is sampled by transformers and compared with all the three phases. If any network is seen to be out of *sync*, all the other networks will automatically provide their reserve power to compensate for the loss of power. If, however, the affected network seems to be collapsing, then under the *Frequency Separation Protocol*, it will isolate itself from the rest of WSCC grid via the auto preset controls in order to protect the rest of the grid. This also occurs on a regular basis when the Switching/Measurement stations between the networks measure the net flow of current continuously and apply a charge later. This charge changes almost every hour, since the need for electricity is not the same in different parts of the grid at different times.

Agreement Creation As an illustration of how these agreements are established, the Federal Energy Regulatory Commission proposed that public utilities set up information networks to give wholesale sellers and purchasers of electricity equal access to information on transmission availability and prices in 1995. These are known by several names: “real-time information networks” (RINs), “Open Access Same-time Information System” (OASIS) or “Transmission Systems Information Networks” (TSINs”).

Two working groups came about to create a consensus on the “How” and “What” of the Information Networks. NERC facilitated the efforts of the “What” Working Group, as it came to be called. It was their job to reach consensus on the information that should be included on a TSIN in order to fulfill FERC’s purpose. The effort resulted in a report, submitted to FERC on behalf of the industry. A sister to the “What” Working Group is the “How” Working Group. Facilitated by Electric Power Research Institute (EPRI), the how group focused on the technical details of developing a TSIN and providing for the functionality described by FERC. The “How” Working Group efforts also resulted in a report submitted to FERC.

FERC acknowledged the efforts of both the “What” and “How” Working Groups when it released its Notice of Proposed Rulemaking on real-time Information Networks and Standards of Conduct on December 13, 1995. Finding both processes representing broad consensus of all segments of the electric power industry, FERC adopted many of the technical parameters suggested in the “What” and “How” reports. Both the “What” and “How” groups provided comments to FERC on its NOPR on February 5, 1996.

FERC’s Final Order 889, announced on April 24, 1996, requires utilities to establish electronic systems to share information about available transfer capability. The order also dictates standards of conduct. Final Order 888 was announced the same day and addresses open access and stranded cost issues.

3.9 A Model for Inter-jurisdictional Coordination in Transportation

The best examples of inter-jurisdictional follow a simple three step pattern:

1. Development of model agreements and policies
2. Negotiating a specific agreement covering participating parties
3. Execution of that agreement in practice

3.9.1 Model Agreements

A model agreement provides “boiler plate” language that could be adopted within any multi-jurisdictional project of a given type, or any universal policy that governs all activities of a given type.

They can be developed in much the same way as a standard (see Section 4). An ad hoc committee is formed under the auspices of a recognized organization, such as Institute of Transportation Engineers or perhaps Caltrans, with a single objective of developing a specific type of model agreement. A negotiation and working group process is set to develop the agreement within a set schedule, after which the agreement is submitted to balloting by involved parties. The agreement is accepted if it passes with a super-majority (e.g., 2/3).

3.9.2 Negotiation of Specific Agreements

The model agreement has no force until it is adopted by a multi-jurisdictional project. Organizations entering into an agreement use the model agreement as a starting point, keeping the portions that are relevant and striking others. Specific terms are added to localize the agreement. Once the agreement is finalized at the staff level, it is submitted to higher levels of the organization for formal approval.

3.9.3 Execution

The negotiated agreement provides the structure for how the system is operated on a day-to-day basis. The agreement is only meaningful if all involved parties adhere to its terms, and use it to improve their coordination.

3.9.4 Areas Where Model Agreements Are Needed

We provide three examples of where model agreements would be beneficial. These are used to illustrate how concepts from organizations can be applied to meet the needs of transportation.

Incident Management Fire districts have a long history of providing aid across jurisdictional boundaries. They have established a simple and effective command and control structure that enables different agencies to work together toward a common objective. A fire department never loses command over incidents within its own jurisdiction (except temporarily, if units have not yet arrived), and a fire department never loses command over its own personnel. A similar command structure was eventually adopted by Caltrans and LA DOT within the Smart Corridor, and should serve as the model for future cross-jurisdictional projects in transportation. The agreement can further specify geographical areas of coverage, the types of incidents that would initiate a cross-jurisdictional response and the magnitude of the response (as has also been done in fire departments).

Flow Management During Incidents The electrical power industry has a simple policy for responding to network incidents, that of sharing remaining capacity in proportion to base level capacity. Networks respond automatically by diverting the traffic of electricity. A simple guideline of this type would be highly beneficial in “Smart Corridor” type projects, where several roadways provide capacity in parallel.

Real-time Network Interfaces In the future, transportation networks will become more like electrical networks, in which the system is continuously monitored and controlled from management centers. However, even the electrical power industry does not attempt to centralize management across jurisdictions. Instead, each agency manages its own network, within prescribed guidelines that prevent failures at network interfaces. The system is controlled through a combination of interface monitoring stations, real-time pricing, and safeguards that ensure that problems in one jurisdiction do not spill over into another. A similar model could and should be developed in transportation. Such an approach could begin with bilateral agreements, but may best be implemented through broader networks that ensure the stability and reliability of the network as a whole. By this approach, the transportation grid can be

monitored automatically, with human intervention limited to control measures implemented by individual management centers in response to problems that are detected at interfaces.

3.10 Systems Management Implications Of Standards

The term 'standard' can refer to any social convention (such as standards of conduct or legal standards), but it most often refers to conventions that require exact uniformity (such as standards of measurement or computer operating systems)¹. Farrell and Saloner (1985) see standardization as a synonym for compatibility, giving compatibility between telephones and telephone networks as an example.

Standards can be divided into four general categories:

1. Formal standards
2. Dominant design (informal) standards
3. Alliance standards
4. Government enforced or regulated standards

1. **Formal standards** are created by professional “standards setting” organizations, such as AASHTO, ASTM, and ISO. Each organization has an established procedure for achieving consensus through meetings and, eventually, balloting. Members are drawn from industry and academia. These are also called voluntary standards because there is no legal requirement to follow them, though there can be strong economic incentives to adopt formal standards. Formal standards are often quite mundane, yet nevertheless important, such as the RS-232 standard governing serial ports on computers.
2. **Dominant design standards** emerge from the early stages of product competition. A period of chaos is often followed by relative stability in which the number of manufacturers and designs decreases rapidly. There is very often no consensus among the various players in the market, but rather a competition to gain market dominance. Emergence of a dominant design often provides financial benefits to a particular company, such as the adoption of VHS as a standard in consumer video recorders.
3. **Alliance standards** are ad-hoc and are usually enacted by a consortium of companies, without direct involvement by a standards setting organization. These standards are different from formal standards in that committees are usually set up to define a particular standard, and are not governed by established rules; they differ from dominant design in that they depend on collaboration among competing companies. An example of alliance standards is the electronic commerce standard being developed by the RosettaNET consortium.
4. **Government enforced standards** result from regulations. Examples include passive restraint, fuel economy, and emissions regulations on vehicles. Government enforced standards usually do not force a particular solution, but instead require attainment of a performance objective. Government also plays a role in the emergence of dominant designs due to its purchasing power, especially in defense related products (military standards, in particular). These do not fall in the category of government enforced standards, as there is no mandate for private companies or individuals to follow them.

¹ LIEBOWITZ, S. J. and MARGOLIS, STEPHEN E. (No date). The Fable Of The Keys. In *Journal of Law & Economics* 33 (April 1990). Available: <http://wwwpub.utdallas.edu/~liebowit/keys1.html> [1998, May 13].

3.10.1 Costs and Benefits of Standardization

Standards are highly beneficial to consumers and industry because they enable the product and service development to be decentralized. Instead of a single organization designing all aspects of a system, companies can focus on areas of core competency, and rely on other organizations to create supporting products. As an example, to be competitive in personal computers, a company does not have to be competent in designing processors, memory chips, monitors, keyboards, printers, and all other system components. It can specialize in just one, and still be successful. This is only possible because the interfaces between the system components have been standardized. The existence of well defined interface standards has nurtured the rapid advancement of computer technology, much faster than the pre-PC era when integral designs were the norm.

According to Farrell and Saloner (1985) a consumer's value for a product is also larger when other consumers have compatible products (called a network externality), because this fosters development of related services and products. Examples include CDs, VHS tapes, and television, where standards have stimulated an industry of content creators and distributors. According to the oligopoly model of Katz and Shapiro (1983), customers value a product more highly when it is *compatible* with other consumers' products².

Perhaps the biggest dilemma in standardization is timing. Early standardization can inhibit innovation or, alternatively, fade into obscurity if alternatives become the dominant design. Especially in rapidly changing industries, waiting for a dominant design to emerge can be a more effective method for standardization than the lengthy process of standards setting organizations. Nevertheless, standards do not have to be the best or latest technological solution, and it is sometimes better to lock in on an inferior design (thus overcoming industry inertia) than to wait for the absolute best. Otherwise, it may never be possible to create an industry of supporting products.

A technology may be locked in for a period of time, but be replaced when a major leap forward is possible. Unless the benefits of replacing the technology are substantial, consumers are better off keeping products based on older (and inferior) technologies, avoiding the high cost of replacement and the high cost of creating support infrastructure. There also has to be a period when an enterprise stops chasing new and innovative ideas and attempts to obtain some return on investment through freezing an acceptable standard. In this period, which is akin to a plateau, new product development is not totally stopped but only incremental improvements take place in the standardized product.

In the case of government enforced or recommended standards and in the case of formal standards, companies have an added benefit in advertising conformance to the standard. Additionally, suppliers may be required to conform to a particular standard, and this may produce a higher number of orders. According to Verman (1973), standards have a greater impact when set by prominent standards setting organizations, likely for this reason. A similar theme is echoed by Lowell who, in his 1997 World Standards Day award winning paper³, proposes adherence to international standards as a key "tool" to open new markets.

The potential drawbacks or risks in creating a standard can be described as:

² Katz, M. and Shapiro, C. (1983). Network Externalities, Competition and Compatibility. Woodrow Wilson School Discussion paper #54, Princeton University, 1983.

³ Lowell, Stephen C. (1997). The Modern Day Archimedes: Using International Standards to Leverage World Markets. 1997 World Standards Day contest Winner.

- Adoption of inferior solution (some believe the QWERTY keyboard is an example)
- Fewer technology choices for consumers. This is especially important in high-tech industries where consumer needs and product characteristics need to be balanced, as opposed to “fast moving consumer goods”, where the product architecture and basic form have stabilized.
- Curtailed innovation. Quinn theorizes that standards require many approvals and cause delays at every turn⁴. According to Hemenway (1975), the National Bureau of Standards refused to write interface standards for the computer industry because it feared that such standards would retard innovation⁵.
- Rapid obsolescence due to leapfrogging of technologies (AMPS cellular v/s TDMA v/s CDMA).

The benefits, on the other hand, are:

- Sustained support from business enterprises since they are able to market that solution and obtain some return on investment.
- Sparks further innovation since almost all major players will have achieved the previous level of expertise.
- Cheaper products for the consumer, since a standardized product will have greater demand and economies of scale for the producer.
- Can aid innovation since it can be used as a substratum to improve and change and avoids duplication of effort.
- Gives smaller companies access to new technologies and their benefits. (e.g. EDI for small retailers.)
- Industry-wide sharing of best practices in case of process standards established by voluntary standard setting organizations where all companies benefit.

It should be recognized that whether or not formal standards are established or adopted, informal standards will emerge through dominant designs. Formal standardization has, over time, been especially useful in defining “company neutral” product interfaces. Establishing uniform connector types and configurations, for example, gives equal advantage to all companies in an industry, while raising the potential for success for the industry as a whole.

We now provide examples of alliance, formal and dominant design standards. This is followed by discussing the implications for intelligent transportation systems.

3.10.2 Examples of Standards from Outside of Transportation

The following examples are used to illustrate the standard development process and the effect of standards on industry.

Alliance Standards

RosettaNET is a consortium of 28 companies in software and hardware distribution, manufacture and consumption led by Ingram-MICRO. It is attempting to standardize EDI within the electronics distribution industry. All of the major retailers (Best Buy, Fry’s, Circuit City, etc.) as well as the smaller ones purchase from these distributors, each of which has established Electronic Data Interchange (EDI)

⁴ Quinn, James Brian (1985). Managing Innovation: Controlled Chaos In *Harvard Business Review* 63 (3) May-June 1985; 73-84.

⁵ Hemenway, D. (No date). *Industrywide Voluntary Product Standards*. Cambridge: Ballinger, 1975.

capabilities. Currently, the most common ordering procedure is to identify the inventory needs, check for availability with several distributors, bargain over the prices and quantities and place the order. The problems with the current methods are:

1. Retailers are required to have a separate EDI system for each distributor.
2. The smaller retailers – the so-called “*Mom and Pop’s shops*” -- cannot afford one EDI, let alone ten different systems.
3. The time to complete order negotiations can be long.
4. Information on competing products and special prices does not always reach retailers.

Additionally, retailers very often do not have a sophisticated inventory control procedure and may not know order quantities and current inventories.

The broad standard proposed for Electronic Business Processes is composed of Open Content and Open Transaction Standards.

Open Content

- Standards to improve quality, depth, and consistent flow of content
- Standards to improve IT supply chain reporting and rules

Open Transaction

- Standards to improve open querying and real-time search.
- Standards to define industry-wide commodity processes.

According to Fadi Chedade of Ingram-MICRO, RosettaNet is designed “to harness the imminent, exponential growth of electronic commerce across the IT supply chain by developing, promoting, and leading the adoption of both open content and open transaction standards, along with the necessary metrics to measure the business impact of these standards on members of the supply chain.”

Upon implementation, this standard is desired to produce a wide range of benefits:

1. Product specifications: All distributors will display product specifications in a standardized format that will allow for easy comparison between manufacturers.
2. The interface will be through the Internet on the individual distributor’s World Wide Web page.
3. Distributors will gain knowledge of the product returns – why are the customers returning a particular product and perform statistical analysis on these figures.
4. Facilitation of Electronic Software Distribution: Since this initiative has wide acceptance as seen in the accompanying figure; there are opportunities for creating other value added services based on the electronic business standards like electronic software distribution and relationships with even smaller retailers.
5. Small retailers can now claim to have in inventory as many items as there are in the inventory of the distributor, which in the case of a company like Ingram-Micro can exceed 50,000.

Formal Standards

The Automotive Industry Action Group (AIAG) is an automotive trade association whose members are the North American vehicle manufacturers and suppliers, including the big three automobile manufacturers in the United States (Chrysler Motor Corp, General Motors and Ford Motor Company). These member organizations come together under the auspices of the AIAG to tackle industry issues like:

- Automatic Identification
- Construction Industry Focus Group
- Continuous Quality Improvement-CQI
- Electronic Data Interchange-EDI
- Materials Management
- Procurement & Finance
- Project Management
- Regulatory Issues
- Returnable Containers & Packaging Systems
- Telecommunications
- Truck Advisory Group
- Vehicle Product Data

They investigate the benefits of communication in new areas, examine established processes with an eye toward improvement and compare procedures to determine best practices. The result of this work is the development of new technologies and the standards that govern their usage.

