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# Developing Traveler Information Systems Using the National ITS Architecture

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16. Abstract
This is one of a series of documents providing support for deploying Intelligent Transportation Systems (ITS). This series addresses Traffic Signal Control Systems, Freeway and Incident Management Systems , Transit Management Systems, and Traveler Information Systems. The National ITS Architecture provides a common structure for deploying these systems. An important point of these documents is that you can reap operational benefits while saving staff hours and design costs by using the National ITS Architecture as a deployment guide.

This document focuses on traveler information systems, a component of ITS. It aims to provide practical help for the transportation community with deploying traveler information systems in an integrated, multimodal environment using the National ITS Architecture. ITS is the application of management strategies and technologies to increase the efficiency and safety of national, regional, and local surface transportation systems.

This document covers the basics of traveler information ITS applications (including public-private partnerships), the role the National ITS Architecture can play in traveler information system project development, the development process for a regional architecture, some challenges faced by transportation management agencies, and some best practices and lessons learned for developing and deploying advanced traveler information systems. The regional architecture will indicate how current and future systems in the region may be integrated to obtain the added benefits available through integration of these systems.


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# 1. Introduction and Summary

## 1.1 Purpose and Intended Audience

This is one of a series of documents providing support for deploying Intelligent Transportation Systems (ITS). This series addresses:

- Traveler Information Systems
- Traffic Signal Control Systems
- Freeway and Incident Management Systems
- Transit Management Systems

The National ITS Architecture provides a common structure for deploying these systems. An important point of these documents is that you can reap operational benefits while saving staff hours and design costs by using the National ITS Architecture as a deployment guide.

### 1.1.1 Intended Purpose

This document focuses on traveler information systems, a component of ITS. It aims to provide practical help to the transportation community with deploying traveler information systems in an integrated, multimodal environment using the National ITS Architecture. ITS is the application of management strategies and technologies to increase the efficiency and safety of national, regional, and local surface transportation systems. Intelligent Transportation Systems form the basis for a new way of doing business in addressing the nation's surface transportation needs. Rather than solving transportation challenges solely by building additional roadway capacity, ITS strategies strive to use roadway facilities more efficiently by applying technology and effective management strategies to collect, transfer, process, and share historic and real-time transportation information. This includes the use of computer, communications, sensor, information, and control technologies and a structured approach to manage the planning, development, deployment, operations, and maintenance of ITS systems and projects. Traveler information systems can be enhanced by promoting innovative public/private partnerships, which involves leveraging of the resources from both sides of these partnerships to mutual advantage.

This document is designed as a guide for how the National ITS Architecture can be used in the process of designing, developing, and implementing effective traveler information systems. Development of the National ITS Architecture arose out of a need to provide a common framework for deployment of ITS across the nation. The National ITS Architecture contains the information you need to develop a regional architecture, to be assured you haven't overlooked anything important, and to ensure you are preparing an efficient deployment. This document shows how to enhance existing and emerging traveler information systems, facilitate design and upgrade of future systems, and help overcome challenges commonly faced by transportation agencies involved in the delivery of traveler information systems. This document covers the basics of traveler information ITS applications, the role the National ITS Architecture can play in traveler information system project development, the development process for a regional architecture, and some best practices and lessons learned for developing and deploying traveler information systems. The regional architecture will help to indicate how current and future systems in the region may be integrated to obtain the added benefits available through integration of these systems.

### 1.1.2 What is the National ITS Architecture?

The National ITS Architecture defines the components of the surface transportation system, how they interact and work together, and what information they exchange to provide 30 ITS user services. These 30 user services have been identified by the U.S. ITS community as part of the National ITS Program to guide the development of ITS and are listed in Section 2. A key requirement for development of the National ITS Architecture [FHWA, January 1997] was that it include the transportation functions necessary to provide the 30 user services.

Using the National ITS Architecture will save implementers time and money because it contains much of the up front analysis and planning information necessary to deploy ITS, including project definition and requirements, information exchange requirements, system evaluation criteria, cost development information, communications analysis, and benefits of deployment of specific ITS applications.

### 1.1.3 Intended Audience

The intended audience of this document includes:

- Mid-level administrators and transportation engineers for state and local transportation agencies involved in planning, designing, implementing, operating and maintaining transportation management systems, including the ITS components that can interface with and provide information to traveler information systems.
- Transportation professionals and others interested in understanding traveler information systems challenges and solutions based on the Architecture.
- Managers, transportation engineers, and system engineers in private enterprises with interests in working with public partners with an objective to establish and operate traveler information systems.

If your work involves planning, designing, implementing, operating or maintaining traveler information systems or transportation management systems, and you perform one of the following functions within your organization, this document is intended for you:

| | |
|---|---|
| Regional Transportation Planning | Project Planning and Development |
| Traffic or Transit Operations, Maintenance | Traffic or Transit Engineering |
| Public/Private Partnerships | Project Management |
| Project Implementation | Project Approval |
| Preliminary and Final Analysis and Design | ITS Project Definition |
| Procurement of Services and Equipment | Project Acceptance Testing |
| Project Evaluation | |

## 1.2 Traveler Information Systems

Effective traveler information systems are multimodal and support many categories of drivers and travelers. They apply many technologies to allow customers to receive roadway, transit network, and other information important to their trip. This information assists the customers in selecting their mode of travel (car, train, bus, etc.), route and departure time. Transit schedule and status information may be obtained from Transit Management Systems. Most of the roadway-based information is collected by surveillance equipment (vehicle detectors, cameras, automated vehicle location systems) and is processed by computers in transportation management centers for further distribution to traveler information systems. Other information used in a traveler information system may be static in nature, such as; map databases, emergency services information, and information on motorist services and tourist attractions and services. The technologies for requesting, receiving, and interacting with all of this information can be based in the home, office, passenger vehicle, commercial vehicle, transit vehicle, public transit station, or in the case of personal communication devices, can travel with a person.

### 1.2.1 Traveler Information System Functions

Effective traveler information systems provide multi-modal trip planning, route guidance, and advisory functions for travelers and drivers of all types. They also may enable travelers to confirm and pay for services and may include personal emergency notification capabilities. Trip planning information and assistance may be provided pre-trip or en-route. Pre-trip planning assistance provides travelers with roadway information, including road condition, traffic information and travel times, and transit information which can be used to select route, mode, and departure time. This support may be requested from home, the workplace, park and ride facilities, transit stations, and other locations. En-route traveler assistance provides the traveler with roadway and transit information while traveling, including traffic information, roadway conditions, transit information, route guidance information, and other information such as adverse travel conditions, special events, and parking.

Below are descriptions of the top level functions performed by advanced traveler information systems.

- Multi-Modal Trip Planning - provides region wide information and assists trip planning by travelers including private car and traditional transit modes, plus rideshare matching and reservation and demand responsive transit reservation. Links to information and reservation services may enable travelers to include heavy rail and airlines as part of their trip planning.

- Route Guidance Services and Information - autonomous or dynamic (supported with real-time information) modes of on-line guidance provide route planning and turn-by-turn directions and other navigation assistance. Current roadway link travel times may be provided directly to drivers, allowing selection of routes to avoid the worst congestion or other adverse conditions.

- Advisory Functions - advisories may include incident warnings, delay notifications, anticipated travel times to destination (accounting for real-time conditions) and to next intermodal connection (e.g. transit stop), adverse travel condition advisories, intermodal connections and schedule adherence, CVO restrictions (height, weight and hazmat), parking information and status, identification of next few transit stop locations (if on transit), upcoming tolls, etc.

- Interfaces with Traffic Management Systems in the region to obtain traffic, incident, and roadway information on both freeways and arterials and with Transit Management Systems in the region to obtain transit information, including schedules and status. This information may be augmented with additional surveillance information and information from numerous other sources.

### 1.2.2 Characteristics of Effective Traveler Information Systems

Interviews with traveler information system operators and travelers have identified some key features of effective traveler information systems. Effective traveler information systems:

- Provide information that is timely, accurate, reliable, relevant to making travel decisions, and marketable.

- Provide information for the entire region. This requires the participation of public agencies across jurisdictional boundaries.

- Operate with efficient, well-trained staffs.

- Are integrated easily with other ITS systems—emergency management, freeway management, traffic signal control, and transit management—to obtain adequate traveler information.

- Are easy to use and easy to access by the traveling public.

- Are easy to maintain (with in-house or contract resources) and do not require excessive costs and time to operate. Ideally, traveler information components need to be interoperable between different manufacturers and vendors. This reduces maintenance costs and provides added flexibility in repairing equipment faults and malfunctions, finding spare parts, and developing system upgrade paths.

- Provide services that are affordable to end users.

### 1.2.3 Benefits of Traveler Information Systems

In general, each traveler information system must be designed to meet the specific social and political objectives of each community. Many traveler information systems strive to achieve the following:

- Promote the choice of travel mode based on real time and accurate status.
- Reduce intermodal travel times and delays for individual travelers.
- Reduce traveler stress for trips to unfamiliar destinations.
- Reduced crash risk and fatalities (e.g. reduced driver distraction in unfamiliar routes).
- Reduce overall system travel times and delays.
- Reduce system costs through public-private partnerships.

Traveler information systems have demonstrated benefits in several areas including travel time, consumer satisfaction, system throughput, on-time performance, and environmental impacts. In addition, they have been shown to reduce congestion and the number of accidents on roadways. Table 1.2-1 summarizes the range of traveler information system benefits as reported by the U.S. Department of Transportation [Mitretek, 1997].

**Table 1.2-1. Summary of Traveler Information System Benefits**

| | |
|---|---|
| **Crash Risk** | Decreased driver stress, Predicted reduction: 4% to 10% |
| **Fatalities** | Decreased with fast EMS response - GPS fix & route guidance |
| **Travel Time** | Decreased by 4% to 20%, more in severe congestion |
| **Throughput** | Simulations show 10% increase resulting from real-time traffic information receivers in 30% of the vehicles |
| **Delay** | Savings up to 1,900 v-h peak hour, up to 300,000 v-h annually |
| **Emissions estimates** | Decreased HC emissions by 16%–25%<br>Decreased CO emissions by 7%–33% |
| **Customer Satisfaction** | Less Stress Perceived; Wireless comm. to emergency center yields perception of heightened security from 70% to 95% |

### 1.2.4 Challenges Facing Implementers of Traveler Information Systems

Today, many public sector transportation agencies are incorporating some traveler information capabilities into their ITS systems to provide their users (drivers and other travelers) with regional transportation information. In addition, the private sector is entering the business of providing traveler information services for a fee. And it is important that private investment be encouraged to leverage available public resources. Of course, the availability of free traveler information will impact a customer's willingness to pay for fee-based traveler information services. Thus, exploration of public-private partnerships are a must for delivery of value-added traveler information services. Various partnership forms can encourage private partner participation in traveler information system deployment, testing and then into operation. In these traveler information partnerships, the major public and private partners have important contributions of complimentary interests, strengths, skills, and products, giving a balanced partnership and resulting in benefits to each. In some of these partnerships, startup economic aid may be provided by public agencies. Further discussion is provided in Sections 2 and 4 on the topic of Public-Private Partnerships.

The private sector, as an information service provider (ISP), is generally expected to collect basic traveler information from public agencies, supplement it with additional information, process and combine it for presentation in useful ways and for use in derivation of information to provide added services such as providing routes and route guidance directions. The information and services are provided to users, with some products and services provided for a fee, and others paid for by advertising. Agency agreements, and the definition, development, and integration of all the necessary interfaces will pose some challenges. The National ITS Architecture, by defining the necessary interfaces and information flows between systems, provides a framework for this operational cooperation between systems to occur. It is important to enlist all major stakeholders in the region into these partnership agreements.

Although the technology for generating and providing sophisticated traveler information services exists, the marketing of these services is new. Perhaps the marketing of Internet-related products will offer a model. Like the Internet, traveler information services depend on computers, communications and networking technologies, usefulness of the products, and the willingness of the public to pay for the necessary personal equipment (e.g., in-vehicle devices and personal digital assistants) and for the associated services.

# 1.3 The National ITS Architecture Can Help You

## 1.3.1 Help for ITS Planners and Implementers

Similar to a model home blueprint, the National ITS Architecture provides a common structure for the design and implementation of ITS. The National ITS Architecture defines the functions (e.g., gather traffic information) that must be performed by components or subsystems, where these functions reside (e.g., roadside, traffic management subsystem, in-vehicle, information service provider, etc.), the interfaces and information flows between subsystems, and the communications requirements for the information flows (e.g., wireline or wireless). Just as the model home design is often changed to meet the needs and living space requirements of individual families, the common structure provided by the National ITS Architecture can be tailored to meet a region's unique transportation needs.

In addition, the National ITS Architecture identifies and specifies requirements for standards needed to support national and regional interoperability, as well as product standards needed to obtain a plug and play capability to yield economy of scale considerations in deployment. These standards will include the formal definition of the physical interfaces and information exchange requirements of the National ITS Architecture.

***A lot of time and effort went into developing the National ITS Architecture—for a very good reason—to make the process of designing and implementing these systems easier for you.***

***YOU CAN SAVE STAFF HOURS AND ENGINEERING DESIGN COSTS BY USING IT.***

An agency using the National ITS Architecture can save time and money in the development of a project from its inception through its implementation. Some capabilities of the National ITS Architecture that will be particularly important to your development of an effective traveler information ITS application are listed below.

- Correlates services and requirements to subsystems and data flows, thus providing traceability for a project to the selected architecture.
- Illustrates the benefits that can be obtained through efficient grouping of ITS functions plus sharing of information for multiple purposes across the transportation system, avoiding redundancy and saving money.
- Provides a view into the future to identify services and functionality that may not have been initially considered, currently needed, or even feasible. This provides a checklist of future capabilities that could be planned for now in anticipation of future needs. Planning for these future needs in database and interface designs will save substantial costs of modifications needed for these later additions.
- Provides an extensive list of the transportation agencies (by matching the functions they perform with the corresponding subsystem names in the National ITS Architecture) that you should consider talking to during initial planning of an implementation (i.e., the stakeholders).
- Defines the kind of information that may be available from or obtainable by agencies and that one should consider sharing with these agencies. You can use this information as a checklist in planning the traveler information project and in discussions with other stakeholders to show how they can participate through sharing of the information.
- Serves as a good starting point or template (which can be tailored) for developing the regional architecture that will drive the designs for specific projects. Starting with the National ITS Architecture, one can merely delete the functions and information flows that do not apply and then incorporate any specific local requirements and considerations. This is more fully addressed in Section 3.
- Provides a departure point for developing functional requirements and system specifications to be included in a procurement package, including identification of the interfaces (some of which may have approved standards or standards work under way) and data exchanges that must be included.
- Provides ballpark estimates of costs for a wide range of ITS-related equipment and services that can be considered for initial project costing.
- Can support a check on the product being provided by a design contractor (if the contractor is asked to demonstrate the use of the National ITS Architecture and its relationship to the design being offered).

For many of the reasons stated above, the National ITS Architecture can serve as a good starting point for developing a *regional architecture* in the transportation planning arena. A regional architecture which responds to a wide range of stakeholders and to local transportation needs and problems can serve as a guiding framework for coordinated development of ITS within a region. This will evoke the discussion of operations roles and responsibilities, phasing considerations for planned ITS enhancements, and regional agreements on technology and standards.

**Using the National ITS Architecture and ITS standards will provide broad, long term benefits:**

- ***Interoperability:*** The National ITS Architecture has identified where standards are needed to provide a sound foundation for system interoperability (interfaces and products). Because the National ITS Architecture is serving as the common foundation for ongoing ITS standards development work, factoring it into your current system enhancements will facilitate the transition to a standard interface definition in the future. Using standard interfaces will provide for national and regional interoperability and even interchangeability of some devices used in ITS traffic management, even though they may be from different manufacturers.

- ***Increased competition:*** By requiring use of open standards (non-proprietary), multiple vendors will be able meet the standards and be able to respond to RFPs. Support and upgrades will also be available from multiple potential sources, avoiding the problems of being locked in to one source (e.g., the vendor goes out of business).

- ***Future expandability:*** By designing within a common framework and using open standards, you will create an environment that integrates legacy systems with new ITS applications and allows more functionality to be added as needed.

- ***Lower costs:*** ITS equipment and device compatibility will create larger total markets attracting more suppliers resulting in more capable products at lower prices. The resulting long-term costs of deployment will be pushed down by these economies of scale for off-the-shelf ITS equipment and products and by competition through open-system enabling of multiple vendors.

- ***Increased transportation system integration:*** The open nature and structure of the National ITS Architecture and use of standards-compliant components will make integration of complex traffic management components and regional systems easier. Improved integration of systems operated by different agencies will permit effective information sharing and more effective use of resources. Seamless traveler services across agency lines will become a reality.

- ***Assistance in project development and regional planning activities:*** As evidenced from the above discussion, the National ITS Architecture can be usefully applied to both project development and longer term regional planning activities. Accordingly, this document will address these activities in two separate sections for clarity and ease of reference for the reader.

### 1.3.2 ITS Standards

Using the National ITS Architecture to plan, design, deploy, and integrate traveler information systems will help ensure that your system will be compatible with existing, planned, and future systems in your region. Your traveler information system will also have an open systems architecture, use industry-accepted standards and interfaces wherever they exist, and will minimize reliance on proprietary information, interfaces, and protocols. Ultimately, these standards will promote national interoperability of some key services to ensure that travelers from outside your region will also be able to benefit from the ITS services you provide. Consistent with the National ITS Architecture, the U.S. DOT is supporting and guiding development of selected ITS standards by funding Standards Development Organizations (SDOs).

# 1.4 Document Organization and Summary

## 1.4.1 Document Organization

This document is divided into five major sections with the content of the document as illustrated in Figure 1.4-1.

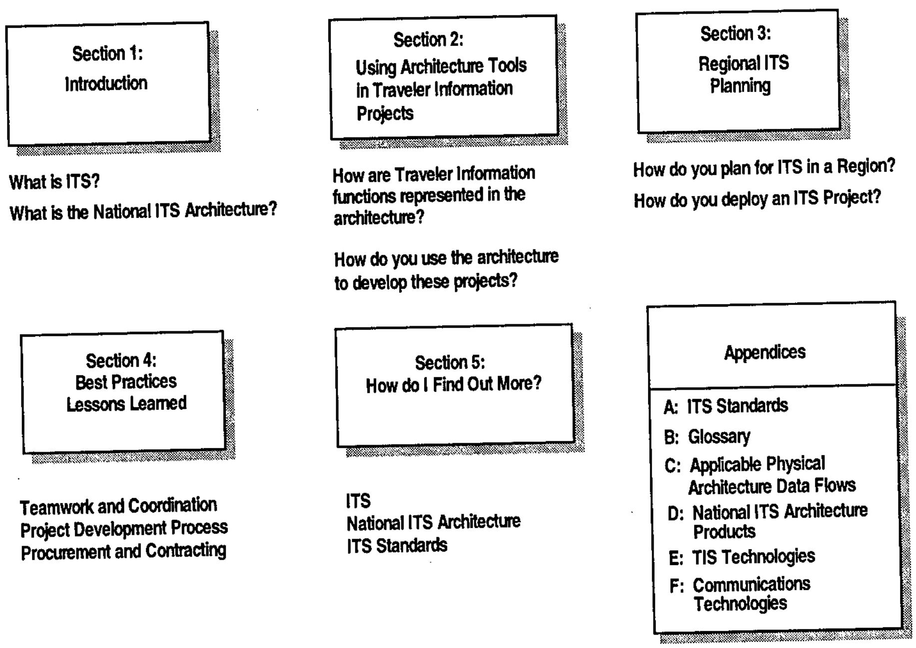


**Figure 1.4-1. Document Organization**

## 1.4.2 Document Summary

This document covers many important areas and you are encouraged to read the entire document. However, if you are unable to do so, the summary presented below will point you in the direction to find the information you are seeking.

**For example:**

- If you are beginning a major traveler information system project, proceeding to review Sections 2 and 4 might be best.
- If you are involved in long-term planning of your regional transportation system, starting your review with Section 3 might be best.

## Section 1: Introduction and Summary

Section 1 briefly discusses ITS, the National ITS Architecture, benefits of traveler information systems, some challenges facing implementers, traveler information system functions, and briefly discusses capabilities provided by the National ITS Architecture and why you should use it.