The Manufacturing Assembly Pilot (MAP) project, an 18-month pilot launched in January 1994, was completed in 1996. This project attempted to demonstrate industry-wide use of electronic commerce (EC) technologies to improve communication throughout a multi-level supply chain that could save the automotive industry an estimated \$1 billion per year. “The objective of the MAP effort is to improve the quality of information flowing down the supply chain and move it quickly, as quickly as a day per tier, from the OEM to the last supplier in the chain. As the suppliers at each tier in the chain begin to experience the benefits of these changes, they will improve their business practices to take advantage of the speed at which accurate and reliable information is available to them. This will in turn lead to a more agile supply chain⁶”.

MAP project recommendations centered on implementing EDI and re-engineering associated business processes. This included standardization of material release data, process orders, and production plans. A standard data dictionary was developed, along with standardized message sets for data exchange. This project resulted in 58% lead time reduction, 24% improvement in inventory turns and 75% reduction in error rates, illustrating that implementing common EDI capabilities and business practices is useful for the entire automotive supply chain. The chain studied in the project consisted of 16 companies, including the automakers.

The significance of this project lies in industry-wide application and acceptance whereby the major automobile manufacturers are not only participating in the various projects but also contributing resources and benefiting from the best practices across the industry.

In the automobile industry, not all suppliers are big and hence do not have resources to reengineer their business processes to maximize profit. Projects such as MAP can help reduce costs for such measures. Additionally, many suppliers have similar business structures and processes and hence common solutions can be applied to individual cases with minimal modification.

The important issues here are compatibility and a smooth supply chain. Since this organization is composed of the big three automakers in the United States, there is considerable clout in the industry.

⁶ <http://www.aiag.org/map>

This is different from the standardization effort in RosettaNET in that RosettaNET appears to be a one-time standard creation effort whereas AIAG is an ongoing organization with formal procedures.

Dominant Design Standards

Video Cassete Recorders In 1963, the very first home videotape recorder appeared in the Nieman-Marcus Christmas catalog: the Ampex Signature V costing \$30,000. This product found success in the broadcast market, but was ahead of its time for consumers. Nevertheless, other companies continued development. Sony introduced its CV series half-inch, black/white open-reel format in 1965 ("CV" ostensibly stood for "consumer video"). In April 1969, Sony announced that it had developed a *magazine loaded* video tape recorder that used a one-inch tape. JVC followed soon, announcing that it had developed a machine that uses half-inch tape.

In this period, several firms were already developing the next generation products or competing formats, RCA with its *Selectavision*, CBS with its *Electronic Video Recording* and Teldec and Philips with their videodisk technologies were the frontrunners. 1972 saw the advent of Cartivision, which housed half-inch tape in a clunky cassette roughly the size of a hardcover book. The cassette employed a coaxial system wherein the two tape reels were stacked on top of each other.

In the early 1970s, several Japanese manufacturers introduced home video taping equipment. Sony clinched the first battle in the standards war by inviting JVC and Matsushita to join the new standard for cassettes using the ¾ inch tape, later to be called U-Matic format. The three firms agreed by December 1970 and Sony marketed its U-Matic compatible VTR in late 1971. It failed in the marketplace because of high cost and shortage of media (e.g., no pre-recorded tapes).

It was not until the mid-seventies that a true consumer oriented product came to fruition. SONY developed its Betamax format for video recording and playback as the first mass-marketed home video system, finding ways to efficiently use the space on half-inch magnetic tape. Sony invited Matsushita and JVC to license the Betamax technology in December 1974. In April 1976, the three companies agreed to have a meeting where Betamax, VHS and a third design (VX) would be compared. The JVC machine was smaller than the Betamax, but was strikingly similar in other respects. "Both were two-head, helical scanning machines using half-inch tape in a U-Matic type of cassette. Both also used azimuth recording and countered the problem of cross-talk by juggling the phase of the color signal".⁷ The talks ended with JVC unconvinced that Betamax was superior to its own design.

Sony was the first in the market, selling 30,000 Betamax VCRs in 1975. However, JVC was not far behind, releasing its VHS format in 1976 in a machine that had twice the recording time of Sony's Betamax machines. Through various collaborative efforts, four other Japanese electronics manufacturers joined JVC by January 1977 and, as a response, Sony joined forces with Zenith. Matsushita, the parent of JVC attempted to persuade RCA to join the VHS camp. RCA indicated that the recording length of two hours should be increased to three or four hours and in a few weeks the JVC engineers had a prototype ready. RCA joined the VHS camp in March of 1977. This continued as a pattern and VHS had an edge over the Betamax recording time throughout. VHS followed any Betamax improvements in quality closely and came out with its version not too long after. However, in the case of recording time, the VHS later had almost twice the recording time of Betamax.

⁷ Liebowitz, S. J. and Margolis, Stephen E. (No date). *Path Dependence, Lock-In, and History*. Available: <http://wwwpub.utdallas.edu/~liebowit/paths.html> [1998, April 12].

Then came the inevitable *price wars* in which RCA cut prices and Sony was eventually forced to follow suit. In 1978, Sony's share was 19.1 % of the market whereas RCA had almost twice the number at 36%. By 1981 the Betamax format VCRs as a whole accounted for only 25 % of the entire market. Beta VCRs started selling for less than the comparable VHS format VCRs. In 1988, Sony admitted to plans for a VHS line of VCRs. VHS players commanded 95% of the market at that time. A year after Sony's first VHS recorders hit the market in September 1988, the Betamax share of the consumer VCR market had dropped to less than 1%.

Despite its head start and prestige, Sony was overtaken by the late 1970s by the VHS system developed by JVC. Thus, after a period of relative chaos in terms of competing designs, the market finally had perhaps two dominant designs, one the VHS and the other, Sony's Betamax.

The major reasons for the success of VHS however, were that, Sony thought that one hour of playing time for Beta, geared to taping TV shows, would be sufficient for home use. VHS was first to come out with a two-hour duration, making it suitable for the prerecorded movies that are now a multibillion-dollar industry. Technologically, the two formats were perhaps equal. The law of increasing returns played a significant part in the demise of Betamax. When the number of Video titles available on Betamax format declined, the format became less popular with home users.

In this case, not having standards initially aided the consumers since it forced the competing consortia to improve and innovate in terms of the length of recording time and the quality of the picture. This also initiated interest in other technologies for recording and playing pictures and sound and led to leapfrogging of technologies. Having a standardized format when VHS became the dominant design catalyzed several ancillary industries -- videocassette manufacturers, video rental stores and pre-recorded movie cassette manufacturing came into being, benefiting the customer even more. Finally, one can say that the current status of the industry is that of maturity where no significant improvements are being made in terms of VCR performance, but are becoming obsolete with the advent of Video CD and DVD players (another example of leapfrogging).

QWERTY Keyboard The patent for the typewriter was first awarded in 1868 to Christopher Sholes, who developed the machine for several more years. One of the problems faced by Sholes was the jamming of the type bars when certain combinations of keys were struck in very close succession. As a partial solution to this problem, he arranged his keyboard so that the keys most likely to be struck in close succession approached the type point from opposite sides of the machine. This arrangement assigned the letters Q-W-E-R-T-Y in the first row of the keyboard. Since QWERTY was designed to accomplish this now obsolete mechanical requirement, maximizing speed was perhaps not an explicit objective.

E. Remington & Sons bought the rights to the Sholes patent on the typewriter in early 1873. Mechanical improvements were made to the design and commercial production commenced in late 1873. In 1888, QWERTY beat out a competing 72 key design in a typing speed competition. The winning typist later demonstrated his typing skills on the Remington machine and popularized it through his numerous public appearances. Many other designs existed at the time that might have been selected for the competition, so it might be argued that the emergence of QWERTY as the dominant design was accidental.

Professor August Dvorak patented the Dvorak Simplified Keyboard (DSK) in 1936. He claimed that it dramatically reduced the finger movement necessary for typing by balancing the load between hands and loading the stronger fingers more heavily. He claimed that this gave the DSK advantages in terms of the high speed of typing, reduced stress on typists and ease of learning. In experiments by the U.S. Navy, typing efficiency increased when the DSK was used and this added efficiency would "amortize the cost

of retraining a group of typists within ten days of their subsequent full-time employment.⁸ These claims were refuted by a General Services Administration study in 1956 conducted by Earle Strong, which concluded that there were no benefits to retraining typists on the Dvorak Simplified Keyboard⁹. Another reason for this hype on the advantages of DSK over QWERTY are: Prof. Dvorak was the person who conducted these and other tests at the US Navy and thus had a stake in the DSK succeeding. Also, he held a patent for the DSK and stood to gain substantially in monetary terms if the DSK were adopted universally.

Despite the claimed advantages, the Dvorak keyboard was never accepted in the marketplace. The reasons for the success of the QWERTY can be summarized as:

1. The correlation between the supply and demand of skilled typists trained in the QWERTY keyboard arrangement.
2. The incentives offered by the manufacturers: Training programs to secretaries and clerks created its own demand, because every trainee would be of more use to a future boss if he bought Type Writers¹⁰.
3. The fact that even competitors began to supply keyboards with the QWERTY format ensured that the new typists stressed learning the QWERTY and this increased the pool of such trained personnel.
4. QWERTY was comparable to other machines if not superior as demonstrated by its triumph in various competitions.

It has been argued thus that the design wasn't that important at all, but the marketing, the timing, the technical interrelationship and the fact that it was not possible to reverse the trend of high investment made in these machines by the businesses.

3.10.3 Standards Being Developed in Intelligent Transportation

Transportation standards are being 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).

⁸ David, Paul (1985). Clio and the economics of QWERTY. In *American Economic Review*, 75, p.332-337.

⁹ Liebowitz, S. J. and Margolis, Stephen E. supra note 1.

¹⁰ Wakkerman, Johannes Cornelis Henricus, QWERTY-nomics in regional development: path dependency in industry allocation, infrastructure systems and implications for public policy. At <http://home.worldonline.nl/~wakkerm/index-roth.htm>

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.

Standards Creating Organizations in Transportation

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.

3.10.4 Implications of Standards for Systems Management

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.

Interviews were also 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: 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 manufactures 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 Detectors: 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.

3.10.5 Recommendations 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 6 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. Nevertheless, there is value in developing standardized management processes, as in military standards for systems engineering or ISO standards for quality. And whereas standardization of system interfaces is clearly not appropriate for a single state, standardized processes for executing ITS projects could be appropriate at a state level. We believe that this is best applied in standardizing inter-jurisdictional agreements, as suggested earlier.

Organization	Standard	IMPACT AREAS					
		S u r v e i l l a n c e	I n f o D i s s e m	C o n t r o l	T o l l C o l l e c t	C o m m u n i c a t i o n	M a n a g e m e n t
AASHTO	NTCIP dynamic message signs		X				
AASHTO	NTCIP highway advisory radio		X				
AASHTO	NTCIP environment sensor stations & TWIS	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	
SAE	Navigation and route guidance man-machine interface		X				

Table 3-6: Impact Areas of Standards

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CHAPTER 4: POLICY LEVEL

4.1 Introduction

In 1991, federal legislation (ISTEA) established a program to encourage implementation of Intelligent Transportation Systems. Toward this objective, the National ITS Architecture (NA) was developed and is now being disseminated to guide transportation professionals in identification, design and deployment of ITS projects. The NA provides a conceptual framework for understanding ITS and its relationship to all transportation activities; it encourages standardization of elements, interfaces and system behavior; and it facilitates both technical and institutional integration. Federal and state ITS funding are increasingly requiring conformance with NA. For these reasons, this new standardizing and integrating force will be important for transportation professionals in California.

This chapter begins with a definition of Institutional/Policy Issues, then summarizes results from the following policy-oriented study efforts:

- Identification of stakeholder groups in California
- Summary of key documents reviewed
- Discussion of key policy issues for each major stakeholder group
- Identification of major policy challenges for ITS deployment in California

4.2 Definition Of Institutional Issues

This section describes the general institutional issue areas that were used as a point of departure to identify the major institutional/policy challenges to ITS deployment in California. These institutional issue areas were obtained from the “ITS Architecture - Implementation Strategy” (FHWA, 1996), with the addition of one further issue area – Market Acceptance.

1. First-User Benefits: Early benefits can be considered with regard to 1) user benefits and 2) related system benefits. Potential first-user benefits to be assessed include improved safety, increased economic productivity, enhanced environment, increased economic productivity, increased mobility and the growth of new industries.

2. Market Acceptance: Several aspects of ITS will require significant changes in user beliefs and behaviors associated with transportation. It is anticipated that an important factor in the success of ITS products and services is the reliability of transportation products and the convenience of delivery of transportation services and information. In addition to individual consumer acceptance, the issue of private providers’ acceptance of ITS services is important.

3. Privacy: A number of concerns have been raised about loss of privacy associated with various ITS market packages. This includes concerns over being able to identify vehicles (via network surveillance); the ability to track movements (via dynamic toll and parking management and fleet management); and the potential resale of personal data gathered by traveler information services.

4. Environment/Energy Impacts: A major goal of contemporary transportation policy--as exemplified by provisions in both ISTEA and the Clean Air Act Amendments of 1990 (CAAA)--is to deploy transportation systems which minimize adverse environmental impacts, and where possible, promote environmental gain.

5. Cost-Benefit Allocations: The primary focus of examining the benefit and cost allocations is to help determine if ITS implementations will provide for an equitable distribution of costs and benefits such that no sector of the public is unduly burdened, and most individual benefits are reaped in proportion to payment. An equitable distribution of costs and benefits imposes no major shifts in the allocation of costs between the consumer and the public sector.

6. Budget Instability: Several major ITS studies (including DOT, 1995, Booze, Allen and Hamilton, 1995, and Horan, et al) have found that budgetary constraints remain an important concern for local implementers considering possible ITS solutions. The architecture is aimed at minimizing the marginal cost of conformance through its open and distributed nature.

7. Regulatory Constraints: The deployment of ITS architecture involves a host of investment and procurement decisions. While some of these decisions will fall within the normal purview of the public and private sector, many of the market packages will represent significant challenges to both sectors. State and federal regulations governing motor vehicle safety, motor vehicle licensing and registration, environmental quality and land use may all be implicated in particular ITS applications.

8. Education and Staffing: Necessary training and education steps are required to ensure the early successful implementation of ITS. Such training would encompass the architecture as well as the technical and non-technical issues associated with conforming ITS implementations.

9. Inter-jurisdictional Disputes & Local Government Coordination: Many institutional issues arise from the integration of different components of a transportation system into a single [super] transportation system. That interconnection of parts requires the interconnection of the institutions, local jurisdictions and transportation modes associated with those parts.

10. Liability: The National Architecture is designed to take into account the manifold legal issues inherent in any effort to manage the implementation of transportation technologies involving numerous public and private organizations. Most of these legal issues fall under the broad categories of liability, privacy, antitrust, inter-jurisdictional cooperation and intellectual property. In general, the National Architecture imposes no major shifts in legal responsibility; both the subsystems and the market packages follow the distribution of costs and ownership typically associated with transportation.

11. Antitrust: Antitrust laws in the United States restrict anti-competitive conduct by private entities and in some limited cases by public actors. Of greatest relevance to the National Architecture is the Sherman Act, 15 U.S.C. Section 1 and 2, which restricts monopoly behavior and conspiracies to restrain competition. If present, the threat of antitrust liability would seriously deter the cooperation among private and public entities that is necessary for the architecture to succeed.