- ✓ ITS uses a combination of management strategies and computer, communications, surveillance, and control technologies to increase the efficiency of national, regional, and local surface transportation systems.
- ✓ There are a growing number of successful ITS traveler information system projects yielding some very encouraging benefits.
- ✓ The development of traveler information systems faces many challenges, best addressed from the vantage point of public/private partnerships involving representatives of all transportation agencies, of elected community representatives, and of all agencies that might benefit from or need the support of timely distribution of traveler information to a broad community, including both broadcast and route oriented distribution.
- ✓ Using the National ITS Architecture as a tool in developing your traveler information systems will help provide for ease of additions of interfaces to future subsystems.
- ✓ The Architecture supports integration of surface transportation systems. This includes, for example, the integration of traveler information systems with traffic signal control, freeway management, incident management, transit management, highway-rail coordination, and parking management systems.

## Section 2: Use of the National ITS Architecture Tools in Traveler Information Projects

Section 2 identifies the functions of traveler information systems as defined by the National ITS Architecture. The section then explains how the Architecture can be used to develop ITS traveler information applications. Some representative scenarios are used as examples to help you use the National ITS Architecture.

- ✓ Traveler information is collected by various types of surveillance equipment, is usually processed by computers, and may be distributed as pre-trip and/or en-route information. Very briefly summarized are the basic types of information dissemination systems and the many visual and audio dissemination technologies that may be employed. Technologies and communications are described further in appendices.
- ✓ Public-private partnerships are discussed from the perspective of Traveler Information Business Models. The complimentary nature of traveler, private sector and public sector resources, motivations, expectations and benefits is described. Roles are described as public, private and public-private partnering and a few important institutional/legal issue areas are described
- ✓ The National ITS Architecture provides a common structure for the deployment of ITS; it defines 19 interconnected physical subsystems, the transportation functions each subsystem performs, and the information subsystems exchange with each other to provide 30 user services.

- ✓ The functions associated with traveler information systems reside in many subsystems of the National ITS Architecture including the center subsystems (such as the Information Service Provider Subsystem), vehicle subsystems, roadside subsystems, and traveler subsystems (such as the Personal Information Access Subsystem and the Remote Traveler Support Subsystem).

- ✓ The National ITS Architecture can be applied to most project development steps, and is particularly helpful in the identification of solutions and the planning and design of the solution.

- ✓ The Architecture only defines the functions that each physical subsystem performs plus the interfaces and data flows between them. Designers have complete freedom in deciding which functions are required for their needs, what equipment to use to implement the selected functions, and what technologies will be used. Designers are encouraged to be compatible with the Architecture and with ITS standards to achieve interoperability, to provide for future enhancements and expandability, and to obtain the long-term benefits of higher quality and lower costs from expanding market and competition economies of scale.

## Section 3: Regional ITS Planning

Section 3 describes planning for ITS applications and formulating ITS projects in a regional context.

- ✓ Using the National ITS Architecture provides a good starting point for developing a regional architecture in the transportation planning arena.

- ✓ Involving comprehensive representation of regional transportation stakeholders in developing a regional architecture to address needs and problems can produce broad cooperation.

- ✓ Developing a regional architecture can guide development of ITS within a region and produce agreement on roles and responsibilities, phasing considerations for the most effective implementation of planned ITS capabilities, and regional agreements on technology and standards thus promoting interoperability and higher levels of benefits.

## Section 4: Lessons Learned / Best Practices

Section 4 provides advice on developing and implementing traveler information projects using lessons from agencies that have developed and implemented ITS systems, or are currently developing and implementing ITS projects, plus lessons and best practices information from relevant areas of other civil and defense technology projects. Information is provided on various topics in ITS relevant to the deployment of traveler information systems.

- ✓ Stakeholder involvement and coordination, plus teamwork and selecting the right project staff may be the keys to success on any ITS project. This is even more true in traveler information projects, since the TIS needs to interface with all systems having information relative to traveling in the region and special relationships between the public and private parties must be defined and made to work.

✓ Fundamental steps used by transportation agencies in the formulation and implementation of projects involve assessing problems or needs, the search for, analysis of, and selection of a solution, design of the project, and finally, the funding, procurement and implementation. These are the same process steps described in Section 2.

✓ Transportation agencies face many impediments in the procurement and contracting of developing projects, as procedures, controls and measures which have been put into place over the years for construction projects have had to be accommodated. However, there is some relief for these impediments. This section sheds some light on the more common problems that have been experienced, and some of the lessons that experience has provided.

**Section 5: How Do I Find Out More?**

Section 5 shows readily accessible places to find additional information on traveler information systems, ITS, the National ITS Architecture, and ITS Standards.

**References**

These references pages provide a brief listing of references that may be important to those involved in any of the key roles or activities involved in planning, development and deployment of a traveler information system.

**Appendices**

Finally, this document contains six appendices: Appendix A discusses ITS Standards; Appendix B provides a Glossary; Appendix C presents the Physical Architecture Data Flows associated with traveler information systems; and Appendix D is a synopsis of each of the 16 volumes that make up the National ITS Architecture documentation. The remaining two appendices, Appendices E and F, provide some background on traveler information and communications technologies, respectively.

✓ ITS Standards described in Appendix A are those applicable to traveler information systems. ITS standards have been and are being developed to support the integration of transportation systems. ITS standards should be used to help ensure interoperability of ITS subsystems and devices plus interchangeability of like devices.

✓ Physical Architecture Data Flows listed in Appendix C indicate the information that is intended by the National ITS Architecture to flow across interfaces of traveler information systems with other transportation systems in the region, including traffic signal control systems, freeway management systems, and transit management systems.

# 2. Use of the National ITS Architecture Tools in Traveler Information Projects

## 2.1 Overview

This chapter presents the details of how the National ITS Architecture can be applied to traveler information system project development activities. An overview of traveler information systems and a general project development process is presented first to establish the context for this chapter. Next, the key concepts of the National ITS Architecture are discussed to ensure that the reader understands the fundamentals and structure of the tool. The following section then shows how to apply the National ITS Architecture concepts and databases to the various steps presented in the general project development process. Lastly, two project application scenarios are presented which use realistic examples to illustrate the points made in the previous sections.

## 2.2 Traveler Information System Applications

This section provides an overview of the various traveler information services and technologies, a discussion of the key requirements and characteristics of effective traveler information systems, and a discussion of the very important topic of public-private partnerships in the delivery of traveler information.

### 2.2.1 Overview

Traveler information technologies allow travelers (and soon-to-be travelers), to receive roadway and transit network information. There are two basic categories of traveler information: pre-trip and en-route. These categories and the type of information provided under them are based on when information is obtained relative to the start of a trip.

#### 2.2.1.1 Pre-Trip Traveler Information

Pre-trip planning systems provide travelers with roadway and transit information which can be used to plan a trip, including which route to take, what transportation mode to choose, and what time to depart. Whether provided to travelers at home, the workplace, park and ride facilities, transit stations, or intermodal locations, pre-trip traveler information can help relieve congestion by allowing travelers to make informed decisions—for example, to reroute, delay start of the trip, shift modes, or avoid travel altogether. Pre-trip traveler information also supports itinerary planning, which can provide information on the entire trip from one point to another, even if it involves multiple modes.

In providing pre-trip traveler information, the focus is on travel behavior and decision support. This requires providing accurate and timely information to travelers before their trip. Touch-tone telephones, personal computers, pagers, personal digital assistants (PDAs), kiosks, and automated data retrieval systems which augment existing human-operator interfaces have the potential to substantially improve the accessibility of traveler information, thus influencing traveler behavior.

Transit agencies, in particular, have made great strides in decreasing the time a customer has to wait to obtain travel information. As an example, telephone call-in can provide detailed information such as the closest transit stop to the caller's origin, directions to a stop, the closest stop to the caller's destination, detailed directions on transit between the origin and destination stops, and directions to the final destination from the last stop. Automation has led to a greater amount of information being provided in less time to travelers, and in most cases at a reduced operating cost.

### 2.2.1.2 En-Route Traveler Information

En-route traveler information can provide the traveler with roadway and transit information while traveling. Information is typically provided using roadway devices, devices at transit platforms and stations, and devices mounted within vehicles, be they automobiles, buses, or trains.

Along the roadway, variable message signs and highway advisory radio messages provide information regarding traffic congestion, incident and construction locations, weather advisories, and special events which may impact travel on a particular section of roadway. Dashboard devices can provide a variety of en-route traveler information to both the traveler as well as transportation providers. Active warning systems can alert motorists of an impending adverse or potentially dangerous travel condition, such as a sub-standard curve or the low clearance of a bridge located en-route. Sophisticated route guidance systems can assist motorists in route planning as well as provide timely directions via a computer-synthesized voice, graphics, or some combination. Finally, new radio advisory systems can override standard radio broadcasts to provide real-time traveler information, such as the location of an incident to motorists.

Within transit networks, en-route information can include the expected arrival of the next vehicle and the route identifier (provided at station stops); or the next stop and anticipated time of arrival (provided within the transit vehicle).

### 2.2.1.3 Traveler Information Technologies

Most traveler information is collected by surveillance equipment (vehicle detectors, cameras, automated vehicle location systems), and is processed by computers in a transportation management center for distribution using audio and visual technologies. These technologies can be based in the home, office, passenger vehicle, transit vehicle, public transit station, or in the case of personal communication devices, can travel with a person. These technologies are summarized in Table 2.2-1.

Descriptions of these technologies are included in Appendix E, and a short discussion of applicable communication alternatives is included in Appendix F. In addition, the National ITS Architecture team conducted an in-depth survey of communications technologies—this survey is included in the *Communications Analysis* document of the National ITS Architecture.

**Table 2.2-1. Traveler Information Technologies**

| Type of Information | Type of System | Visual Dissemination | Audio Dissemination |
|---|---|---|---|
| Pre-Trip Information | Computer Based Systems | • Internet<br>• Electronic Bulletin Board Services<br>• Videotex | • Internet-based broadcasts |
| | Telephone Based Systems | • Technology not currently applicable | • Traveler Advisory Telephone |
| | Television Based Systems | • Broadcast Television Media (ISP)<br>• Teletext<br>• Cable Television<br>• Interactive Television | • Audio is broadcast with most television based systems |
| En-Route Information | Roadway Based Systems | • Variable Message Signs | • Highway Advisory Radio |
| | In-Vehicle Systems | • Active Warning Systems<br>• Route Guidance Systems | • Radio Data Systems (FM Subcarrier)<br>• AM and FM Radio (Broadcast) |
| | In-Transit Vehicle Based Systems | • Message Boards | • Automated Annunciation Systems |
| | Station Based Systems | • Kiosks<br>• Display Monitors<br>• Message Boards | • Public Address Systems |
| | Personal Based Systems | • Personal Digital Assistants (PDAs)<br>• Pagers | • Technology not currently applicable |

## 2.2.2 Traveler Information Requirements and Characteristics

### 2.2.2.1 Traveler Information Requirements

Traveler information, both pre-trip and en-route, can be categorized as either static or real-time. Static information may be defined as known or planned events which change relatively infrequently, while real-time information may be defined as the most current available information at a given point in time. Real-time information differs from static information in that it continually changes based upon a wide variety of events.

**Static Information**

Static traveler information, much of which can be considered pre-trip in nature, includes:

- ✦ Planned construction and maintenance activities which reduce the number of travel lanes along a section of roadway, or impact the frequency and/or travel time of transit service.

- Special events which generate significant increases in traffic that can impact travel along specific roadways, and sections of roadways.
- Toll information (cost, payment options).
- Transit information (fares, schedules, fare purchasing options, routes).
- Intermodal information (connections, services).
- Commercial vehicle regulations (height and weight restrictions, hazardous materials).
- Parking information (locations, cost).
- Yellow Pages information (services, tourist attractions, lodging, food, etc. available at destination).
- Directions to destination.

**Real-time Information**

Real-time information can be distributed both pre-trip and en-route. As an example, incident information is just as important to travelers who routinely check current conditions along their normal commuting route, prior to starting their trip, as it is to motorists currently traveling along the route where the incident has occurred. Real-time traveler information desired by travelers include:

- Roadway travel conditions associated with travel delay, such as congestion, locations of queues, and incident locations.
- Potential alternate routes which can facilitate travel, particularly in the event of a temporary roadway or transit line closure.
- Weather advisories detailing snow, ice, and fog which can impact travel.
- Transit schedule adherence.
- Park-and-ride and parking lot status (space available/not available).
- Anticipated travel time to destination (accounting for real-time conditions).
- Identification of the next stop on a train or bus.

### 2.2.2.2 Traveler Information Characteristics

Interviews with operators and users of traveler information systems have been used to define the following important characteristics of travel information:

- **Timely, Accurate, and Available.** For travel information to be useful, it needs to be current and received in time to allow a user to act on it (e.g., route, mode, time). Travelers also want and need to know that the travel information is correct, whether it concerns the arrival time of the next train or the location and severity of traffic problems. Finally, potential users want information to be available when needed, and be consistent in quality (as measured by its accuracy, timeliness, and relevance to travelers' trip needs).

- **Cost Effective.** Consumers will pay for timely and accurate traveler information (and associated products and services) which is relevant, helps save time, and is provided at a reasonable cost.
- **Provides Route and Decision Guidance.** Traveler information must contain sufficient detail – about locations, times, and possible alternates – to be useful in planning travel, or to allow en-route adjustment of plans.
- **Easy to Access and Easy to Use.** Traveler information should be accessible in a variety of forms and locations – in-vehicle, personal devices, kiosks, home computer — and be easy to use, since users perceive access time as an additional cost associated with using traveler information.
- **Safety Implications.** The extent to which traveler information can help users to avoid a dangerous situation, or to feel protected in the event of a bad accident or other emergency, is very important. Another safety consideration is the degree to which accessing in-vehicle information may cause a distraction for the driver.

### 2.2.3 Public-Private Partnerships

An extremely important issue in defining and developing traveler information systems is that of public-private partnerships, and the respective roles of public agencies and private firms in implementing, operating, and maintaining these systems. While a major thrust of ITS is to stimulate these partnerships, the nature of public-private partnerships is still evolving. This excerpt from *Shared Resources: Sharing Right-of-Way for Telecommunications* offers the following:

> *Public-private partnership agreements define how the project will be set up and includes choices related to the form of property right, exclusivity, geographic scope, social issues, and procurement considerations.*

General agreement between public and private partners may take the form of a legal written document or memorandum of understanding, stating how partners will cooperate to deliver products, services and information to the public.

#### 2.2.3.1 Business Plans

Business plans are used to define and structure the public/public and public/private partnerships that are needed to build, operate, and maintain the traveler information system. They define the roles and responsibilities of the public and private sectors, the structure of the relationships between partners, and the financial plan to be applied to the TIS.

Business plans will shape how the traveler information business emerges in your area. A top-level view of a business plan is shown in Figure 2.2-1.

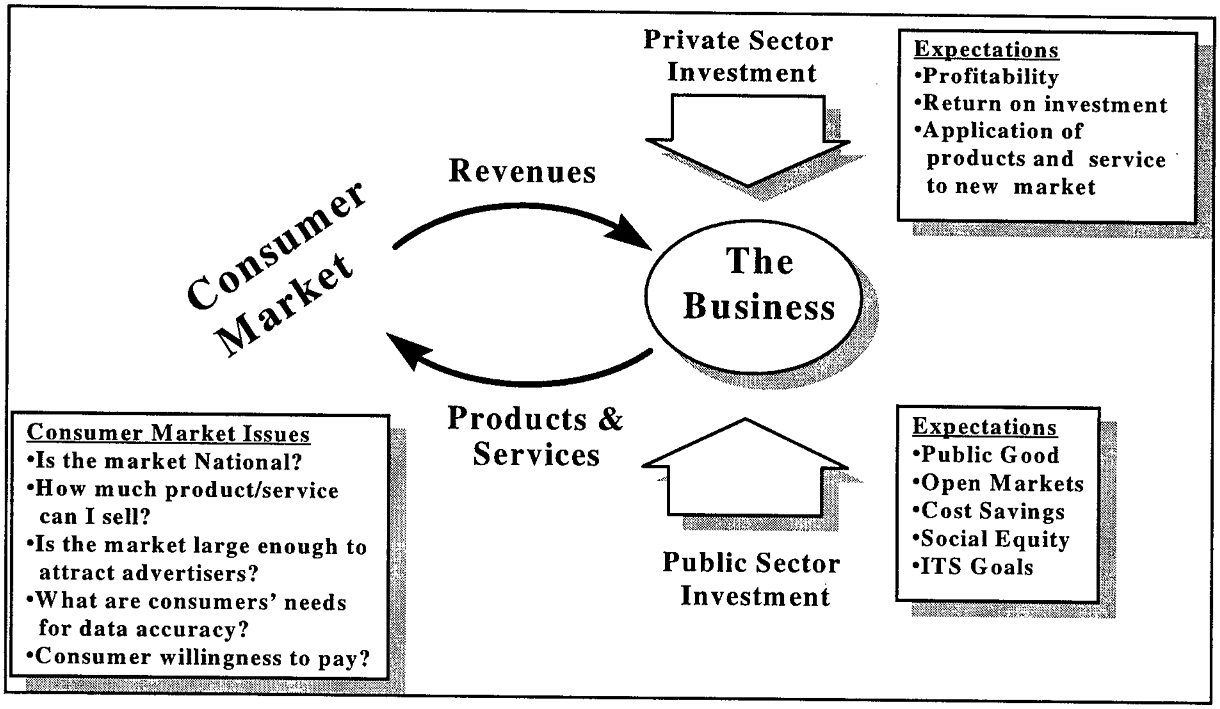


**Figure 2.2-1. Top-Level View Of A Traveler Information Business Plan**

Figure 2.2-1 illustrates three primary forces that shape the traveler information business. They are:

1. Consumer Demand and Willingness to Pay — generally based on the perceived value of traveler information.
2. Private Sector Expectations — shaped by profitability, return on investment, and market size.
3. Public Sector Expectations — shaped by the goals of ITS (efficiency of transportation, improved air quality, etc.), public policy, and social interests.

Technology also plays an important role in defining what products and services can be delivered in the market place. To date, significant investment in field equipment, algorithms, map technology, in-vehicle devices, personal information devices, and communications have placed traveler information systems on the brink of popular demand. In addition, field operational tests sponsored by the U.S. DOT have helped to establish an environment where technologies can be tested and refined.

### 2.2.3.2 Consumer Market And Willingness To Pay

This element of the business model covers the consumption side both in terms of potential consumer products and the demand for traveler information itself. For the purposes of this discussion, we will focus on three areas (or consumer market segments).

- ✦ Commercial Traffic Reporting Agencies
- ✦ Autonomous and Advisory Traveler Information Systems

- Subscription or Fee based Traveler Information Services

A brief discussion of each follows.

### Commercial Traffic Reporting Firms

Currently, the most visible and perhaps mature form of traveler information are traffic and transit reports broadcast over radio and television. Most radio stations, and increasingly television stations in metropolitan areas, provide transit and roadway incident and congestion information, especially during morning and afternoon rush hours. This information is generally provided to radio and television stations as a service by commercial traffic (including transit) reporting firms. These firms gather roadway information from aircraft or video cameras, incidents and planned roadway construction from transportation agencies, and current roadway conditions from drivers with cellular telephones.

These firms are able to accumulate airtime on stations across the country and can provide a national network of advertising media to large sponsors. This has proven to be financially successful endeavors in many geographic markets. But, it is interesting to note that this successful business has not yet tapped into direct-pay consumers. As is true with much of the media business, success is based on an entertaining presentation of the content and advertising. (Excerpt from *Generating Revenue in the Traveler Information Marketplace*, Wollenberg, S., Presentation at 1996 World Congress on Intelligent Transportation Systems.)

### Autonomous and Advisory Traveler Information Systems

The market for navigation and guidance travel information systems is growing. Indicators of this are sales figures and sales projections (market forecasts) for in-vehicle based devices. A recent study (Frost & Sullivan) indicates the rate of growth in this segment. The study researched two aspects of navigation and guidance systems—autonomous and advisory systems. Autonomous systems are defined as fully independent units, while advisory systems provide the capability of dynamic travel information content (e.g. traffic congestion, incidents, etc.).

The study states:

> *The potential market for these products include private automobiles, recreational vehicles, emergency service vehicles, and rental cars. The approximately 122 million privately owned cars in the United States represent an enormous potential market.*

A summary of this market research and forecast is included in Table 2.2-2.