12. Patents: Because many ITS implementations will involve public and private cooperation, there can be concern (and disputes) about the retention of property rights, the patents, copyrights and other intellectual property rights. The governing law here is particularly complex, however, there is nothing inherent in the architecture that should complicate the process of arriving at mutually acceptable agreements in this area.

4.3 Stakeholder Groups

In California (as in other states), the architecture will be implemented through and/or affect a variety of stakeholder groups. The Implementation Strategy of the National Architecture explicitly addressed this facet by describing the various stakeholder groups based on the graphic contained in figure 4-1. The following discussion extends that description to focus specifically on the stakeholders in California.

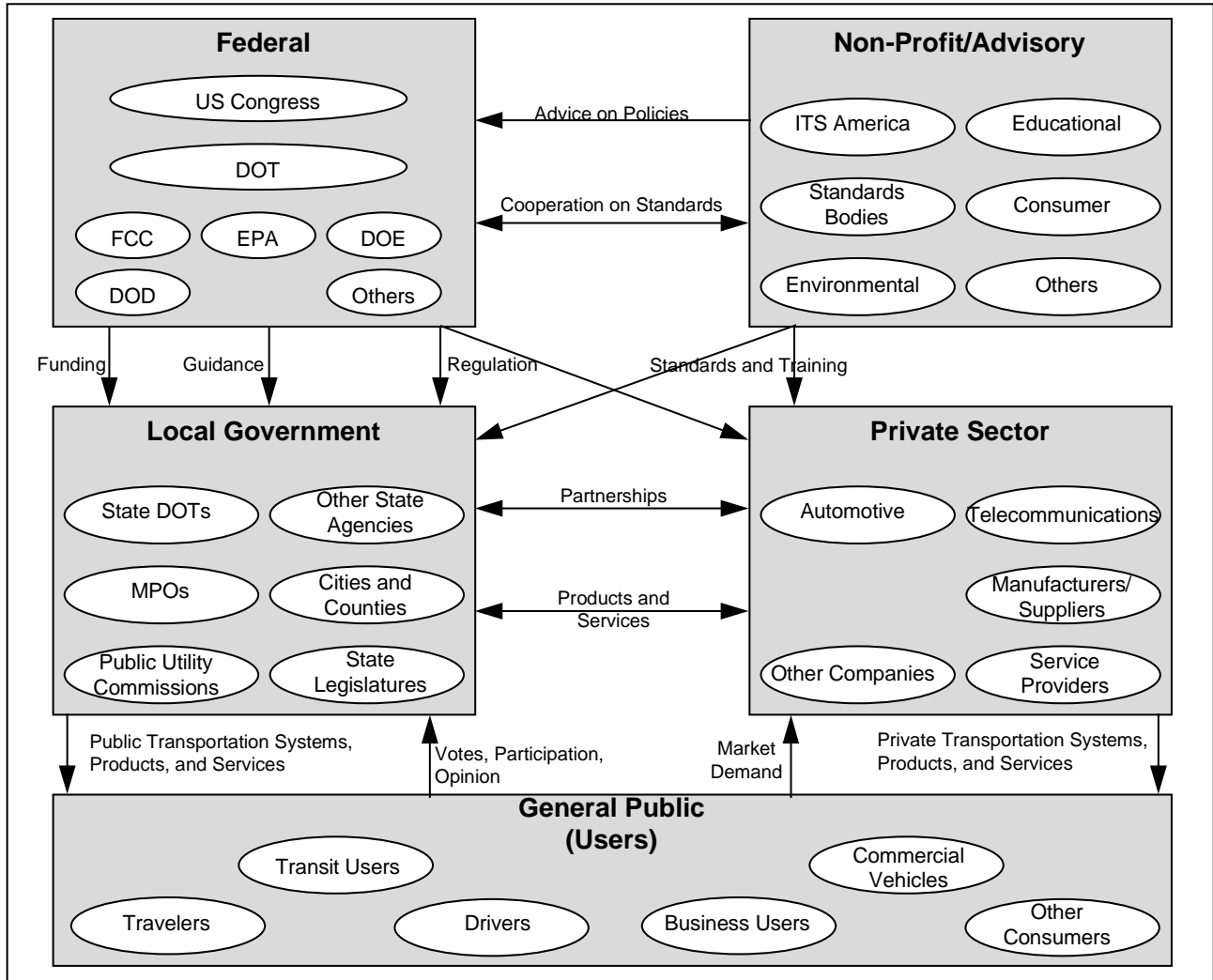


Figure 4-1: The Institutional Layer of the National Architecture

(source: National Architecture, Implementation Strategy)

4.3.1 Public Sector (and Non-profit) Involvement in ITS

A distinguishing feature of the surface transportation policy is the cooperative partnership between the U.S. Department of Transportation, the states, and localities. The following is a brief indication of the various implications of different stakeholders for local state and local implementation of the NA.

- **State DOT: Caltrans** California plays a major role in the planning, capital support, operations and maintenance of the state's transportation system. There are multiple divisions and offices that could intersect with ITS architecture deployment. For example, at the local (District) level, the districts plan, procure, and often manage TMCs that need to coordinate across jurisdictional boundaries. At the headquarters level, there are various offices that deal with crosscutting issues (New Technology), AVI Issues/Standards, CVO, and ATIS, all of which would be engaged in the architecture deployment process.
- **MPOs** The MPOs have enhanced regional planning and programming responsibility through ISTEA and CAAA, and this can (and should) include planning ITS systems. A major issue will be to work with MPOs and related planning enterprises to ensure that the key functionalities and concepts of the system architecture get incorporated into the planning process..
- **Counties and Cities** Cities and counties are the major infrastructure purchasers. As such, the extent to which they purchase systems that are architecturally compatible (e.g. open systems) will lay the groundwork for regional interfacing. Two related issues could be the cost burden (particularly for lagging communities) as well as tradeoffs between regional architecture needs and local needs.
- **State Legislature** The state legislatures provide both general policy fiscal support as well as occasional policy initiative. For example, in California, the state legislature led the initiative for a common AVI standard throughout the state.

The "third" sector, otherwise known as the non-profit sector, plays a key role in advising the public sector and integrating public and private sector needs. This sector includes advisory organizations (such as CAATS), standards-setting bodies (such as IEEE), advocacy groups (such as environmental and consumer groups), and educational organizations. Various roles are as follows:

- **Environmental** Environmental groups have generally been major stakeholders in transportation, often playing key roles in advocating for transit-friendly, multi-modal transportation policies and programs. For this reason, the architecture needs to allow for different groups--such as environmental groups--to rightfully believe that transportation priorities have not been pre-empted by the architecture, but rather that the architecture can be used to implement local priorities on issues such as environmental quality.
- **Consumer Advocates** As ITS is intended to provide a variety of individual consumer benefits, various consumer groups (e.g. AAA, AARP), will have an interest in ensuring that the consumer is adequately represented in the architecture. For example, in Southern California the Auto Club is active in both representing the public as well as developing a variety of related products and services.
- **Partnerships/Committees** A variety of partnerships (formal and ad hoc) have been developed relevant to ITS deployment. In California, CAATS represents the public and private sectors in advancing ITS. In southern California, the Southern California Economic Partnership (SCEP) and the Priority Corridor Steering Committee are two groups active in advancing ITS deployment, and are relevant to a number of architecture considerations.

- **Educational Institutions** Educational institutions provide an important source of training for transportation professionals in both the public and private sector. ITS Training can be a part of formal programs, such as undergraduate and graduate degrees in transportation planning and engineering. Training can also be in the form of onsite, continuing education programs specifically geared to ITS topics. In California, both the UC system and private colleges provide general training programs, though the need for architecture-related training will almost certainly grow and need to be addressed.
- **Professional Societies** Professional societies (ITSA, ITE, APA, etc.) play a key role in information transfer, standards setting, and education and training. As such, they will need to participate in developing the appropriate institutional and technical support for the deployment of the architecture.

4.3.2 Private Sector Involvement in ITS

Private sector funding and technical expertise is necessary to develop ITS technologies and to help ensure that new transportation system infrastructure is properly operated and maintained. Some of the chief reasons for encouraging private sector involvement in ITS include:

- Efficiency
- Faster service
- New sources of capital
- Generation of new income
- Shift of risk
- Market responsiveness
- Access to special knowledge and/or technology

The institutional layer highlights the role played by the various aspects of the private sector. As delineated in various ITS plans and reports, the private sector is expected to lead the development of ITS products and services. The National Architecture is explicitly geared to be responsive to private sector needs and requirements. However, unlike the legislation and practices that can aid in characterizing public sector decision-making relative to ITS, private sector decision-making is even more diffuse. ITS is envisioned to have a variety of private sector participants, from automobile manufacturers (OEMs), to telecommunications companies, to product entrepreneurs, to major trucking companies.

The private sector has established expertise in many areas including technology, traffic engineering, marketing, finance, research, and operations. It is driven to expand these areas by reinvesting revenue from product and service sales back into its business area. Revenue is sought in the consumer public and the government marketplaces. Investments in research, development, and marketing by the private sector and the costs of deploying an ITS system represent the majority of the costs of ITS. The volume sales potential of the general consumer market, if realized, can provide a large revenue source and a strong motivation for the private sector.

As delineated in Table 4-2, the private sector can play a variety of roles in the design and provision of ITS products and services. These diverse roles require different areas of expertise and have different profit potential.

Table 4-2 Private Sector Roles and Functions (source: N.A. Implementation Strategy)

Role	Functions Performed
Service Provider	Capital Investments Consumer Responsiveness
Operator	Day to Day Management
Consultant/Systems Integrator	Design/Build
Packaged Software Provider	Develop off the shelf software serving common automation needs.
Telecommunications Provider	Telecommunications Services
Support Services Provider	Maintenance, Training, Certification
Product Developer	General Purpose and Application Unique Hardware and Software development.

The products and services that the private sector develops bring the benefits of ITS to the users of the transportation system. The private sector must always be looking to the future for new technology applications and developments in order to keep up with demand and stay ahead of the competition. The private sector must anticipate the market demand in order to be ready to supply the products and services needed. By anticipating market demand, the private sector's role is expanded to include an ITS vision for the future. Private sector strategies and plans that are developed will influence the future of ITS.

The private sector also plays a role in the development of industry standards, which make interoperable systems possible. These industry standards are often developed from a consensus process at Standards-Development Organizations. To the private sector, standards may enhance confidence to develop and deploy new products and services.

Some of the private sector roles are as follows:

- **Auto Industry** Because a very large portion of the overall funding of ITS services is expected to be on private autos and commercial vehicles, the auto industry will play an integral part in developing technology which goes in the automobile and standards which link various equipment within the vehicles. In California, some automobiles are starting to include ATIS systems as an option, as well as Mayday systems (the latter available Nationwide).
- **Product Providers** New technology for better instrumentation of roadways, exchange of information, and advanced vehicle sensors and control will require development of advanced technologies. A major force in ITS will be the various communications companies which are seeking to expand their portfolio of products and services. The architecture will need to be developed cognizant of the market, technology, and regulatory developments taken place in this fast growing industrial sector (which includes electronics, software, communication, and system integration firms). Many ATIS and ATMS firms are active in California, and the types of standards and protocols that are established here could have an impact nationwide.
- **System Integrators** ITS and the National Architecture imply a host of systems integration efforts at the local, regional, state, and multi-state levels. System Integrators will play an important role in designing, implementing, and managing integrated ITS systems. Many of the nationally recognized system integrators are active in California, and creating architectural designs (e.g. Showcase) that could have statewide if not national application. Ensuring the consistency of these designs with the national architecture is both a major opportunity and a major challenge.

- **Service Providers** There is significant new business opportunity in providing ITS services, especially the information dissemination services. Opportunities are also available for integrating operators, hammering out policies, and general management of cooperative ventures. The role of the Information Service Provider (ISP) is one that has been identified in several major California ITS plans.

Last but not least the traveling public and commercial travels greatly impact and are affected by ITS developments. These include travelers, drivers, commercial users and other drivers.

- **Travelers** The architecture must deliver benefits to the travelers if it is to be a viable market-based system. The deployment of the architecture will need to ensure that a range of travelers are intended beneficiaries, including drivers, transit users, bicyclists, and pedestrians. Because of the high levels of congestion in metropolitan areas of California, most market analysts expect California travelers to be among the earliest adopters.
- **Drivers** Although transportation policy encourages use of multiple modes of travel, the predominate form of travel continues to be automobile travel, thus making it the major market for ATIS and related services. The National Architecture will need to provide valuable services to the segment, while at the same time ensuring adequate safeguards ensuring safety while traveling.
- **Other Consumers** The ongoing information revolution is creating entirely new markets for information. For example, media companies are considering a range of programming options for home use. National Architecture will need to be accommodative of new developments which could provide new platforms for services and products.
- **Commercial Users** Commercial users are vital stakeholders in ITS. Because this segment often experiences tangible (e.g., financial) gain from ITS, they provide reliable measure of the manifest demand for various services. Moreover, they represent key early beneficiaries that can aid in ensuring successful early experiences with ITS. The National Architecture will need to ensure that the needs and interests of commercial users are centrally represented in the architecture design and implementation.

4.4 Documents Reviewed

This section summarizes each of the key documents reviewed during the course of the study, particularly those relevant to Institutional and Policy issues in California ITS deployment. Each summary begins with a narrative of key points, followed by a structured analysis of the document’s contents as they relate to each of the institutional issues identified above, including specific page references.

4.4.1 Advanced Transportation Systems Program Plan

This document provides an overview of the Advanced Transportation Systems (ATS) Program, a program designed to direct Caltrans’ work in the development and deployment of advanced transportation technologies. The document “defines the mission and goals of the program and identifies a 15-year ATS deployment vision which relies on both governmental action and market forces, and which will require extensive cooperation on the part of the state, its political subdivisions, and private industry” (3). Specific state initiatives, including proposed legislation and a Caltrans 5-year program, are intended to improve California’s transportation systems across all modes and to support the private sector’s role in providing the leading-edge mobility services outlined in the 15-year deployment overview. The program recognizes that energy and environmental goals must be met in responding to mobility and safety needs. In the section titled, “Fifteen-year ATS Deployment Overview,” an estimation of the benefits and the costs of elements of the advanced transportation system to be delivered to transportation users over the next 15 years is detailed (in very general terms), with an outline of “scenarios depicting what can happen if an effective ATS **partnership** is realized, **not a prediction or plan of what will happen**” (29, bold in original). In “Realizing the Vision,” state actions and challenges to make the plan a reality are identified in the three subsections: “Systems Integration”; “Institutional and Legal Issues”; and “State Policy and Legislative Initiatives.” In the “Five-year Program” section, current year activities within the Caltrans program are detailed, with an activity plan with anticipated milestones for the following four fiscal years highlighted and program resource needs discussed.