**Table 2.2-2. Market Forecast for Autonomous and Advisory Navigation and Guidance Systems**

| Year | Autonomous Systems (Units) | Advisory Systems (Units) |
|---|---:|---:|
| 1994 | 1,000 | 270 |
| 1995 | 2,800 | 360 |
| 1996 | 7,700 | 550 |
| 1997 | 19,700 | 880 |
| 1998 | 42,700 | 1,900 |
| 1999 | 84,200 | 4,800 |
| 2000 | 148,800 | 15,100 |
| 2001 | 216,100 | 47,700 |

**Subscription or Fee-Based Traveler Information Services**

This market remains largely untapped. However, a growing body of market research indicates a potentially bright future.

A recent Harris Research Group survey (in the New York metropolitan area) indicates that almost one-third (31%) of those surveyed said that traveler information would have an effect on how often they travel on certain forms of transportation. (Indications in your region may vary.) A 78% majority of people surveyed during this Harris effort said they would be willing to pay something to access an improved traveler information system.

Specific results are summarized in Table 2.2-3.

**Table 2.2-3. Consumer Willingness to Pay - Survey Results**

| Percent | Willing to Pay |
|---|---|
| 56% | $5/month |
| 40% | $10/month |
| 30% | $15/month |
| 44% | $1 per telephone call to obtain travel information |
| 64% | 50 cents per telephone call to obtain travel information |

Source: *TRANSCORE, Inc.*

### 2.2.3.3 Public and Private Sector Expectations

The public and private sectors generally have differing points of views and consequently differing expectations with regard to traveler information systems. A potential hindrance to a successful partnership agreement is the stark difference in the way the public and private partners do business. These differences are due largely to the different measures of success used by the two sectors. This will likely impact the way partners want evaluations to be conducted, and how success of the venture is ultimately measured.

### Private Sector Expectations

The private sector's biggest indicator of success is profitability, with volume (number of units sold), price and quality of its products and services being key determinants. Vendors want a national market where the same product works anywhere in the country and are concerned about the potential size of the traveler information systems market. Companies involved in traveler information systems today understand that their investments may give them a significant advantage in both product development and market research, leading to earlier production of a marketable product and increased market share of sales to the general public (*IVHS Institutional Issues and Case Studies*, FHWA, 1994). Consequently there is a desire on the part of early investors to safeguard their investment by protecting (not sharing) the market and information with potential competitors.

### Public Sector Expectations

The public sector's indicators of success are generally the same as those for ITS on a national level—reducing congestion, improving driving safety, etc. Other considerations for the public sector may include: revenue generation, cost savings, motivating private investment, and open markets.

Universities (whether public or private) participate in public-private partnerships. They pride themselves on advancement of science, technology and engineering, the reputation of their professors and the quality of the students they attract and matriculate.

### Roles and Responsibilities

The traditional roles of the public and private sectors will continue to shape their future roles in traveler information systems ventures. For example, the public side will likely continue to install and operate variable message signs, and roadway sensors, while the private side will continue to provide information through broadcast media including radio and television. Nonetheless, many opportunities for partnering exist. These are depicted in Figure 2.2-2.

Additional public sector roles may include:

- Providing static information (construction event notices and transit schedules)
- Providing seed money for infrastructure and integration
- Sharing risks and funding

Additional private sector roles may include supplementing basic information provided by public agencies, product development, and market research.

- Coordination of wireless communications (sub-carrier) leases
- Providing staff to support Traveler Information Center operations
- Sharing risks and funding

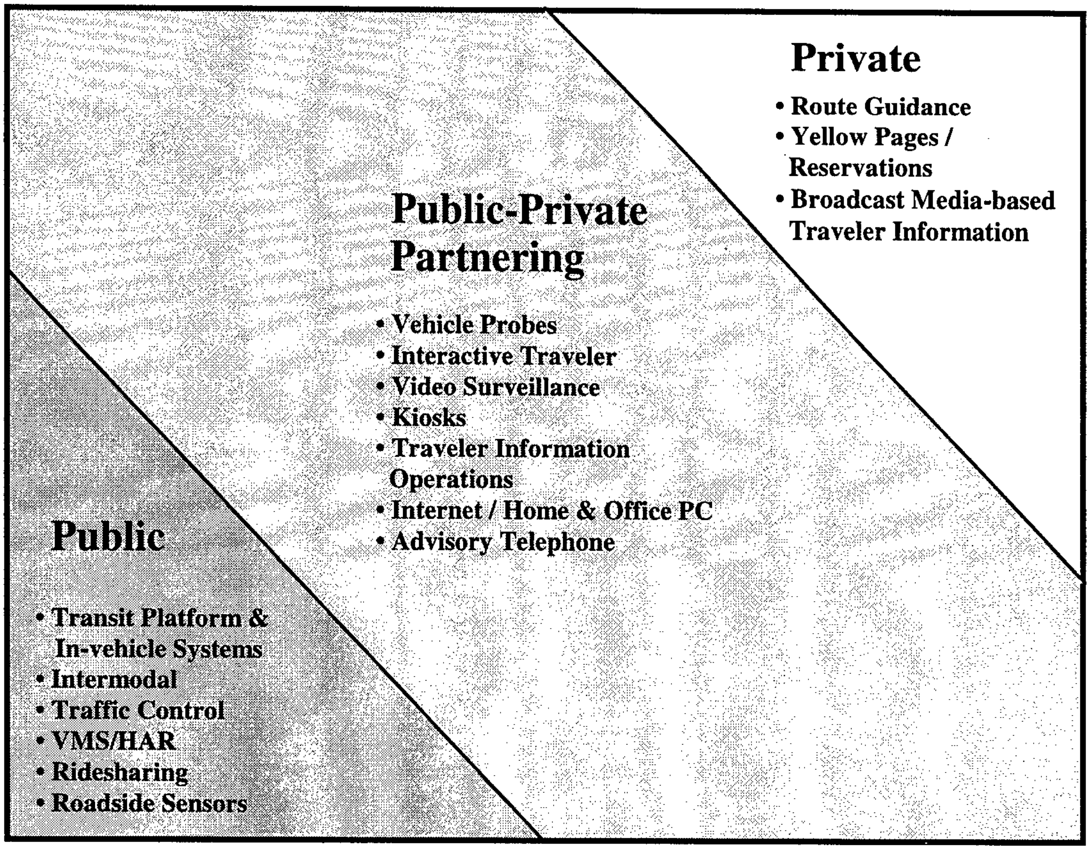


**Figure 2.2-2. Public and Private Sector Roles**

#### 2.2.3.4 Business Plan Partnership Structure

As stated previously, a business plan outlines the structure of the relationship between partners. Figure 2.2-3 shows a detailed view of a business plan. It is comprised of four functions—data collection, data fusion, value added, and data distribution—any of which can be provided by public, private, or public-private partnering.

**Data Collection**

Data collection has traditionally been managed by the public sector. This has evolved from infrastructure put in place as part of a traffic or transit management system and includes: roadway traffic sensors, vehicle tags and beacons, and video surveillance cameras. However, the private sector often supplements the data provided by public agencies to provide complete coverage of the region. In addition, commercial traffic reporting agencies (and some public sector agencies) have used aerial surveillance to monitor roadway conditions. Examples of data collected and devices are shown in Figure 2.2-3 and Figure 2.2-4.

**Data Fusion**

Data fusion refers to two processes: data synthesis and data translation. This is shown graphically in Figure 2.2-4. Data synthesis is the combining of data from multiple sources, typically different agencies, into one source for subsequent distribution. Data translation includes the computer algorithms required to transform one or more pieces of information into another piece of information. This may include the translation of:

- Volume and occupancy into speed and travel time
- NTSC video signal from cameras into a digital format or video snapshot
- Signpost and odometer readings from buses into bus location (longitude latitude), location on route, and schedule variance (time and distance)
- Incident reports from various sources into incident location, type, and expected delay (duration)

**Value-Added Function**

The value added function includes any form of repackaging of information into a form that can be provided to consumers. This role is one typically performed by the private sector (e.g. commercial traffic reporting agency), but includes any repackaging of content delivered by public agencies to motorists—for example, using variable message signs and highway advisory radio.

Private sector value added content may include confirmation of traffic and incident reports from the public sector, and the creation of 20 second radio messages. As previously discussed, private companies may provide additional surveillance (air, vehicle probes, CCTV video) to supplement basic information provided by agencies to provide total coverage of an area.

Radio and television stations bundle the transportation information provided by private firms, along with weather information, financial reports, and news, as a value-added service to their main programming. This concept is shown in Figure 2.2-4.

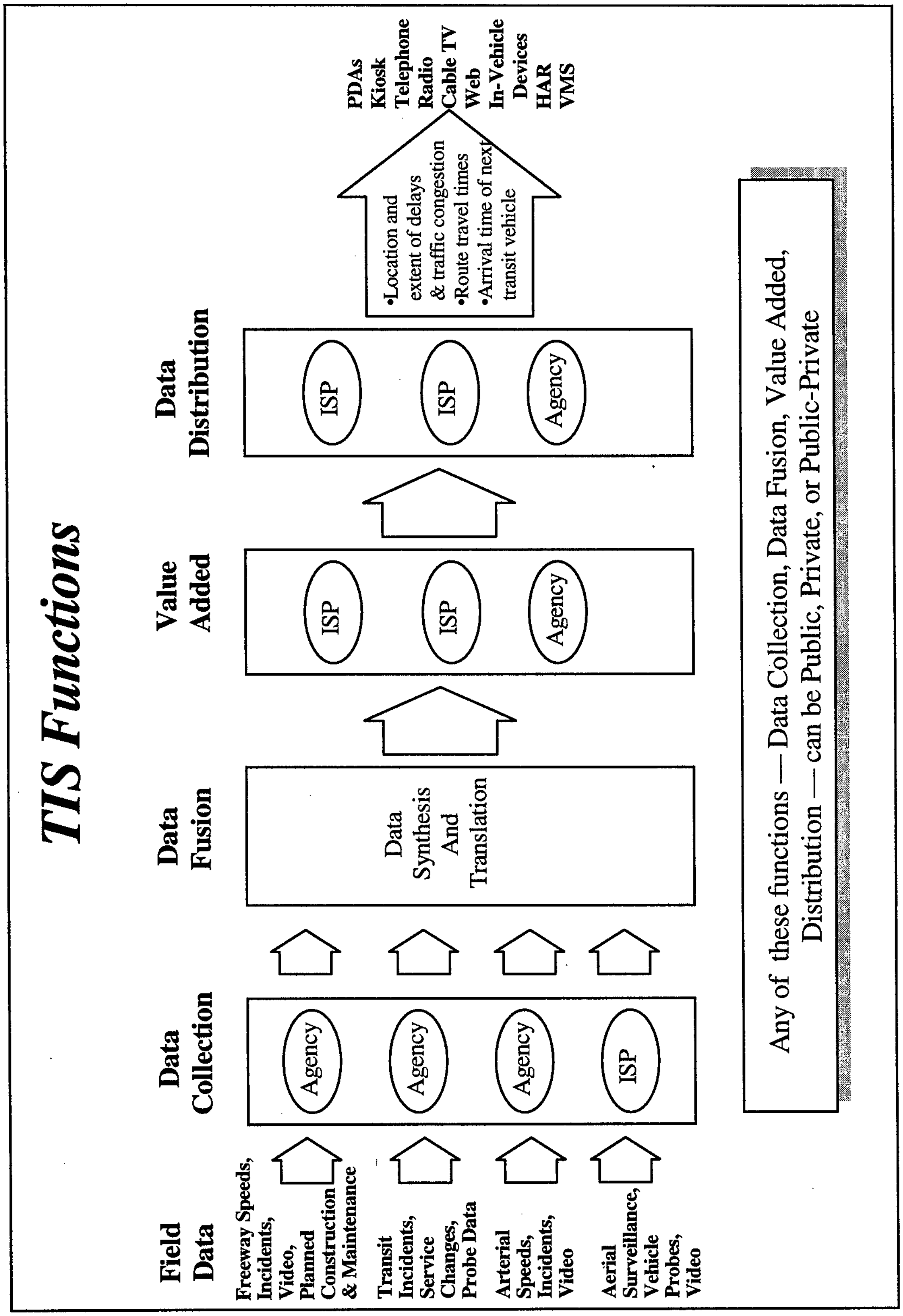


**Figure 2.2-3. TIS Functions**

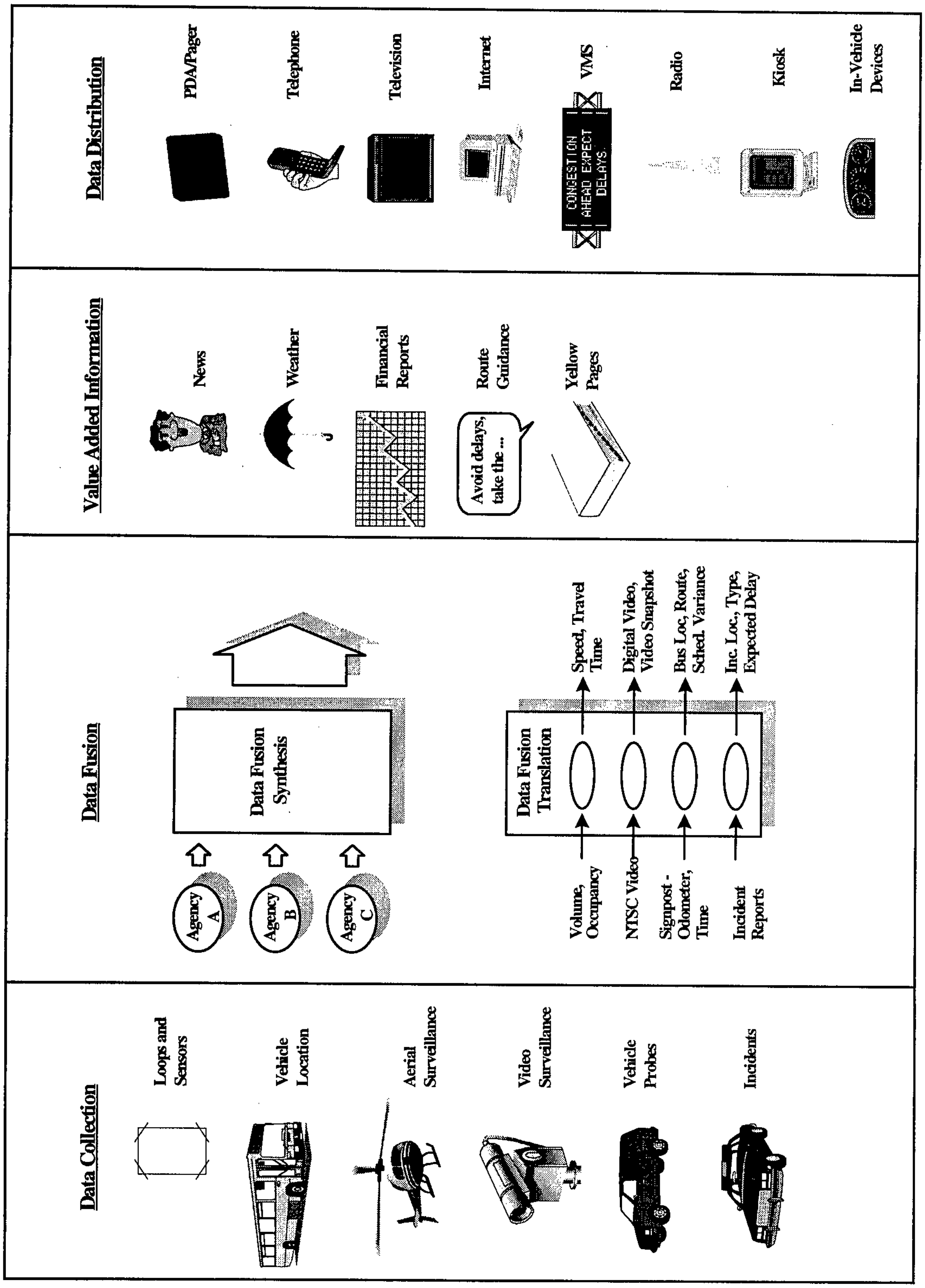


**Figure 2.2-4. TIS Business Model Examples**

Additional traveler information may also be provided in the form of alternate route information (route guidance), and yellow pages and reservation functions.

Other resources which may be contributed by a private sector partner include: office space, computers and equipment, operations and maintenance staff, software development, research (market, technology), and products.

**Data Distribution**

Finally, data is distributed to the consumer through a number of communications media and devices, ranging from hand held and in-vehicle devices to the Internet and commercial radio broadcast. Data content can be tailored to fit the needs of the consumer as market niches develop for specific types and delivery mechanisms of traveler information. Traveler information technologies are discussed in Appendix E, and communications technologies are discussed in Appendix F.

#### 2.2.3.5 Institutional / Legal Issues

A number of institutional and legal issues may impact partnership agreements. This includes:

- Length of Partnership Agreement
- Guarantee of Information Delivery
- Compensation for Information

These are discussed below.

**Length of Partnership Agreement**

The length of the partnership agreement may vary and depends on two key drivers:

- How much time will the public sector subsidize and support efforts while a self-sustaining traveler information market develops?
- How much time will the private partners support efforts while a profitable traveler information market develops?

**Guarantee of Information Delivery**

As previously shown in the discussion on TIS business models, delivery of information to consumers depends on the commitment to deliver information between the data collection processes (generally managed by the public sector), the data fusion process (which may be managed by either public or private sector), and the value added function and data distribution (generally managed by the private sector). Two issues must be considered: guarantee of timeliness and frequency of delivery of information, and guarantee of information accuracy.

In addition, issues such as the need to correct problems within a certain amount of time to provide continuous and reliable information services to consumers need to be addressed.

**Compensation for Information**

In essence, the extent to which public agencies can receive compensation depends on whether their authorizing legislation defines them as highway service providers or revenue generators.

Special purpose transportation agencies such as turnpike and transit agencies have the least constraining legislation, which allows considerable latitude in accepting any type of compensation available and using such compensation for the agency's transportation purposes.

State DOTs are highway service providers and are generally more limited in their authority to receive compensation. In some cases, states have elected to avoid negotiating for cash compensation rather than debate their authority to receive such revenues. In-kind services are often used instead of cash payment in order to avoid the problems some agencies have receiving cash payments. (*Shared Resources: Sharing Right-Of-Way for Telecommunications - Final Report,* US DOT, 1996).

These issues have shaped many agencies' policies on public information and associated compensation.

## 2.3 Development of Traveler Information Projects

Transportation agencies go through a variety of steps and processes in developing and deploying transportation improvement projects. The nature and level of formality of these processes depends on the scope of the project, state and local procedures, funding requirements, and legislative requirements, among other things. For traveler information related projects, establishing agreements between public agencies and private sector companies may also affect the project development process. However, there are certain fundamental steps that are fairly common across these processes. These basic steps include:

1) Identification of transportation needs or problems

2) Identification of potential solutions to the problem

3) Planning and design of solutions to the problem

4) Funding, procurement, and implementation of the solution to the problem

Each step of this development process is briefly described below as it relates to transportation issues that agencies or public works departments involved with traveler information provision may experience. In some cases, traveler information should be thought of as a complementary enhancement to other solutions, and not as a stand-alone solution to transportation problems.

### 2.3.1 Identification of Needs or Problems

Typically the first step an agency takes in developing and implementing a project is the identification of existing transportation needs, objectives, or problems. These may be identified through a number of activities, whether through a traditional transportation planning process, public questionnaire, a problems/needs identification study, or an ITS Early Deployment Planning (EDP) process. For example, an agency may identify a particular section of roadway that has frequent delays due to traffic volumes and an unusually high rate of incidents.

### 2.3.2 Identification of Solutions

Based on the identified problem, in this example delays on a section of roadway with high traffic volumes and a high occurrence of incidents, the agency will identify potential solutions to the problem. Potential solutions to this particular problem may include some combination of:

- Implementing a system of Variable Message Signs to warn travelers of incidents and delays
- Establishing a direct connection with local traffic information service providers to provide them with up-to-the-minute status information on current incidents and traffic delays
- Establishing more service patrols for quicker incident response
- Implementing CCTVs at key locations for quicker, more accurate detection, verification, and response to incidents
- Developing and implementing a cellular call-in solution

When evaluating the potential solutions, it is important to keep in mind institutional considerations and implications for operations and maintenance.