Issue Area	Page	Institutional/Policy Implications for California
First User Benefits <ul style="list-style-type: none"> • Improve Safety • Increase Transportation System Efficiency • Enhance Environment • Increase Economic Productivity • Increase Mobility • Encourage New Industries 	52, 68-69,	All six sub-areas of first-user benefits are mentioned throughout the plan; recommendation of non-profit corporation for ATS commercialization; recommendation to establish a grants and loads for small business to develop marketable products;
Market Acceptance		Not discussed in this document.
Privacy	66, 70	Recommendation to develop state policy to ensure private for California citizens is protected in their use of any and all ATS deployments in California involving governmental entities

Environment/Energy Impacts	100-101, 120-123	Mentioned throughout plan, with focus on improving environmental quality, reducing energy impacts through alternative fuels, Work Smart project
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Issue Area	Page	Institutional/Policy Implications for California
Cost/Benefit Allocations	22, 52-55	Described in very general, speculative terms; facilitation of cost-sharing from available resources is guiding principle of ATS program
Budgetary Instability		Not discussed in this document.
Regulatory Constraints	68, 69, 70	Streamline partnership arrangements; review regulations government telecommunications industry and recommend changes to restrictive laws; proposal of AVI tags on all new vehicle procurements and study of ways to quickly retrofit public fleet vehicles; Automated Highway Maintenance and Construction Technologies (AHMCT) program is directed toward implementing products and processes that improve safety and efficiency of highway O&M
Standards	61-65	Concern expressed on geographically compatible systems across California and nation
Education and staffing	66	Recommend development of efficient and fair labor arrangements in implementing ATS applications; Title 13c addresses situations where the public transportation provider is “absorbed” by another agency and employees face termination due to obsolescence
Interjurisdictional Issues	66, 70	Recommend cooperative agreements among key transportation agencies; establish coordination teams to oversee ATS programs and activities in each region;
Liability	66, 69	Promote joint research by managing liability exposure to public and private organizations; listing of options to contain liability for ATS research and testing (include legislatively containing liability exposure, establishment of a liability pool or superfund, and/or providing partial governmental coverage on selected research and development activities); related to standards issue in order to reduce liability
Antitrust	66	Recommendation to develop cooperative research and development and production agreements (for public-private partnerships)
Patent		Not discussed in this document.

4.4.2 ITS/NA Implementation Strategy

This is perhaps the defining document regarding ITS institutional issues. The Implementation Strategy (IS) defines a series of steps that encourage efficient deployment of National Architecture (NA)-compatible systems. It defines the NA, identifies market packages and synergy, discusses technology and standards requirements, and maps the ITI to the NA. It then describes the Institutional Layer as including “the policies, funding incentives, working arrangements, and jurisdictional structure that supports the technical layers” of the NA. Chapter 3 identifies groups of stakeholders and discusses constituents of each, defines 12 institutional issue areas affecting deployment (listed below) and discusses the deployment implications of each issue area as they relate to market packages (but not stakeholders). Chapter 4 provides guidance to state and local agencies, relating the NA to the transportation planning process, including developing a market package plan, defining a regional architecture, developing a strategic deployment plan, implementing and evaluating the system. Chapter 5 makes recommendations to USDOT about supporting the NA.

For each issue area below, the document defines the constituent issues, assesses NA relevance, and discusses deployment implications. Selected institutional/policy implications are quoted below.

Issue Area	Page	Institutional/Policy Implications for California
First-User Benefits	3-26	Discusses user benefits in terms of the six ITS system goals.
Market Acceptance		Not discussed in this document.
Privacy	3-38	“Privacy concerns are found to create a substantial user acceptance problem.”
Environment & Energy	3-30	“Actual impacts achieved will be highly dependent upon how local agencies apply the architecture to their needs.”.
Cost/Benefit Allocations	3-28	“The design of the market packages facilitates associating costs of the market packages to the beneficiaries of those costs.”
Budget Instability	3-46	“The budgetary impacts of implementing these core (NA) functionalities should be determined through the regional transportation planning and programming process.”
Regulatory Constraints	3-45	“High-technology procurements are generally viewed as difficult for the public sector for they are not amenable to low-bid procurements.” “Public/private partnerships ... can evoke concerns about various practices ...”. “Perhaps the most important regulatory constraint facing (NA) ... is regulation of communications frequencies...”
Standards	3-46	“Fortunately, the national ITS architecture does not impose any immediate standards on ITS design; rather it highlights areas where standards would be beneficial and appropriates the standard decision-making process to organizations typically involved in transportation standard setting.”
Education & Staffing	3-42	“In order for an architecture to be successful, it must be implemented; in order for it to be implemented it must be understood.” “...will represent a significant challenge.”
Interjurisdictional Coordination	3-31	“Many interjurisdictional constraints will await ITS regardless of the architecture.”

Liability	3-33	The NA “aims to minimize any additional liability by imposing no major shifts in legal responsibility”.
Antitrust	3-35	“In general, antitrust is not viewed as a major barrier to ITS deployment”.
Patents	3-37	“Where there is potential conflict, the allocation of (intellectual property) rights is best addressed early on as part of the agreements envisioned by the architecture.”

The SHOWCASE Project

Summarizing the objectives of Showcase, along with presenting information collected from surveys to numerous local, public, and regional agencies regarding an inventory of their systems, these documents outline the Showcase project as a significant Intermodal Transportation Management and Information System demonstration aimed at optimizing and coordinating freeway and arterial operations with public and private transportation systems within the Corridor.

The documents are organized into the following 6 sections:

- **Section 1** presents a brief introduction and scope of the document;
- **Section 2** describes the survey methodology used in data collection (2 different surveys used, Transportation Management Systems Survey and Transportation/Information Providers Survey);
- **Section 3** defines the existing corridor infrastructure and transportation information systems (e.g., Caltrans/CHP District 7, LACMTA, City of Pomona, Santa Monica Freeway Smart Corridor, Los Angeles Metro Rapid Transit System, Long Beach Transit, AMTRAK), as well as the programmed or planned traffic management and traveler information programs;
- **Section 4** defines the existing information systems in other regions within the State of California (YATI, TransCal, TravInfo, Central Valley Transportation Management Center, San Francisco Bay Area Interim Traffic Management Center, HELP/Crescent Program);
- **Section 5** presents the existing transit information systems (transit service providers, ITS user services in public transportation, overview of existing transit management and information systems); and
- **Section 6** discusses the database which was created from the data collected.

Issue Area	Document	Institutional/Policy Implications for California
First User Benefits	Vision statement, Corridor Systems Infrastructure Structure, Introduction, Existing California Information Systems (YATI), Existing Transit Information Systems	<ul style="list-style-type: none"> • Reduced traffic congestion • Improved efficiency • Improved reliability • Improved safety • Improved air quality and environment, • Intermodalism
Standards	Vision statement	Points out where standards will be required (for national interoperability), recommended (for data exchange), and encouraged (for economy of scale)
Education and Staffing	Existing Transit Information Systems	Transit operators developing significant experience in application of technology to issues related to transit management and provision of user information

Interjurisdictional Issues	Concept of Operations	Can operate within range, from independently to a centralization of some/all traffic management functions (level of participation from agency/user is not fixed)
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4.4.3 Caltrans TMC Master Plan (June 1993)

The Transportation Management Center (TMC) Master Plan defines a hierarchical management and operations structure for California TMCs, which are to be co-managed by Caltrans and CHP. Three “regions” of the state, (North) Coastal, Valley and Southern, each are coordinated by one “Regional” TMC and contain Urban TMCs managing specific urban areas, Satellite Operations Centers (SOC) for seasonal operations, and Mobile Operations Centers (MOCs) for emergency situations. Regional TMCs are connected electronically to the Caltrans and CHP Headquarters Information Center. Higher-level TMCs take over control from lower-level TMCs under certain circumstances. TMCs will manage transportation multi-modally, using Open Systems architecture to insure interoperability and to provide traveler information.

Issue Area	Institutional/Policy Implications for California
First-User Benefits	Not discussed in this document. (Immediate benefits will be most visible during responses to major emergencies.)
Market Acceptance	Not discussed in this document
Privacy	Not discussed in this document
Environment & Energy	Not discussed in this document. (Overall TMC Plan goal is to create environment and energy benefits.)
Cost/Benefit Allocations	Not discussed in this document
Budget Instability	Because TMCs provide essential services, funding stability is critical.
Regulatory Constraints	Not discussed in this document
Standards	<ul style="list-style-type: none"> • Interchange of data between TMCs requires strong communications standards. • Provision of traveler information requires communications standards • System-Performance data bases at each Urban TMC must be compatible. • Each TMC must utilize modular, scalable, open-systems design.
Education & Staffing	Not discussed in this document. (Technical expertise will clearly be needed to design and operate TMCs.)
Interjurisdictional Cooperation (IJC)	<ul style="list-style-type: none"> • Requires cooperation between three regions of state managed by Regional TMCs. • Requires cooperation between cities within each Urban TMC’s urban area. • Requires cooperation between each Regional TMC and subordinate SOCs. • Requires high degree of cooperation between Caltrans and CHP. • Implies cooperation with other modal agencies for providing traveler information, but mechanisms were not clearly articulated.
Liability	Not discussed in this document
Antitrust	Not discussed in this document
Patents	Not applicable - open-systems design generally avoids proprietary issues.

4.4.4 California Advanced Driver Information Systems (CADIS)

The California Advanced Driver Information System (CADIS) is designed to provide drivers with in-vehicle components that will improve the efficiency of their commute. Such components include devices that provide information about factors affecting commute and devices that automate driving.

Because the specifics of CADIS have not been developed, the issues affecting CADIS are broadly examined and cannot be considered a definitive or exhaustive examination of the institutional issues affecting how information flows through CADIS. The CADIS document reviewed here broadly assessed benefits and limitations to the implementation of in-vehicle components which are designed to provide drivers with ITS information. Furthermore, the issues important to the interface between privately-owned in-vehicle devices and publicly-owned infrastructure was discussed.

This study was intended to discuss issues affecting near-term implementation of CADIS. This includes enhancing efficiency using human-controlled vehicle operation. ITS advancements in transportation can be grouped into two functional areas: 1) advances that enhance current (human-controlled) vehicle operation, 2) advances that automate vehicle control. The CADIS advances discussed in this study largely emphasize enhancements rather than automation. In particular, the study emphasizes ATMS (Advanced Transportation Management Systems) as a method of enhancing current (human-controlled) vehicle operation.

Issue Area	Page	Institutional/Policy Implications for California
First User Benefits	26 08, 12 24 07	<ul style="list-style-type: none"> • faster emergency detection and response times • increased transportation system efficiency via AVI tags • reduce harmful emissions • increase mobility via navigation information • increase economic productivity via AVI tags • encourage new industries through the private competition of CADIS interface and technology products • reducing the variance in travel time and stress associated with travel benefits all social and economic levels
Market Acceptance	25 28	<ul style="list-style-type: none"> • Relinquishing control of one's vehicle requires a dramatic change in how people view transportation via automobiles • AVCS Safety must be definitively predetermined before users will entrust their safety to this system
Privacy	35	(re: AVI tags) drivers may not want their exact location know every time they go by an AVI reader
Environment/Energy Impacts	26 27	<ul style="list-style-type: none"> • air pollution caused by vehicle accelerations, high speed and wind resistance is reduced with AVCS • CADIS anticipates reducing the amount of pollutant runoff by reducing amount of land dedicated to roadway surfaces and parking lots

Cost/Benefit Allocation	34 07 24 26	<ul style="list-style-type: none"> • as well benefiting transportation industries, initial market for devices will benefit “well-to-do Yuppies”. • reducing the variance in travel time and stress • associated with travel benefits all social and economic levels • congestion pricing - charge for use is envisioned • public funds will be used for some aspects of CADIS, therefore increasing accessibility to all levels of the public
Budget Instability	23	Free market pricing in the form of “congestion pricing” so that individuals pay only for what they use
Regulatory Constraints		Not discussed in this document.
Standards	09, 12	Regions must provide a standard mechanism by which information is disseminated and used real-time qualitative congestion information transmitted via unused bandwidth of existing commercial FM carrier. On board CPU would decode information and transmit audio information to driver In addition, safety (in the form of demanding attention of drivers) may be an issue with some of the proposed methods of disseminating transportation information to drivers.
Education and Staffing		Not discussed in this document.
Interjurisdictional Cooperation		Not discussed in this document.
Liability	28, 29	AVCS automated travel exposes public and private sectors to liability if the vehicle is involved in an accident
Antitrust		Not discussed in this document.
Patents		Not discussed in this document, however, partnerships with private sector will make patents an issue

4.4.5 CAATS Business Plan (March 1996 Draft)

This document describes CAATS and defines an Action Agenda for California, which consists of:

1. Refine and Implement a Business Plan
2. Develop a 5-year Deployment & Commercialization Plan - using a Deployment Council & Expert Teams
3. Conduct Education & Outreach - reaching all stakeholders with materials and “Peer Consultation”
4. Develop Regional System Architecture & Standards - over 5 years; led by Expert Team using ITE, IEEE, etc.
5. Provide an Information Clearinghouse - monthly newsletter; WWW site.
6. Conduct Annual Meetings & Other Forums - Annual meetings in Nov./Dec., other forums as needed.
7. Provide Support for Industry - Workshops, business incubators, venture-capital program.
8. Broker Public/Private Partnerships - especially projects funded by Caltrans under AB2516.
9. Facilitate Development of Testing & Qualification Criteria - led by Expert Team.
10. Increase Funding - support lobbying efforts by others, issue Opportunity Alerts, quarterly investment forums.
11. Operate Opportunity Bank - to identify and promote promising business opportunities.

Issue Area	Page	Institutional/Policy Implications for California
Budget Instability	33	“Friends of CAATS” could be effective at lobbying for funding.
Environment & Energy	14, 21	How will environmental and economic objectives be balanced in the “Vision” and the resulting CAATS Action Agenda?
Education & Staffing	28 25	<ul style="list-style-type: none"> • <u>Clearinghouse</u>: Monthly newsletter and WWW site will be important training tools -- but how will they relate to other educational efforts? • <u>Education & Outreach</u>: Conduct/support lobbying efforts for funders & stakeholders.
Interjurisdictional Cooperation (IJC)	23 25 31	<ul style="list-style-type: none"> • <u>Deployment/Commercialization Plan</u>: Statewide plan likely to require cooperation between jurisdictions in each region and possibly between public and private sectors • <u>Education & Outreach</u>: Outreach effort will likely promote IJC • <u>Public-Private Partnership Broker</u>: Caltrans funding for projects may require IJC.
Antitrust	30 31 33	<ul style="list-style-type: none"> • <u>Support Network</u>: CAATS “Business Incubator” and “Venture Capital” efforts must not (appear to) favor (or exclude) specific organizations • <u>Public-Private Partnership Broker</u>: Must not favor specific organizations • <u>Quarterly Forums</u>: Must not favor specific organizations
Patents	31 30	<p><u>Public-Private Partnership Broker</u>: Must establish policies regarding ownership of intellectual property developed by such joint ventures.</p> <p><u>Support Networks</u>: Business incubators and financing programs must establish policies regarding ownership of intellectual property developed with CAATS assistance.</p>

4.4.6 Institutional Challenges to the Development and Deployment of ITS Systems in California, PATH Report, 1996.

This document provides an overview of the key institutional challenges that could affect the development and deployment of ITS technologies in California. The findings are based on a series of in-depth interviews and review of research related to "non-technical" constraints both in California and at the national level. Based on this review, the authors outline three core areas that require attention: research collaboration which focuses on public/private partnerships in the development of new technologies; regional management--which focuses on the coordination of metropolitan planning and deployment of IVHS/ATS systems, and stakeholder acceptance--which focuses on the institutional and Market Acceptance needed for IVHS/ATS systems to be successful. After describing how each of these three areas are manifest in California, the report then provides an inventory of relevant lessons that could be learned from other experiences occurring around the country, including at the national level. The study concludes by outlining major research implications of the findings, and provides summary recommendations for developing a broad-based, robust program in California aimed at the resolution of these constraints. In general the study support the importance of the institutional issues outlined in the National Architecture and its implications for California deployment.