### 2.3.3 Planning and Design of the Solution

Once an optimal solution to the problem has been identified, the agency typically begins a process of planning and designing the solution or system. The planning phase may include activities such as determining implementation and phasing strategies, and identifying and securing of funding sources. The design phase may include activities such as preparing detailed specifications (for hardware, software and communications) and designing systems configurations.

### 2.3.4 Funding, Procurement and Implementation

Once the agency has identified the most feasible solution to the transportation challenge, the system or portion of a system is procured. The traditional approach to procurement is a two-step process: (1) the letting and completion of a contract to retain architect/engineering services to prepare detailed design specifications for the facility and (2) the letting and completion of a separate contract for the construction of the project. Due to the rapidly changing and technological nature of ITS, the system manager approach to procurement can also be used. In this case, the system manager performs the design and writes the specifications. The hardware and construction is bid in the conventional manner, but the system manager remains to develop the software, integrate all the different components, and provide documentation and training for the operating personnel. See Section 4 for a discussion of these and other procurement alternatives.

A successful process will result in the desired objectives ( which respond to the problems and needs that are identified in the first step) being satisfied by the implemented system. Successful operations of the system (often overlooked during the project development process) over a sustained period of time is the true indicator of how well the overall process worked.

## 2.4 Key Concepts of the National ITS Architecture

The National ITS Architecture is available as a resource for any region and will continue to be maintained by the U.S. DOT independently of any specific system design or region in the nation. It represents the work and collective thinking of a broad cross-section of the ITS community (systems engineers, transportation practitioners, technology specialists, system developers, consultants, etc.) over several years. As such, the National ITS Architecture contains material that will assist agencies at each step of project development (which will be presented next in Section 2.5) and in thinking about how an individual project, such as a traveler information project, fits into a larger regional transportation management context (to be discussed further in Section 3).

Because of the extensive geographic and functional scope of the National ITS Architecture and the requirements which drove its development, it is structured somewhat differently and uses different terminology than is typically used today in the transportation community. It was developed to support ITS implementations over a 20-year time period in urban, interurban, and rural environments across the country. Accordingly, general names were given to the physical transportation system components and locations in order to accommodate a variety of local design choices and changes in technology or institutional arrangements over time. This allows the general structure of the National ITS Architecture to remain stable while still allowing flexibility and tailoring at the local implementation level. This difference in language can be easily overcome with a better understanding of how the National ITS Architecture is organized and how it relates to familiar systems of today.

As background, this section explains the essential terminology and concepts needed to understand, navigate, and use the National ITS Architecture and then provides a summary of the key documents produced under the National ITS Architecture development effort which will be referred to in the next section. The portions of the material which are particularly relevant to traveler information systems are also highlighted. The reader who is already familiar with the National ITS Architecture may wish to skip ahead to the next section for information on how to use this information and methodology in the context of project development. The following concepts and terms are explained in this section:

- User Services and User Service Requirements (2.4.1)
- Logical Architecture (2.4.2)
- Physical Architecture (2.4.3)
- Equipment Packages (2.4.4)
- Market Packages (2.4.5)

### 2.4.1 User Services and User Service Requirements

User services represent what the system will do from the perspective of the user. A user might be the public or a system operator.

Table 2.4-1 presents the 30 user services which formed the basis for the National ITS Architecture development effort, grouped into seven bundles for convenience. These user services were jointly defined by a collaborative process involving USDOT and ITS America with significant stakeholder input. Clearly, a different set could have been defined. The important point is that the concept of user services allows the process of system or project definition to begin by thinking about what high level services will be provided to address identified problems and needs. The bolded entries in the table are most relevant to traveler information systems.

A number of functions are required to accomplish each user service. To reflect this, each of the user services was broken down into successively more detailed functional statements, called *user service requirements*, which formed the fundamental requirements for the National ITS Architecture development effort. For example, the pre-trip travel information user service is actually defined by over 40 "functions" (the hierarchy of user service requirements makes it difficult to provide an exact number). In the Traceability Matrix of the National ITS Architecture documentation, the user service requirements can be reviewed. Many of these user service requirements can be implemented today, although some of them may be more representative of future capabilities and should be deferred for now. User service requirements can be used as a departure point for the development of project functional requirements and system specifications, as will be discussed in Section 2.5.

**Table 2.4-1. User Services for the National ITS Architecture**

| User Service Bundle | User Service |
|---|---|
| Travel and Transportation Management | **En-Route Driver Information**<br>**Route Guidance**<br>**Traveler Services Information**<br>Traffic Control<br>Incident Management<br>Emissions Testing and Mitigation<br>Highway-Rail Intersection |
| Travel Demand Management | **Pre-Trip Travel Information**<br>**Ride Matching and Reservation**<br>Demand Management and Operations |
| Public Transportation Operations | Public Transportation Management<br>**En-Route Transit Information**<br>Personalized Public Transit<br>Public Travel Security |
| Electronic Payment Services | Electronic Payment Services |
| Commercial Vehicle Operations | Commercial Vehicle Electronic Clearance<br>Automated Roadside Safety Inspection<br>On-Board Safety Monitoring<br>Commercial Vehicle Administrative Processes<br>Hazardous Material Incident Response<br>Commercial Fleet Management |
| Emergency Management | Emergency Notification and Personal Security<br>Emergency Vehicle Management |
| Advanced Vehicle Control and Safety Systems | Longitudinal Collision Avoidance<br>Lateral Collision Avoidance<br>Intersection Collision Avoidance<br>Vision Enhancement for Crash Avoidance<br>Safety Readiness<br>Pre-Crash Restraint Deployment<br>Automated Highway Systems |

Table 2.4-2 provides an illustration of user service requirements using an excerpt from the pre-trip travel information user service.

**Table 2.4-2. Example of User Service Requirements: Excerpt from Pre-Trip Travel Information**

1.1.0 (ITS) shall provide a Pre-Trip Travel Information (PTTI) capability. to assist travelers in making mode choices, travel time estimates, and route decisions prior to trip departure. It consists of four major functions, which are, (1) Available Services Information, (2) Current Situation Information, (3) Trip Planning Service, and (4) User Access. Information is integrated from various transportation modes and presented to the user for decision making.

**1.1.1** PTTI shall provide travelers with information on those travel services available for their use.

**1.1.1.1** PTTI shall provide users with available services information that is timely.

**1.1.1.1.1** PTTI shall provide users the latest available information on transit routes.

**1.1.1.1.2** PTTI shall provide users the latest available information on transit schedules.

**1.1.1.1.3** PTTI shall provide users with real time schedule adherence information.

**1.1.1.1.4** PTTI shall provide users the latest available information on transit transfer options.

**1.1.1.1.5** PTTI shall provide users the latest available information on transit fares.

**1.1.1.1.6** PTTI shall provide users information on accessing ridematching services.

**1.1.2** PTTI shall provide the capability for users to access information on the current condition of transportation systems.

**1.1.2.1** PTTI transportation services current situation information shall be provided in real-time.

**1.1.2.1.1** Real-time information provided by PTTI shall include the current condition of any incidents.

**1.1.3** PTTI shall include a trip planning service.

## 2.4.2 Logical Architecture

A logical architecture is best described as a tool that assists in organizing complex entities and relationships. It focuses on the functional processes and information flows of a system. Developing a logical architecture helps identify the system functions and information flows, and guides development of functional requirements for new systems and improvements. A logical architecture should be independent of institutions and technology, i.e., it should not define where or by whom functions are performed in the system, nor should it identify how functions are to be implemented.

The logical architecture of the National ITS Architecture defined a set of functions (or processes) and information flows (or data flows) that respond to the user service requirements discussed above. Processes and data flows are grouped to form particular transportation management functions (e.g., manage traffic) and are represented graphically by data flow diagrams (DFDs), or bubble charts, which decompose into several levels of detail. In these diagrams, processes are represented as bubbles and data flows as arrows. Figures 2.4-1 and 2.4-2 depict simplified data flow diagrams from the National ITS Architecture documents. Note that each bubble in the logical architecture is a process that describes some logical function to be performed.

For example, as shown in Figure 2.4-1, at the highest level of the National ITS Architecture, the Provide Driver and Traveler Services process (which includes traveler information functions) interacts with seven other processes.

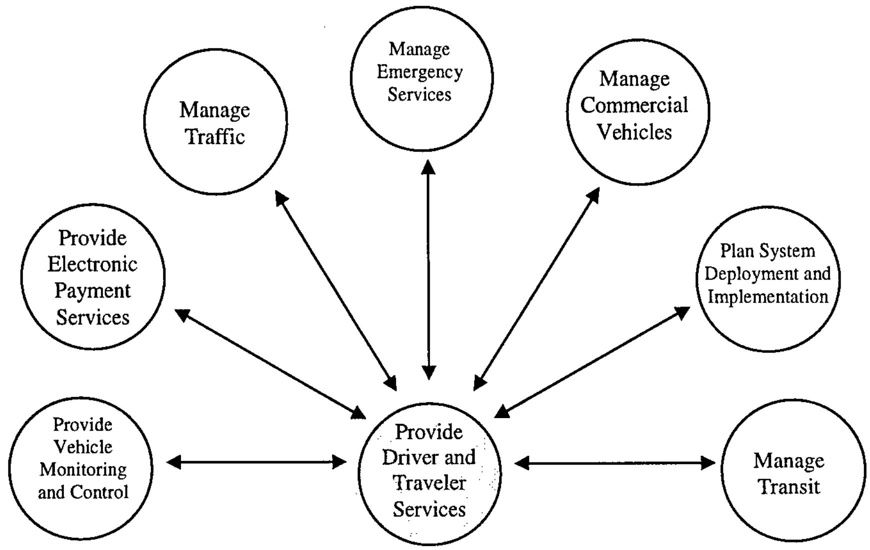


**Figure 2.4-1 The Eight Major Processes within the Logical Architecture**

Figure 2.4-2 illustrates how the Provide Driver and Traveler Services process is then further broken down into eight sub-processes, and how one of those processes, Provide Trip Planning Services, is broken down even further. Each of the processes in the logical architecture are broken down until the point at which a complete functional view of a system emerges. At the lowest level of detail in the functional hierarchy are the *process specifications* (referred to as *P-specs* in the documentation). Figure 2.4-2 shows four example process specifications within the functional decomposition. These process specifications can be thought of as the elemental functions to be performed in order to satisfy the user service requirements (i.e., they are not broken out any further). The information exchanges between processes and between P-specs are called the (logical) *data flows*.