Issue Area	Page	Institutional/Policy Implications for California
First User Benefits	12	<u>Market Acceptance:</u> Paper notes stakeholder acceptance issues, including market share concerns for ATIS—as third of three core areas of concern.
Environment & Energy	21	<u>Stakeholder Acceptance</u> - Paper outlines range of concerns from environmental stakeholders in terms of ITS impacts.
Standards	78	<u>Regional System Architecture:</u> Notes role of National Architecture in facilitating development of innovative institutional arrangements.
Education & Staffing	15	<u>Research Dissemination:</u> Paper reviews variety of institutional research which could have implications for overcoming institutional barriers.
Interjurisdictional Cooperation (IJC)	10	<u>Metropolitan Coordination:</u> Highlights lack of public/public coordination as one of three core areas that could inhibit deployment of ITS in California.
Antitrust	6	<u>Commercialization:</u> Describes barriers to public/private partnerships as including concerns over antitrust as a second of the core barriers.

4.4.7 Smart Traveler

Smart Traveler is a way to obtain personalized travel information that allow CA users to develop a personalized multi-modal travel plan. Personalized travel information is obtained via phone service, personal computer, computerized kiosks, in-vehicle devices, and interactive television.

The Smart Traveler documents discussed user interfaces and user services of the Smart Traveler program. The user interfaces were described above. The user services include pre-trip travel information, en route updated travel information, ride matching and reservations, en route transit advisory, electronic payment services, public travel security, personalized public transit, traveler services, route guidance.

This document is intended to identify issues affecting the implementation of ITS through Smart Traveler.

Issue Area	Page	Institutional/ Policy Implications for California
First User Benefits	1-2 CAATS	<ul style="list-style-type: none"> • Estimated that more than 400,000 new CA jobs can be created by the year 2010 in advanced transportation industries. • Not discussed in this document, however, quality <u>real-time</u> transportation information must be reliable or else purchasers of travel information products will discard them - what is the feasibility for quality real-time transportation information via Smart Traveler? • Not discussed in this document, however, what is the outlook for providing drivers with en-route alternative routes around accidents and congestion? How is en-route information anticipated to be provided? • Not discussed in this document, however, increased mobility, improved land use and enhanced environment are likely to result if Smart Traveler succeeds
Market Acceptance	1 CAATS	
Privacy		Not discussed in this document; however potential carpoolers have already expressed a reluctance to give home address and phone numbers for inclusion in a citywide database. Is progress being made to reduce potential carpooler's apprehension regarding this?
Environment/Energy Impacts		Not discussed in this document
Cost/Benefit Allocation		Not discussed in this document, however, it may be anticipated that multiple interfaces will allow users from all social and economic levels to participate in Smart Traveler
Budget Instability		Not discussed in this document, but may be an issue if local governments are expected to pay for Smart Traveler rather than individuals - will individuals pay for the service? If so, how?
Regulatory Constraints		Not discussed in this document.
Standards	1-2 CAATS	<ul style="list-style-type: none"> • Information provided would need to be standardized • CA is the only state currently ready for deployment of traveler information and therefore is anticipated to drive national and international standards in this area
Education and Staffing		Not discussed, however, Smart Traveler information is designed to be accessed via user-friendly interfaces
Interjurisdictional Issues (ICJ)	1 CAATS	Transportation information provided would need to be standardized - what steps have been taken toward this goal?

Issue Area	Page	Institutional/ Policy Implications for California
Liability		Not discussed in this document; however, might liability be an issue with regard to behavior of carpool participants?
Antitrust		Not discussed in this document, however, should be considered an issue due to public/private partnerships anticipated in the production of Smart Traveler technology
Patents		Not discussed in this document, however, should be considered an issue due to public/private partnerships anticipated in the production of Smart Traveler technology

4.4.8 Building the ITI: Putting the National Architecture Into Action

This document is a high-level handbook for transportation managers to provide focused information about the ITS Architecture to those implementing the ITI. Information is provided on what the ITI components are, what the architecture is, what the architecture says about ITI, and the benefits of having and using the architecture to guide deployment. Defining the basic subsystems and interconnections between subsystems required to implement ITS, the architecture says that ITI, as an integrated system of transportation components, is part of a core set of capabilities to permit efficient operation and management of roadway and transit resources. Deployment objectives are highlighted in detailing each of the nine ITI components (Traffic Signal Control, Transit Management, Freeway Management, Electronic Toll Collection, Regional Multimodal Travel Information, Electronic Fare Payment, Railroad Grade Crossings, Emergency Management Services, Incident Management). Purposely not providing the actual design or telling local officials what to buy, the architecture gives everyone a common starting point and a common language, and thus, provides for a common framework for discussions with manufacturers and other implementers, as well as serves as the foundation for standards development. Specifically, the architecture is flexible, does not lock one into rigid deployment options, and provides the basis for ‘buying smarter’ (i.e., gives a region the option to upgrade or replace parts of the system without having to start from scratch) by addressing all of the subsystems and interfaces that may be required in any ITI deployment.

Issue Area	Page	Institutional/Policy Implications for California
First User Benefits	6, etc.	Improved safety (reduced accidents from advanced/automated warnings), greater efficiency (more traffic handled at greater speeds compared to pre-existing congested conditions), reduced congestion
Budget instability	39-40	Need to plan ahead for system integration, with emphasis on “buying smart” and knowing what “sister agencies” in same and surrounding jurisdictions are planning
Standards	2, 19, 20-21, 29, 39, 42	Can use these requirements to ensure that equipment purchases will be reasonably compatible with future systems; benefits of using architecture to guide deployment include national compatibility, multiple suppliers, future growth, support for ranges of functionality, synergy, risk reduction

Interjurisdictional Cooperation (ICJ)	10, 15	Multi-jurisdictional operating agreements ensure routine cooperation, coordination, and communications among all agencies; part of “buying smart” issue
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4.4.9 Consumer-Driven ITS Deployment in Southern California

Serving as a policy implications guide for the Auto Club of Southern California, this document focuses on the issues that deal with user/market acceptance of Advanced Traveler Information Systems (ATIS) products. This report consists of three parts: a literature review of consumer acceptance, a review of California initiatives, and an analysis of an Expert Roundtable session. Key issues that arise include: the need to develop new methodologies to understand how the consumer/traveler interfaces with technology; willingness to pay for ATIS products (still unclear); the benefits that can be provided to the consumer/traveler on the basis of past research identifying travelers’ behaviors and needs; and the differing perspectives from both public and private sector in providing traveler information and, consequently, the uncertain prospect for developing future public/private partnerships.

Issue Area	Page	Institutional/Policy Implications for California
First User Benefits		Improved safety is a key issue for selling ATIS technologies Increased system efficiency; Increased economic productivity. Increased mobility: need to question what mobility means. Create environment for ITS Market; encourage new industries Private sector pushes for public sector to provide a good “hands-off” regulation environment/reliable infrastructure for a level field to operate on
Market Acceptance	8-9, 36, 44-46 11-12, 57 24-25, 26-27, 56-57 7, 8, 58-59 5-6, 12, 36, 39	<u>Consumer relationships:</u> Need to improve communication with consumers, to address needs and concerns of traveling public <u>Consumer interests:</u> Traffic information not a “killer application”; importance of safety as a product dimension; the need to bundle technologies; consumer interest in paying for traffic information is low; all of these reasons can be considered a constraint on Market Acceptance <u>Consumer behavior:</u> Summary of current traffic information research; the difficulty of understanding changing consumer behavior <u>Public/Private alliances:</u> ACSC’s implications of partnerships with other private and public organizations; unclear roles <u>Methodology:</u> New methodologies are needed to address Market Acceptance
Cost and Benefits	45-46	Need for different market packages to provide different gradations of functionality (market segmentation issue); public investigation on providing the widest benefits to public
Cost/Benefit Allocations	34, 40-41, 63-64	Are travelers/commuters willing to pay for services: public sector must attend to needs of the broader public
Regulatory Constraints	58-59	Public/private partnerships as alliances in transition
Interjurisdictional Cooperation (IJC)	62	Need for coordination among local governments to deploy ITS

Liability	61	Limitation for new technology and public/private relationships
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4.4.10 Southern California Priority Corridor Policy Assessment (Expanded)

Key stakeholder interviews were conducted in June and July 1996 as part of a project for FHWA assessing the four ITS Priority Corridors (Southern California, Houston, Gary-Chicago-Milwaukee, and I-95). Questions were asked on the institutional, programmatic, and operational aspects of the program, with interviewees asked to comment on the successes and shortcomings of the Priority Corridor effort to date. Following is a summary of key findings regarding institutional issues affecting ITS deployment in the Southern California Priority Corridor.

Issue Area	Institutional/Policy Implications for California
First User Benefits	<ul style="list-style-type: none"> • Safety and efficiency across jurisdictions and across modes. • Stakeholders view the primary accomplishment as the creation of an environment in which the development and deployment of ITS can be sustained in the future. Thus, there are few tangible benefits to initial ITS users, especially the public. • The initial beneficiaries of the regional integration efforts will be existing systems that will operate more effectively.
Market Acceptance	<ul style="list-style-type: none"> • Private sector has concerns over public sector's lack of focus on consumers' needs. • Raises the of standards, especially communications between ITS elements. A consistent communications protocol is vital. • Additionally, the private sector believes the public sector is not giving enough time to allow markets to develop (e.g., one-year demonstration projects). Public sector should be emphasizing the development of standards, instead of private sector functioning.
Privacy	This issue did not arise in the Corridor interviews.
Environment/Energy Impacts	This issue did not arise in the Corridor interviews.
Cost/Benefit Allocations	This issue did not arise in the Corridor interviews.
Budget Instability	Funding is a major challenge to the Corridor effort. While adequate for the planning stage, the significant gains expected from regional cooperation and integration from deployment of projects will be lost without full funding.
Regulatory Constraints	<ul style="list-style-type: none"> • Pronounced procurement problems (14 months from beginning to end) hampered the Corridor effort, especially at the beginning. • Procurement process needs changing.

Standards	<ul style="list-style-type: none"> • The Corridor effort represents an important step in building “enabling architecture,” building within a framework that has the capacity both to be responsive to a given area’s needs and to interface with other systems. • For the private sector, standards are a way to reduce perceived political risk and the developing standards will aid in attracting private-sector participation. • Standards will help create a more level field to use for product development.
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Issue Area	Institutional/Policy Implications for California
Education and Staffing	<ul style="list-style-type: none"> • More support from high-level (CEO) leadership within agencies is needed. • Administrative instability through staff turnover is cited as one of the reasons for the slow start to this Corridor effort. • The learning processes that must take place will be a challenge since local agencies need assistance in purchasing systems. • Issues looming ahead include: operations and maintenance considerations (requiring technical expertise and funds) and more outreach.
Interjurisdictional Cooperation (ICJ)	<ul style="list-style-type: none"> • Central to the Corridor effort. • More cooperation is needed between public agencies to facilitate interjurisdictional integration. • More outreach needs to be conducted (especially to cities and other smaller local agencies). • High-level (CEO) leadership is needed. • A major problem for the future lies in sustaining the momentum for the ITS effort. If the federal government does not continue support of the Corridor effort, local entities may conclude that there is no reason to continue coalition-building in the attempt to achieve regional benefits. • More needs to be done in building public-private relationships. • Although (CAATS) and (SCEP) play an active role in joining public and private sectors, the private sector is wary about public-private partnerships for several reasons, especially about the retention of proprietary market-research results.
Liability	<ul style="list-style-type: none"> • A major institutional issue for the private sector. • Private sector is concerned about its own liability as an information service provider (ISP) when it repackages that information to sell to the public. Hence, “asset management” is an upcoming issue, with the private sector questioning if there is enough of a market to make it profitable to repackage and sell this data in ways beyond those already available.
Antitrust	This issue did not arise in the Corridor interviews.
Patents	<ul style="list-style-type: none"> • Issue of “intellectual property” rights. • The private sector currently seeking to protect their proprietary interests while still operating within the “open system” context. • The boundaries are still being defined.

4.5 Major Issues For California Deployment

Based upon the literature review, the matrix below was constructed to summarize the important institutional issues to each of the key stakeholders in California ITS deployment.

4.5.1 Important Institutional Issues to Stakeholders

Stakeholders	Institutional Issues												
	First User Benefits	Market Acceptance	Privacy/Security	Environment/Energy Impacts	Cost/Benefit Allocations	Budget Instability	Regulatory Constraints	Standards	Education and Staffing	Interjurisdictional Issues	Liability	Antitrust	Patents
Government	■	■	■	■	■	■	■	■	■	■	■	■	■
1. Federal (FHWA)		--	--	--	--	--		--	--	--			
2. State (Caltrans)		--		--				--		--			
3. Local (cities, MPOs)		--			--	--		--	--	--	--		
Private Sector													
1. Consultants to Govt.						--			--				
2. Vendors to Govt.		--	--			--					--	--	--
3. Mass marketers, ISPs	--	--			--			--			--	--	--
Non-Profit		--											
1. Partnership Groups *					--		--	--			--	--	--
2. Standards Groups**							--						
3. Public-interest groups***		--	--	--	--								
General Public (Users)													
1. Travelers	--	--	--		--								
2. CVO							--		--				

* e.g. CAATS, SCEP

** e.g. IEEE, ASTM

*** e.g. EDF, STPP

4.5.2 Interview Focal Areas

Government

First User Benefits, Market Acceptance, and Privacy

Current Assumptions and Concerns about Market Acceptance
Stakeholder Involvement and Issues in System Architecture and Design
Expected Role of Private Sector (including ISPs) in System Design
Equity Issues and Provisions Considered in System Architecture
(Needed) Provisions for Privacy and Security
Architecture Provisions for Ensuring Privacy and Security

Cost Benefit Allocations and Budget Instability

Current Investment orientation toward ITS (especially basic versus advanced)
Major financial options (including public/private partnerships)
Assumptions about government funding
Influence of Architectural Choices on Cost/Benefit Allocation

Standards

Current Role of Standards in Ensuring Interoperability
Gaps in Interoperability to the Addressed Architecture
Institutional Arrangements Needed for Standards Agreement
Impact of Open Versus Propriety Systems

Interjurisdictional

Current levels of cooperation among systems
Institutional mechanisms for ensuring cooperation (present and potential)
Tradeoffs and Synergies between regional goals and local goals
System Emphasis for coordination (and potential gaps)
Roles of different policies and programs (federal, state, local, in ensuring cooperation).
Role of planning versus operational management in facilitating cooperation
Specific areas where an “architecture” could assist in cooperation.

Policy and Process

Major Policies Affecting System Design and Performance
Relative Influence of ISTEA, CAAA and other legislation on system Architecture and Design
Influence and Concerns of Various Stakeholders, including concerns about environmental impacts of system
Potential barriers (and solutions) for efficient architecture deployment, including procurement issues and training requirements.

Architecture Summary

Major Areas for Architecture Applications
Major Institutional Issues Preventing Architecture Application
Recommendations for Statewide Architecture Consideration

Private Sector

First User Benefits, Market Acceptance, and Privacy

Current Assumptions and Concerns about Market Acceptance
Perceived Involvement and Influence in System Architecture and Design
Barriers to Participation in Architecture Development
Equity Issues and Provisions Considered in System Architecture
(Needed) Provisions for Privacy and Security
Architecture Provisions for Ensuring Privacy and Security

Cost Benefit Allocations and Budget Instability

Current Investment orientation toward ITS (especially basic versus advanced)
Major financial options (including public/private partnerships)
Assumptions about government funding
Influence of Architectural Choices on Cost/Benefit Allocation

Standards

View of Standard Needs and Importance
Gaps in Interoperability to the Addressed Architecture
Institutional Arrangements Needed for Standards Agreement
Impact of Open Versus Propriety Systems

Policy and Process

Major Policies Affecting System Design and Performance
Perspectives on Barriers to Public and Private Contributions to Achieving Consensus on
Architecture Choices
Potential barriers (and solutions) for efficient architecture deployment, including procurement
issues and training requirements.

Architecture Summary

Major Areas for Architecture Applications
Major Institutional Issues Preventing Architecture Application
Recommendations for Statewide Architecture Consideration

Non-Profit

First User Benefits, Market Acceptance, and Privacy

Current Assumptions and Concerns about Market Acceptance
Stakeholder Involvement and Issues in System Architecture and Design
Expected Role of Private Sector (including ISPs) in System Design
Equity Issues and Provisions Considered in System Architecture
(Needed) Provisions for Privacy and Security
Architecture Provisions for Ensuring Privacy and Security

Cost Benefit Allocations and Budget Instability

Current Investment orientation toward ITS (especially basic versus advanced)
Major financial options (including public/private partnerships)
Assumptions about government funding
Influence of Architectural Choices on Cost/Benefit Allocation

Standards

Current Role of Standards in Ensuring Interoperability
Gaps in Interoperability to the Addressed Architecture
Institutional Arrangements Needed for Standards Agreement
Impact of Open Versus Propriety Systems

Interjurisdictional

Current levels of cooperation among systems
Institutional mechanisms for ensuring cooperation (present and potential)
Roles of different policies and programs (federal, state, local, in ensuring cooperation).
Role of planning versus operational management in facilitating cooperation
Specific areas where an “architecture” could assist in cooperation.

Policy and Process

Major Policies Affecting System Design and Performance
Relative Influence of ISTE, CAAA and other legislation on system Architecture and Design
Influence and Concerns of Various Stakeholders, including concerns about environmental impacts of system
Potential barriers (and solutions) for efficient architecture deployment, including procurement issues and training requirements.

Architecture Summary

Major Areas for Architecture Applications
Major Institutional Issues Preventing Architecture Application
Recommendations for Statewide Architecture Consideration

4.6 Institutional/Policy Challenges to ITS Deployment in California

The major challenges to efficient and full deployment of ITS in California can perhaps be best understood when considered in terms of three overarching themes:

- **Organizational Capacity**
- **Regional Integration**
- **Private-Sector Participation**

Each of these themes embrace a number of institutional challenges to ITS deployment, as discussed below. A California implementation strategy should address each of these themes comprehensively.

4.6.1 Organizational Capacity

ITS deployment involves a broad spectrum of organizations cutting across all levels of government agencies, political jurisdictions, and modal responsibilities, plus emergency-response functions and private companies that sell products and/or services to government or to the public directly. Study interviews have identified three related areas in which organizations in California appear to be lacking in the capacity to implement ITS fully and efficiently. These are: commitment, education, and funding:

1. **Commitment** - Two organizations -- Caltrans and MPOs -- were identified as not yet having made a full, top-down commitment to deployment of ITS. While Caltrans has been a nationwide leader in certain areas of ITS, most notably research and urban TMCs, some Caltrans staff felt that the amount of staff time budgeted by Headquarters for ITS will not be sufficient for full and efficient deployment. It was also stated that Executive Directors of the major MPOs in the state have not embraced the vision of ITS, hence, have not given planners the encouragement or education needed to assimilate (“mainstream”) ITS into the transportation planning process. (At the same time, several transportation professionals questioned whether the ITS mainstreaming vision *should* be adopted.)
2. **Education** - While organizational leaders need to embrace the *vision* of ITS and the guidance of NA, staff-level technicians and planners need to understand the *elements* of ITS and NA and the potential *benefits* attainable from ITS projects. Interviews suggest that knowledge of ITS at the staff level is still inadequate, for the reasons discussed earlier. Fortunately, a number of ITS educational efforts are now underway or in preparation. These include:
 - **FHWA** - Has developed a 5-year strategic plan for ITS “professional-capacity building”, addressing a broad range of educational efforts including: (1) awareness (elected officials, CEOs of transportation agencies, etc.), (2) in-depth training (public agencies, undergraduate universities), and (3) advanced training (graduate-level universities). A number of one-day “awareness” seminars are being offered, and FHWA has also developed several 3-day courses.
 - **CAATS** - has conducted workshops statewide to encourage ITS implementation.
 - **Universities** - UC Institute of Transportation Studies Technology Transfer Program is offering a number of ITS-related courses. UC Davis has been launching a new graduate program “Transportation Technology and Policy”.
 - **Project California (“CalSkills”)** - is primarily serving a “broker” role, to identify professional educational needs and to match them with available training resources. (ref: CalSkills report.)

What is not clear, however, is how these educational efforts are being marketed. Specifically, will they reach the technical and planning staff who need the information? Will those staff have the management support to take full advantage of the education offered? Without this knowledge at the staff level, ITS will never be fully mainstreamed. There is a potential role for Caltrans in helping insure that these education efforts reach the appropriate individuals at the regional and local levels.

3. **Funding** - Many interviewees felt that inadequate funding will be a major hindrance to full ITS deployment in California. While federal and state funding have supported research, testing and demonstration deployments, it was repeatedly stated that full deployment of ITS will not be possible unless ITS can compete successfully with other transportation needs in the regional planning process. This, in turn, will be predicated upon achieving success in the areas of commitment and education discussed immediately above. Another major and recurring concern regarded operations and maintenance (O&M) funding, which will also depend heavily upon the degree to which ITS becomes mainstreamed into the regional planning process.

In summary, these three interrelated areas of commitment, education and funding will determine the extent to which California organizations will be able to fully and efficiently deploy ITS.

4.6.2 Regional Integration

The integration and coordination of ITS products and services throughout a region is a major issue affecting deployment of ITS. This study has identified two aspects of regional integration as barriers in California: inter-jurisdictional coordination and costs versus benefits.

Inter-Jurisdictional Coordination

Several ITS implementers interviewed in this study voiced the opinion that successful ITS deployment is hindered by limited coordination between local entities (e.g. Caltrans Districts, local government agencies, and private companies). This appears to result from insufficient incentives and institutional structure to promote coordinated deployment of ITS projects. Evidence supporting the importance of incentives and inter-agency coordination can be found in the Southern California Priority Corridor (SCPC), which was catalyzed by substantial federal funding under the Priority Corridors program.

As originally envisioned, the focus of the SCPC was to move beyond the numerous but isolated ITS tests and activities in Southern California, into a “system of systems” (i.e. a comprehensive demonstration of coordinated freeway and arterial management technology with an intermodal emphasis). In the development stage, the need for strategic coordination among regional entities became clear, and a steering committee made up of about two dozen government agencies was created. It is revealing that this steering committee spent almost one year developing a mutually-acceptable mission statement -- but it was widely believed that this was a necessary precursor to effective deployment of the resulting “Showcase” project.

This “institution-building” (the creation of new organizational structure and protocols to facilitate interjurisdictional coordination) was also found to be necessary in the other three Priority Corridors, and the incentive of substantial federal funding was clearly an inducement to make this happen (ref: Horan, 1996). Interviews conducted for this study have corroborated these findings of the SCPC study.

Local Costs versus Regional Benefits

Another regional-integration issue is the problem of “local costs vs. regional benefits”, which has several dimensions. Absent federal or state funding, most of the cost for ITS projects must be borne by local government agencies, yet some of the benefits realized by these same investments may be region-wide (e.g. integration of a local ATMS with Caltrans or adjacent jurisdictions). Moreover, the regional benefits are not always fully apparent. By definition, ITS projects seek to promote the development of a seamless, multimodal, interjurisdictional transportation system -- the benefits of which are less visible at the local level. Also, the coordination of complex technology in region-wide systems requires more time than for isolated projects, and local governments have been hesitant to invest in ITS projects that require more time than isolated projects. Further constraining the cost/benefit picture, ITS benefits are not fully understood by local transportation practitioners and policymakers, as was discussed above.

A third dimension of the cost/benefit assessment relates to control. Especially with the NA’s emphasis on integration and interoperability, local governments fear they may be required to relinquish some degree of control over the ITS projects they fund. Local governments are understandably reluctant to invest in projects for which they may not have full control. Finally, the NA’s emphasis upon “open systems” design makes some local governments less willing to participate in regional ITS projects because some already have a substantial investment in proprietary systems (“legacy systems”). These existing systems may be serving local needs satisfactorily at present, but would require additional cost to integrate into a regional system.

4.6.3 Private-Sector Participation

Private sector participation and partnership are obviously vital to the implementation of ITS, given that “[t]he National ITS Program targets private sector ITS funding at 80%” (ref: ITS and the Environment: Issues and Recommendations for ITS Deployment in California). However, private-sector funding to date falls far short of that goal and major questions remain regarding the method in which the public and private sectors can cooperate in the most productive manner. These questions cut across five institutional issue areas: Inter-jurisdictional Cooperation, Regulations, Budget Instability, Standards, and Patents.

Participation by the private sector in ITS takes several forms, listed in order of increasing partnership (except for the last category), and increasing order of likely private sector investment:

- Contracting or Purchasing: This is the most common role to date of a private firm in public-private partnerships. It involves the private firm’s fulfillment of a contract for specific products or services to the government agency, with relatively low risk to the private firm.
- Shared risk: Manifests itself as a form of cooperation where the size of a consumer market may be unclear and both partners invest in providing services. Examples of this are common in the ATIS area: TravInfo channels its information distribution through value added resellers of travel information. In the Minneapolis area, the Travlink program demonstrates a complex partnership involving several public agencies (MNDOT, the local MTC, FHWA, FTA, et al.) and several private entities (Motorola, US West, et al.). The public sector develops and maintains the TIC and database using open systems, and the private companies have free rein in disseminating the information to travelers.
- Shared resources: A relationship where both partners provide the other with access to resources that they would not have outside the partnership. An example of this was granting right-of-access to a private telecommunications company to place fiber-optic cable adjacent to highways. A portion of the cabling was designated for use exclusively by the state, with the rights to sell/lease the remaining capacity.

- Joint Research & Development: This form of the partnership involves the private firm taking a short-term loss in developing technology for a specific project, with plans to recoup the losses through future sales of the resulting innovations. One example of this would be the development of specific software for new traffic control equipment for a TMC.
- Independent Private-Sector Development: There are a number of instances where the private sector is developing ITS technology independently of the public sector (e.g. vehicle route-guidance systems).

The examples cited demonstrate several important prerequisites for private-sector participation: the need for open systems to allow for the ease of private sector involvement and competition, the need for public-sector interjurisdictional cooperation to create the ITS infrastructure upon which private-sector products or services may be built, and the realization of the balance between exclusivity and competition based upon the specific project's risk-to-benefit ratios. The role of the public sector is usually one that provides supporting infrastructure, grants licenses, and minimizes the initial investment required from the private sector (based on the risk-to-benefit ratio). The traditional strength of the private sector is its ability to define markets, market the services to their potential customers, and maintain and improve service. It need not be limited to isolated firms. For example, because of the economies of scale involved in ATIS, franchises could be formed, standardizing the public-information interface.

The participation on the part of the private sector also relies strongly upon the ability of the public sector being able to provide a stable, committed, and business-friendly environment in which to invest. This requires public budget stability, streamlined contractual processes, and again, interjurisdictional cooperation. The public sector may set minimum standards, but should be aware that without incentives to develop beyond these initial standards, advances and improvements may occur at a slower pace.

It was voiced during one interview that ATIS (i.e. Smart Traveler) hasn't been as successfully implemented as it could have been, and that the public sector is slow in coming to consensus regarding deployment, and therefore the private sector is moving ahead. If true, the level of commitment desired by the private sector in public-private partnerships may become more difficult to demonstrate if the public sector is playing "catch up," or the partnership appears tentative. Some issues for further investigation are:

- How to increase the rate at which the public sector is facilitating public-private ITS partnerships?
- How to reduce the barriers to greater investment by the private sector into the ITS infrastructure?
- How does California increase the level of partnership between public and private sector entities?

In summary, increased participation and partnering by the private sector will require addressing five issues. These issues, and the corresponding research questions are:

1. Interjurisdictional Cooperation - Can local government agencies cooperate to create a predictable and business-friendly environment in which private companies can confidently invest in new ITS products and services?
2. Regulation - Can the government procurement process be modified to reduce delays and to provide rewards sufficient to justify private sector risk-sharing in public-private partnerships?
3. Budget Instability - Can local and regional governments commit to build and maintain the ITS infrastructure upon which the private sector is expected to build products and services?
4. Standards - Can "open-systems" standards be developed timely, in order to create a competitive marketplace for ITS products and services.

5. Patents - Can government contracting and standards development foster a competitive marketplace while allowing firms to develop and maintain proprietary technology that gives them a competitive edge?

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APPENDIX A: KEY STANDARDS COMMENTS FROM FOCUS GROUPS AND DEPLOYMENT SYMPOSIUM

MTC Focus Group – June 13, 1997:

Attracting users is the most difficult issue for the ISP. There will be a many to many relationship between ISPs and users. Thus, we must define compatibility to allow supersetting/subsetting between users with varied needs and varied device capabilities with ISPs with varied capabilities/specialties. Sweeney's point that the private sector should provide the bridge between local data collection and the national market. It is not important that each region prepares data in exactly the same format. Private sector can unify the data and make it available.

Procurement is the biggest issue in California.

Surveillance is key. Standards that support private sector access to the right-of-way.

MTA Focus Group – July 1, 1997:

1. Consider a model that differentiates three roles: Federal role -> provide money, Regional Agencies responsible for defining structure, and local agencies define projects that conform with the structure.
2. Project selection is based on need to get more safety and efficiency out of the system. Architecture is invisible "operating system". It can drive the agenda for interoperability and integration but it should not otherwise drive project selection. (It may also help with project scope since we have an up-front idea of the boundaries.)
3. Architecture may be reassuring to officials since it has the weight of consensus behind it.
4. "Design once, deploy many times" slogan.

California ITS Deployment Symposium - Sept. 3, 1997:

1. Standards under development may well be inconsistent due to relatively late data dictionary and message set standards (standards for standards). Without consistency, it will be difficult to determine if a variation developed for California fits with the varied standards as a result.
2. Sustained interest in connecting the four priority corridors via a common ATIS interface. California has always been interested in a statewide ATIS system. ATIS is more likely to go national than ATMS.
3. General consensus that we need to review our standards participation and make sure we are addressing the interfaces that are most important to California.
4. California is leading in ATMS in a lot of ways. There's a good presence, and there are several priority corridor things that involved CVO, but you don't hear about them because they are already ATMS and ATIS that are applicable to CVO and are applicable. It needs to be more of a nationwide effort, but the approach in the priority corridor along the Cal border is one model to be used elsewhere.
5. California's private sector system integrators, perhaps the most important contributors to center to center standards from the state's perspective, are not being subsidized to support these standards. This is an issue: they can't cover all bases, so they prioritize and support what they can.
6. The issue for California is not so much that we have California representatives at each of the standards committee meetings, but that they represent a common, understood position. We don't know what the real California position on standards is, other than we are for them, sort of...
7. We need to have performance standards – quantity, quality, timeliness; these standards are most important to the commercial market and users.

8. Some dedicated forum/resources would be required to develop a California position to be aired in the various standards committees.
9. There should be a core group identified to coordinate comments to see if we even agree in California- right now there's no mechanism
10. There is (was?) Smart Traveler funding available for standards that may be used for this purpose.
11. We could very easily build off of the Smart Traveler effort, under CAATS, to look at Standards in the states.
12. Perhaps focus this effort on promoting systems under development right now and focusing on areas not already covered by the US DOT program
13. Performance of the TMC in terms of data quality and performance may be important to the ISP.
14. If we concentrate on merging the best ideas from TRAVInfo and Showcase, this will drive the national effort-we should concentrate our efforts here first and then worry later if our focus is on national committees and working with other state programs.
15. In the evolution of deployment, if you take priority corridor, the deployments are all prototypes. You end up with the integration of things that don't fit well yet, but if you look across layers, it does fit and its something we need to do.

(Notes from Closing Summary)

16. Testbed/Center for Interoperability: Can it be amplified in some way to make it more visible.
17. Standards Development: scorecard is okay at NTCIP, but requires continued vigilance to be at the forefront.
18. Is there value to having some sort of California delegation/rapid response team that filters through these standards and can take the opportunity to figure out what our standards are in California are-a unified understanding/basis across programs that shows California is ahead of the interoperable game.

Performance standards: if you are going to connect with the consumer, the end-to-end performance of the system is very important and is not addressed by the interoperability standards under development.

APPENDIX B: POLICY LEVEL INTERVIEWS WITH KEY STAKEHOLDERS

This appendix summarizes results of policy level interviews conducted in Part I of the study. The results of these interviews, conducted in both group and individual formats, are presented next. They include interviews with CAATS Deployment Council members, Caltrans-Headquarters officials, Dean Delgado from Orange County Transit Authority, and Jeneane Prince of Rockwell.

Interview with CAATS Deployment Council

Conducted Aug. 6, 1996 by Horan, Glazer, & Sullivan at SANDAG

Introduction:

The participants included thirteen representatives from not-for-profit organizations, and two from Caltrans. A list of participants appears below.

John Cox	Southern California Economic Partnership
Ron Williams	California Trade & Commerce Agency
Blake Christie	TRW
Bruce Churchill	RMSL Traffic Systems
Bob Ratcliff	California Alliance for Advanced Transportation Systems
Kay Hanson	California Alliance for Advanced Transportation Systems
Ross Cather	Caltrans
Mike Appleby	Auto Club of Southern California
Belle Cole	PMR Group, Inc.
Jesse Glazer	CGS Research Institute
Tom Horan	CGS Research Institute
Kris Sullivan	CGS Research Institute

The purpose of the interview was to identify institutional and systems-management issues that might hinder deployment of the ITS National Systems Architecture (NSA) within California.

It should be kept in mind that focus groups are best-suited to identifying issues and exploring those issues in depth, but they are not intended to produce a representative sample of any particular population. Thus, the comments reported below should not be construed as necessarily representing; rather, they will serve as points of departure for further investigation during Part II of this California Systems Architecture Study.

The 3-hour discussion was structured around a number of topic areas: CVO, Traffic Operations, ATIS, Transit, Education, and Inter-Organizational Issues. Comments made on each of these topics are described below, following a summary of key comments.

Summary & Interpretation of Key Comments

Poorly structured infrastructure is preventing effective NSA implementation

Participants expressed that deployment is very slow; that there is no infrastructure in place. Participants recommended that there needed to be a change in the way ITS projects are programmed, implemented. One suggestion for tracking the effectiveness of ITS deployment was the creation of a deployability index.

A deployability index is intended to measure pace and effectiveness of deployment by quantifying the probability of deployment. The probability of realistically deploying ATS projects would be measured on a scale of 1-5 based on such factors such as financial, institutional and technological barriers, public and political acceptance and affordability concerns with this recommendation was voiced by Cather about who the intended audience of this type of assessment was.

Poorly defined vision is preventing effective NSA implementation

- *Participants expressed a need to better define the vision, the roles, and the responsibilities of parties involved in the California architecture. Specifically, it was recommended that Caltrans needed to be more aware of its role in defining the vision and monitoring the responsibilities of those involved in deploying NSA in California.*

Private sector moving ahead

- *Participants expressed the concern that while the public sector is not able to efficiently come to a consensus regarding deployment. The private sector is moving ahead, especially with regards to ATIS.*

Market Acceptance, First User Benefits, And Privacy

What concerns do you have about market acceptance of ITS products and services?

- *Need for a marketing slogan to promote awareness and call to action. A logo will provide an easy communication tool to identify standards.*

How is stakeholder involvement and issues related to System Architecture and Design?

- *User perspective must come first. Architecture should reflect what user services you want to implement*

Cost Benefit Allocations and Budget Instability and Liability

What concerns are there in financing public/private partnerships?

- *Barriers to private sector providing funding are liability. Don't have the ability to attract the private sector.*

Standards

Are there any gaps in NSA that lead to reduced interoperability?

- *Need for a stronger technical reference model, especially for inter-operability.*

What other needs are there?

- *Need to accelerate ITS standards. Need to publicize the standards process to industry and agencies. Need to define roles, how standards are to be accepted.*

Education and Training

What are the key education/training issues?

- *The ITS Industry is fragmented and ill-defined, particularly from the consumer's point of view. There are fragmented and/or duplicative communications efforts from multiple communities and private enterprises. There is limited "industry" visibility. There is no uniform message and there is consumer apathy.*
- *There is a need for a statewide education campaign that communicates a consistent message. Suggestions to help reach a consensus on a statewide plan include: a web site, expert teams, regional plans, a logo.*

Interjurisdictional

What can you say about the current levels of cooperation among systems?

- *Need better communication between parties.*
- *Lacking an adequate technical model for architecture. Need a stronger technical model, especially for interoperability.*

What are the roles of different policies and programs (federal, state, local, in ensuring cooperation)?

- *Need to index the problem of roles with who is responsible for what. There is a slow path to deployment in California because no infrastructure is in place. What funding sources are available.*
- *Need to shift priority in funding. Local governments need money to implement NSA.*

Policy and Process

What are key the education/training issues?

- *Statewide deployment strategy: educate industry and general public of ATS.*

4.6.2 Interview with Caltrans Officials

Conducted September 13, 1996 by Horan, Hall & Glazer in Sacramento

Introduction:

The participants included ten Caltrans staff plus one representative from PATH and one from CAATS. A list of participants appears below:

Stein Weissenberger

PATH

John Van Berkel	Caltrans-CVO
Jeff McRae	Caltrans-HQ
Jim Pursell	Caltrans-HQ
Mohamed Alkadri	Caltrans-NTRP
Jay Riley	Caltrans-NTRP
Hamed Benouar	Caltrans-NTRP
Patrick Conroy	Caltrans-NTRP
Ramez Gerges	Caltrans-NTRP
George Smith	Caltrans-NTRP
Wayne Henley	Caltrans Traffic OPS
Robert Ratcliff	CAATS
Randolph Hall	University of Southern California
Tom Horan	CGS Research Institute
Jesse Glazer	CGS Research Institute

The purpose of the interview was to identify institutional and systems-management issues that might hinder deployment of the ITS National Systems Architecture (NSA) within California.

It should be kept in mind that focus groups are best-suited to identifying issues and exploring those issues in depth, but they are not intended to produce a representative sample of any particular population. Thus, the comments reported below should not be construed as necessarily representing Caltrans policy; rather, they will serve as points of departure for further investigation during Part II of this California Systems Architecture Study.

The 3-hour discussion was structured around a number of topic areas: CVO, Traffic Operations, ATIS, Transit, Education, and Inter-Organizational Issues. Comments made on each of these topics are described below, following a summary of key comments.

Summary & Interpretation of Key Comments

NSA is Still Unfamiliar to Most Transportation Implementers

The general attitude toward the NSA seemed to be one of benign neglect. While Caltrans headquarters staff are familiar with NSA, district staff are generally not knowledgeable about it. Further, there appears to be a lack of motivation for Caltrans field staff to embrace the NSA, largely because the NSA is viewed as too non-specific. Two suggestions in the area of education of training were made to encourage more effective implementation of NSA: 1) Standards and their development should be accelerated. 2) More education and technical guidance is needed regarding implementation of NSA statewide. It was suggested that this may take the form of a “boiled down” version of the NSA or a “Design Manual” that contained more details about the NSA.

Statewide Leadership is Needed

Key policymakers statewide have not embraced the NSA specifically or ITS in general. This includes critical gatekeepers such as the directors of Caltrans and most major MPOs. Additional education at the CEO level is clearly needed, but this effort must address the vision of ITS and its benefits rather than the NSA in particular. It was felt that ITS has not been “mainstreamed”; that *integration of ITS (and NSA) into the planning process was seen as one essential step* toward this end. Further education efforts at the planning level are needed. Once again, a key issue in this process will be identifying clear benefits to drive adoption of NSA (and ITS) by planners.

ITS Architecture Issues

Although, no major conflicts were seen between the NSA and current Caltrans deployment, conflicts were seen between the NSA and the ITS deployments. ITS deployment (e.g. Showcase and early FOTs like YATI and Transcal) conflicts were found to raise architecture issues (e.g. legacy systems are limiting interoperability). Thus, *ITS architecture issues are emerging from the bottom up, rather than from the top down* as originally envisioned by the NSA. To change this situation, a “call to action” is needed, perhaps taking the form of a “state architecture” along with other motivators.

Several Inter-Organizational Conflicts are Developing

Three inter-organizational issues were identified which may conflict with the deployment of NSA: (1) CVO is pursuing an architecture defined by CVISN, which was said to differ from NSA in significant ways. (2) CARB may seek to utilize in-vehicle ITS technology for air-quality program enforcement, which could adversely impact consumer acceptance of important elements of ITS. (3) In the ATIS arena, there is evidence that the private sector may be moving ahead of the public sector and developing products/services independently. For these reasons, while the cost of technology was seen as important, institutional issues were felt to dwarf technological cost issues.

Commercial Vehicle Operations

Has NSA had an influence on CVOs?

- *NSA has not been embraced by CVOs, and they may not do so in the future.*
- *FHWA has supported two overlapping programs related to CVOs -- NSA and CVISN.*
- *CVOs are adhering more to CVISN than NSA. Major CVOs already have some advanced technology in use or being deployed.*

What is the value of tighter coupling between CVO and ITS?

- *Participants felt it would be of little value. The major markets are:*
 1. *International border crossing,*
 2. *regional (inter-city?), and*
 3. *internal to corridor (intra-city?).**The third market was felt to be most important for ITS.*

How to proceed with CVO's?

- *CVO will set their own standards; they already have a defacto standard for AVI. NSA must recognize and perhaps accept them. U.S. Customs and INS are major players, and INS has its own architecture underway, which was said to be incompatible with NSA.*

Traffic Operations (ATMS)

What is the impact of NSA on traffic operations?

- *There has been little impact so far. Little is known about NSA at the district level, and the NSA was not felt to be useful to field staff. While cost issues are important, institutional issues dwarf technological issues.*

- *Caltrans contracts require compliance with NSA, and there are no known conflicts between NSA and the TMC Master Plan. However, standards will be a key issue and development should be accelerated. Some standards exist (e.g. signal controllers). Caltrans hopes to adopt NTCIP when it is completed.*
- *ITS deployments (especially Showcase) are raising architecture issues. Legacy systems are limiting interoperability. Caltrans plans to integrate surface streets into TMCs, but the limited communications bandwidth (often 1200 baud) between TMCs and street-level controllers may limit operations to “read only”.*

ATIS

What is the driving force behind ATIS in California?

- *The early FOTs are driving ATIS (e.g. TransCal, YATI) and there are different designs in each. The key question is: “how to evolve a first-generation, statewide network.*

What are the lessons from TravInfo re: ATIS?

- *Early FOTs are driving development of ATIS. Transportation databases are distributed. ATIS value-added lies in ISPs aggregating data from these sources and delivering it to travelers. The primary value lies in freeway congestion information, secondarily in traffic (surface street) info. Caltrans is trying to develop a “business model” to guide development of ATIS.*

Any movement to integrate congestion data?

- *One person from Traffic Operations said they “will collect some data statewide”, then added that “TravInfo may have missed the boat.” (i.e. the private sector is ahead of them). Another participant stated that “Smart Traveler is still a committee; nobody is running the show.*
- *Somebody asked: “Who insures quality of data?” and someone else offered that Caltrans is “getting calls regarding quality of data (displayed) on the Internet”.*

Transit

What are the major issues with regard to transit?

- *There are two key issues:*
 1. *Coordinated dispatch, to offer door-to-door services, and*
 2. *Seamless electronic fare payment.*
- *It was observed that the NSA does not offer specific guidance on these issues beyond identifying likely communications paths between system components.*

Education & Training

What are the key education/training issues?

- *There are two key areas where substantial education efforts are needed:*

1. *Policymakers - they do not see the full value of ITS, hence, are not fully supportive. It was said that “the first step is to get buy-in for NSA from state policymakers.” This generated a comment that what is needed is “selling the ITS vision (to policymakers)”.*
2. *Implementers - many are unfamiliar with the NSA, and it expands traditional roles. One person said that we “must educate districts on the NSA and it’s importance -- boil it down to a few points.” Another opined: “The architecture expands traditional roles.” Another said he has “heard many negative things about NSA.” He continued “we need tools for design” or a “design manual” and that many implementors are “relying on consultants to apply NSA to design.” Another participant replied that “many policy and procedure issues must precede the design step.”*

Who needs to “buy off”?

- *Three individuals (policymakers) were named specifically:*
 1. *James Van Loben Sels - Director, Caltrans*
 2. *Mark Pisano - Exec. Director, So. Calif. Assn. of Govts. (MPO for Los Angeles area)*
 3. *Larry Dahms - Exec. Director, Metropolitan Transportation Comm. (MPO for S.F. Bay area)**By implication, managers of other MPOs would also need to be educated about ITS and NSA to gain their support..*

After “buy off”, where do policy decisions get made?

- *A participant said that we “must tie the Architecture into the planning process” and another added: “We haven’t mainstreamed ITS.”*
- *One participant asked rhetorically: “What are we trying to sell?” then continued:*
- *“(1) an expanded functional role, and (2) services to private industry.”*
- *One key question posed by a participant was: “What is the driver?” (i.e. what will drive the adoption of NSA by implementers?)*

Inter-Organizational Issues

How does ITS and NSA relate to environmental and pricing issues?

- *It was stated that California Air Resources Board (CARB) “will become a major player” in ITS, that CARB will want to utilize real-time information from vehicles to identify gross polluters. Another person then responded that auto makers are being pressured for “in-vehicle systems”. It was further observed that “CARB mandates differ from Caltrans.”*
- *At the end of this discussion, one person commented that we “don’t want ITS to be tied to congestion pricing”.*

How does Caltrans fit into the deployment process?

- *There was no common vision about the role of Caltrans in the NSA/ITS deployment process. One person saw ITS as “laying on top of TMCs”, and TMCs are still getting their systems up.” This implies that ITS deployment would not become a key concern until TMCs are operational. This same person continued by stating that “O&M is a huge issue, and funding generally.” Another person contributed that “We need a call to action -- Minnesota has a state architecture.” Another added “Caltrans should*

encourage state efforts in the same direction as regional efforts.” One more said he was “not sure how the state fits into the deployment process.”

4.6.3 Interview with Dean Delgado (OCTA)

Conducted by Glazer and Lohmann via telephone

Inter-Organizational Coordination

Will NSA encourage or discourage cooperation between jurisdictions and organizations?

- *The NSA provides a strategy which will require interjurisdictional cooperation. There is already some evidence of this.*
- *It will help avoid a piecemeal approach.*
- *It will encourage integration, but not necessarily interoperability*

Regulatory Constraints

Are changes needed in the government procurement process to expedite the adoption of the NSA in California? Are there other regulatory constraints?

- *Yes. The contracting process is lengthy, especially for federal moneys.*
- *Money goes from Federal to State to County. The FHWA should look for direct contracting with local governments, similar to what FTA does.*
- *On the contracting side, there are many federal constraints (precludes turnkey or design-build approach). This will probably change once standards are established.*

Standards

What is the impact of legacy and proprietary systems on NSA implementation?
In what areas of the NSA are standards most needed?

- *The standards most needed are TMC to TMC, and motorist vehicles to TMC or TIC. Both are important, but the TMC to TMC is a prerequisite.*
- *Orange County has a great deal invested in proprietary transit systems, but sees an eventual migration to an open system.*
- *100% interoperability not feasible, control issues will result in many “read only” interfaces.*

Budget Instability

Will budget instability affect implementation of the NSA?

- *It is important to have a stable funding source. Without stability, the states and regions will never fully develop an architecture. Predictability is vital.*
- *There needs to be more flexibility in the federal grant system: less focus on specific ITS aspects. Grants should be longer than 1-2 years, and not one-shot.*

Environment/Energy

Will environment or energy issues affect the implementation of NSA in California?

- *Will be issues later on, once NSA is deployed and quantitative analyses are performed.*

- *There will be different impacts depending upon the specific projects.*

First-User Benefits

“First-user benefits” refers to the initial benefits that ITS products and services provide to users and society. How might the NSA affect first-user benefits in ITS? What first-user benefits need to be showcased in order to maximize user acceptance of ITS?

- *The benefits must be showcased: local entities must know how they can benefit from ITS vs. other uses for money.*
- *Quantify the benefits, otherwise implementation will be impeded or will fail.*

Market Acceptance

Will the NSA have an impact on market acceptance of ITS in California?

- *In CA, the NSA will create a market in the private sector. CA can be in the forefront, market the technology, and thus not lose its investment, since NSA is a national issue.*
- *When the structure is defined, it broadens the “playing field,” and entrepreneurs will meet those standards.*
- *Potential for long-term benefits.*

Liability

Will the NSA create any new liability issues, beyond those inherent in ITS?

- *Greater interdependence, as created through NSA, will result in greater shared liability.*

Education & Staffing

Will the NSA create new education or staffing needs that are not already inherent in ITS?

- *ITS education has been too specific to individual needs and projects. With the implementation of the NSA, focus will broaden.*
- *Staffing may be a barrier to implementation: funding and qualified staff will be an issue.*

Privacy

Does the NSA raise any new privacy or security issues beyond those inherent in ITS?

- *Unknown: we can't tell until NSA matures. It is more of an ITS issue.*

Final Remarks

- *Must be significant buy-in from the private sector (in addition to government, of course).*
- *ITS is getting bogged down in institutional issues. Shouldn't wait ten years before implementation: implement and examine successes and failures. More flexibility is needed.*
- *Set up contingencies to manage and absorb risk, both for private and public sector.*
- *Ensure that leadership in various areas (private, public, academic) are involved and have buy-in.*

Interview with Jeneane Prince (Rockwell)

Conducted Nov. 19, 1996 by Horan & Glazer at CAATS Meeting

Inter-Organizational Coordination

Will the National Systems Architecture (NSA) encourage or discourage cooperation between jurisdictions and organizations?

It will encourage cooperation for several reasons:

- *NSA conformance is required for federal funding.*
- *It defines beneficiaries, especially local and regional*
- *It creates a common vocabulary, which helps focus on issues rather than language.*
- *A good example: using transit buses as traffic probes.*

Regulatory Constraints

Are changes needed in the government procurement process to expedite the adoption of the NSA in California? Are there other regulatory constraints?

- *Caltrans procurement process for advanced systems must be changed.*
- *Intellectual property issues are new, problematical (e.g. Travinfo)*
- *Workaround solutions have been found (e.g. SANDAG procurement instead of Caltrans)*

Standards

What is the impact of legacy and proprietary systems on NSA implementation?
In what areas of the NSA are standards most needed?

- *Legacy and proprietary systems are a problem -*
- *Showcase is developing a translator-interface “kernel & seed”*
- *NSA will create pressure to move away from proprietary interfaces.*

Budget Instability

Will budget instability affect implementation of the NSA?

- *Indirectly – rapid technology development means short life cycles, more frequent upgrade*
- *O&M costs are not fully predictable*

Environment/Energy

Will environment or energy issues affect the implementation of NSA in California?

- *Not clear at this time – suggests asking Mike Naezimi (SCAQMD).*

First-User Benefits

“First-user benefits” refers to the initial benefits that ITS products and services provide to users and society. How might the NSA affect first-user benefits in ITS? What first-user benefits need to be showcased in order to maximize user acceptance of ITS?

- *Transit productivity benefits*
- *Collected data - but how should its value be viewed?*

Market Acceptance

Will the NSA have an impact on market acceptance of ITS in California?

- *Yes, it promotes common technology (more consistent to users).*

Liability

Will the NSA create any new liability issues, beyond those inherent in ITS?

- *No new issues.*

Education & Staffing

Will the NSA create new education or staffing needs that are not already inherent in ITS?

- *Yes. It took one year to educate the parties in Showcase*
- *Many CA agencies participated in NSA development, so they have ownership.*
- *As a benefit, it gives implementers a model of the system engineering process (requirements analysis first, etc.), and it helps identify risk factors.*

Privacy

Does the NSA raise any new privacy or security issues beyond those inherent in ITS?

- *No new issues.*

Final Remarks

- *Government decision making does not always focus upon the most important issues; sometimes excessive time is devoted to questions that have minor impact. (Implication: NSA helps focus on most important issues?)*

APPENDIX C: COMMENTS AND RECOMMENDATIONS FROM THE CALIFORNIA ITS DEPLOYMENT SYMPOSIUM

Standards

FINDINGS

1. ITS is complex with many interfaces and the national ITS architecture formalizes these interfaces. Standards development is occurring at a fast and furious pace.
2. Most important California ITS interfaces have been allocated to one or more standards activities. Gaps exist in – recent highway-rail intersection additions; several minor ISP interfaces; financial institution interfaces; toll administration interfaces; weather data input; emissions interface; and several map data interfaces.
3. Current mapping will be reassessed/refined under future task order.

PARTICIPANT COMMENTS

1. One of the standards issues is the “standardization of standards.” There is a huge gap between the three dozen standards committees that have been formed in terms of definitions/meanings.
2. California has the opportunity to take the lead nationally in ATIS, such as with the Priority Corridor’s proposal to connect the four corridor systems.
3. Outside of ATIS, there is little coordination on standards nationally or in California.
4. The major problem is gaps and overlaps and being able to keep up with all that is going on between standards committees.
5. We don’t really know what the California position is other than knowing that we are in support of standards.
6. The problem with standards activities is that they operate at the lowest common denominator level, not at the cutting edge, which is why performance standards aren’t being used.
7. There needs to be a core group identified to reach agreement here in California.
8. California can drive the national standards efforts if we concentrate within the state on efforts like TravInfo, Showcase, and SmartTraveler.

RECOMMENDATIONS

1. Emphasize good system engineering processes first and staff training and RFP’s should reflect this priority. The architecture can be used to ‘rapid prototype’ some of the key early products for ITS systems.
2. California should maintain a leadership position in the application of the National ITS to take advantage of the US DOT’s continued support and pending policies and to facilitate integration of national standards into a California deployment strategy.
3. Define a tailored framework for mapping State efforts to national efforts which will provide a basis for information exchange across parallel project and standards activities and a means for managing these activities towards overall interoperability.
4. Plan incremental roll-out of new standards with schedules and cautious applications of early releases to ensure representation in efforts where California has the greatest stake.

5. Pursue testbed opportunities. A flood of new standards will arise in the next 12 months, resulting in the release of many early standards products, very few of which will have undergone substantial testing. For California implementors, the environment will be one of many proposed standards that are 80-90% stable, some of which have been substantially influenced by California. The state's interoperability testbed is well-positioned to do some of the required testing.
6. Maintain NTCIP Center to Center Participation. The four model deployment approaches in Seattle, Phoenix, San Antonio and New York are too varied to present a consensus approach. Therefore, California should prepare for a proposed standard that will use CORBA as its basis. This approach could garner additional attention for Southern California as a "showcase" for ITS deployments.

Institutional and Policy Challenges to ITS Deployment

I. REGIONAL INTEGRATION

Issue: ITS requires more integration among jurisdictions than traditional projects.

FINDINGS

1. Few institutional structures or protocols exist.
2. There are two California models for large and medium-scale interjurisdictional deployments -- Southern California Priority Corridor (SCPC) and TravInfo.
3. Problems resulted in both models from work-scope changes.
4. Integration costs exceed local benefits.

PARTICIPANT COMMENTS

NOTE: There were no participant comments at the Deployment Symposium on Regional Integration because time constraints did not allow these findings and recommendations to be presented.

RECOMMENDATIONS

1. Develop incentives, model organizational structures, and/or protocols to improve coordination. Two models in particular stand out: Southern California Priority Corridor and TravInfo. These two models provide a point of departure for creating similar organizations and both are based upon the creation of a new ad hoc coordinating body. Case studies of these two models should be prepared and disseminated.
2. To help avoid some of the problems associated with the SCPC and TravInfo: (1) Consider allowing for contracts between the federal agencies and some MPOs, for certain large projects, to improve efficiency. (2) Future funding agreements, especially for innovative projects, should provide flexibility for significant changes in work scope. (3) Caltrans procurement process needs to be streamlined.
3. Outreach and educational efforts are needed to make interoperability benefits fully apparent. Caltrans should consider offering incentives to encourage interoperability and a statewide interoperability framework should be developed.

II. ORGANIZATIONAL CAPACITY

Issue: ITS Deployment requires new skills/knowledge and organizational support.

FINDINGS

1. MPOs have not sufficiently planned/programmed ITS programs.
2. Caltrans has strongly endorsed the NSA, but has not committed enough resources.
3. There is a lack of ITS knowledge at the local level.

PARTICIPANT COMMENTS

1. The lack of organizational capacity has a lot to do with a lack of funding to maintain the systems, so why engage in them.
2. It is not cost-effective to educate everyone right away. It should be started in one area and then expanded as the market opens up.
3. These recommendations need to find their way to the top policymakers in the State. The point should be made that ITS is really just the higher end of the old TSM which needs to be re-applied conceptually. That way ITS will be viewed as a more helpful tool for future applications.

RECOMMENDATIONS

1. To reassert commitment to ITS deployment (1) Caltrans district staff should play a facilitator role with MPO's. (2) Caltrans should take a stronger role in addressing institutional issues in the next version of the ATS Program Plan. (3) Caltrans headquarters should consider allocating additional funding at the district level to ITS projects.
2. Support a comprehensive education effort including: (1) the adoption of a "matchmaker" role for education programs to identify local-agency staff who would benefit from such programs and coordinate with training providers to bring these programs to various localities across the state; (2) the establishment of a peer-assistance network through which experienced ITS implementors would be made available to assist novices, especially during the planning and design processes.

III. PRIVATE SECTOR PARTICIPATION

Issue: Private Sector Participation is lower than expected.

FINDINGS

1. Participation by the private sector in ITS currently takes at least five distinct forms: (1) Vendor/Consultant - e.g. NET, Odetics, PB Farradyne, etc.; (2) Shared Risk - e.g. TravInfo; (3) Shared Resources - e.g. fiber on public right-of-way; (4) Joint R&D - e.g. NAHSC; and (5) Mass Marketers - e.g. in-vehicle navigation systems. Size also matters for potential ITS roles. Given private sector diversity, a single strategy to increase private-sector involvement will not be effective.
2. Private sector participation relies strongly upon the ability of the public sector being able to provide a stable, committed, and business-friendly environment. Past problems include budget instability, rigid and lengthy contractual processes, and a lack of consistent policies across jurisdictions.

PARTICIPANT COMMENTS

1. Everyone has different conceptions of public and private roles such that it becomes easier for the private sector to just jump in and not deal with the public sector.

2. The private sector is having trouble finding partners, mainly because the public sector is wary of partnerships.
3. Given limited resources, if you are in the private sector you'd much rather partner with someone in the private sector than the public sector.
4. It is hard to tell if rapid deployment is really the public sector's initiative. The private sector seems to be ready to go while the public sector seems to be reluctant and confused.
5. There is a lack of consensus about the benefits of partnerships for public agencies.
6. The costs of accessing public data are prohibitive to the private sector, so the relationship isn't symbiotic.
7. The public sector is willing to participate commensurate with the level of improvement provided by the system, but is not going to fund the whole system.
8. The public sector's reluctance is not the fault of Caltrans. It has more to do with State contracting laws and regulations that need to be changed.
9. The public sector needs to become more market-driven.

RECOMMENDATIONS

1. Develop a stratified approach to recognize private sector's diversity. At a minimum, distinct strategies should be developed for each of the five major roles, with perhaps the greatest opportunities lying within categories 2,3, and 4.
2. Improve the business environment in terms of the reliability of the public commitment across jurisdictions and over time, and shorter, more flexible contracting (especially regarding proprietary rights).
3. Efforts should be made to create technically consistent, common public policies to encourage entrepreneurial consistency for public-private business agreements (for example, distribution of ATIS data to ISP's). These policies must be stratified across the five categories.