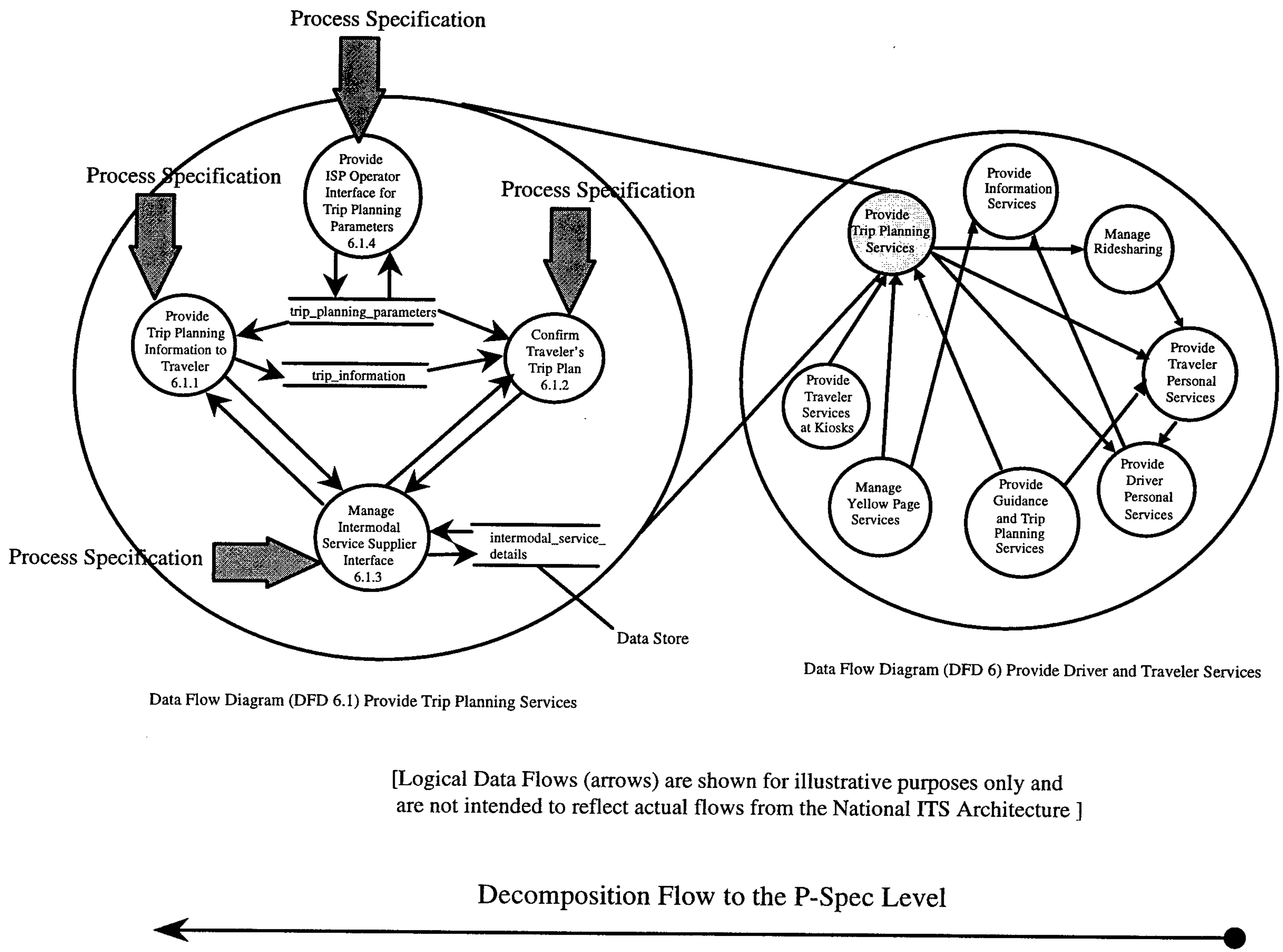


**Figure 2.4-2. Example of Logical Architecture Functional Decomposition**

Example overview descriptions of process specifications relevant to traveler information systems are given below in Table 2.4-3.

**Table 2.4-3. Example Process Specifications (Overview Descriptions)**

| |
|---|
| **Provide Trip Planning Information to Traveler ( P-Spec 6.1.1)**<br>Overview: This process shall be responsible for obtaining all the information needed to fulfill the traveler's request for a trip. The process shall support the request for trips that require the use of more than one mode of transport, and shall use the preferences and constraints specified by the traveler in the trip request, plus data from the store of trip planning parameters, to select the most appropriate modes. It shall send details of the trip requirements to the specialist processes that provide route information for the different modes of transport. When route data is received back from these processes, this process shall ensure that the whole trip is covered by one coherent route for which all the data such as costs, arrival times, modal change points, etc. are known. The information provided to the traveler by the process shall be sufficient to enable the routing, modes and cost of the trip to be understood by the traveler, and to be used as the basis of a subsequent trip confirmation. This process shall exchange all input and output data from and to the traveler with the appropriate traveler interface process. |
| **Collect Traffic Data for Advisory Messages ( P-Spec 6.2.1.1 )**<br>Overview: This process shall be responsible for the collection and fusion of data received from the Manage Traffic function and loading it into the store of traveler traffic information. The data shall be provided to the process as both requested and unrequested data flows. The requested data flows shall be obtained by the process at periodic intervals. The process shall fuse all the received data into a coherent set which is loaded into a data store for access by other processes in the Provide Driver and Traveler Services function. |
| **Provide Traffic and Transit Broadcast Messages ( P-Spec 6.2.1.4 )**<br>Overview: This process shall be responsible for extracting data from stores of traveler traffic and transit information at regular intervals and sending it out to the driver or transit user in a vehicle as a wide area broadcast message. This message shall be output by the process at regular intervals without the need for requests by either of the recipients or the ISP operator. The data read from the store shall be filtered using parameters set up in a store by the ISP operator. |
| **Get Traveler Request ( P-Spec 6.3.1 )**<br>Overview: This process shall be responsible for receiving input data from a traveler located at a kiosk. The process shall provide support for trip planning, traffic, transit and other (yellow pages) services information requests, as well as trip and yellow pages confirmation and payment requests. The process shall send these requests to the appropriate processes within the Provide Driver and Traveler Services function for further processing to generate the responses. The interface to the traveler shall also be provided through a separate process, from which the input flow to this process will originate. |

## 2.4.3 Physical Architecture

A physical architecture is the physical (versus functional) view of a system. A physical architecture provides agencies with a physical representation (though not a detailed design) of how the system should provide the required functionality. A physical architecture takes the processes (or P-specs) identified in the logical architecture and assigns them to physical entities (called *subsystems* in the National ITS Architecture). In addition, the data flows (from the logical architecture) that originate from one subsystem and end at another are grouped together into (physical) *architecture flows*. In other words, one architecture flow may contain a number of more detailed data flows. These architecture flows and their communication requirements define the *interfaces* required between subsystems, which form the basis for much of the ongoing standards work in the ITS program. Development of a physical architecture will identify the desired communications and interactions between different transportation management organizations. Figure 2.4-3 depicts the relationship between the logical and physical architecture.

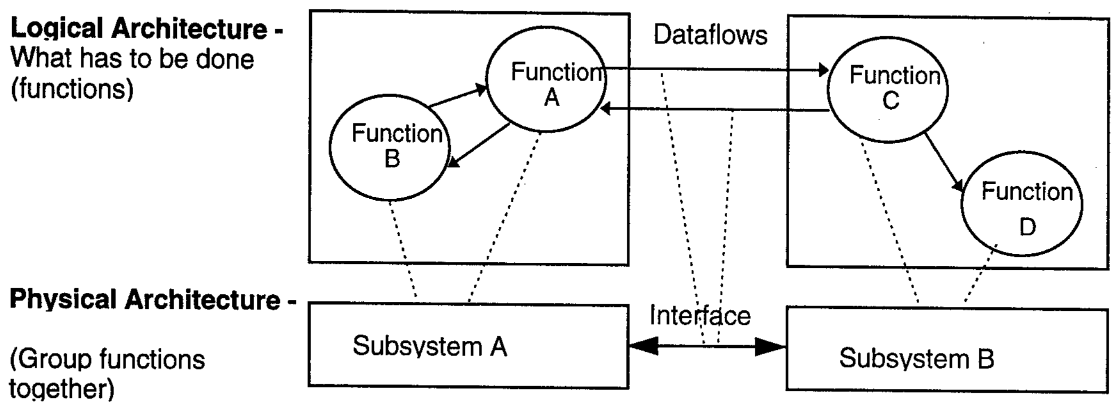


**Figure 2.4-3 Representative Logical and Physical Architecture**

In the National ITS Architecture, the physical architecture is described by two layers: the transportation layer and the communications layer. Each of these is briefly described below.

Transportation Layer

The transportation layer of the physical architecture shows the relationships among the transportation-management-related elements. It is composed of subsystems for travelers, vehicles, transportation management centers, and field devices, as well as external system interfaces at the boundaries (called *terminators* in the documentation). The transportation layer may include:

- Field devices for traffic surveillance and traveler information dissemination
- Traffic signal and ramp metering controllers
- Transportation management centers
- Kiosks, in-vehicle equipment, and other devices that can provide a user interface for traveler information

Communications Layer

The communications layer of the physical architecture shows the flow of information and data transfer for the transportation layer components. This layer depicts all of the communications necessary to transfer information and data among transportation entities, traveler information and emergency service providers, and other service providers such as towing and recovery. The communications layer clearly identifies system interface points where national standards and communications protocols can be used.

Institutional Implications

While an institutional layer is not actually part of the physical architecture, the physical architecture cannot be fully defined in a region without some decisions being made regarding the jurisdictional structure and working relationships that will provide a framework for ITS planning and implementation. These institutional decisions should lead to depiction of who should communicate with whom, and what information should be communicated in the transportation and communications layers, and will vary based on the unique needs and characteristics of a region.

Figure 2.4-4 from the National ITS Architecture, shows the 19 transportation subsystems (white rectangles) and the 4 general communication links (ovals) used to exchange information between subsystems. This figure represents the highest level view of the transportation and communications layers of the physical architecture. The subsystems roughly correspond to physical elements of transportation management systems and are grouped into 4 classes (gray rectangles): Centers, Roadside, Vehicles and Travelers.

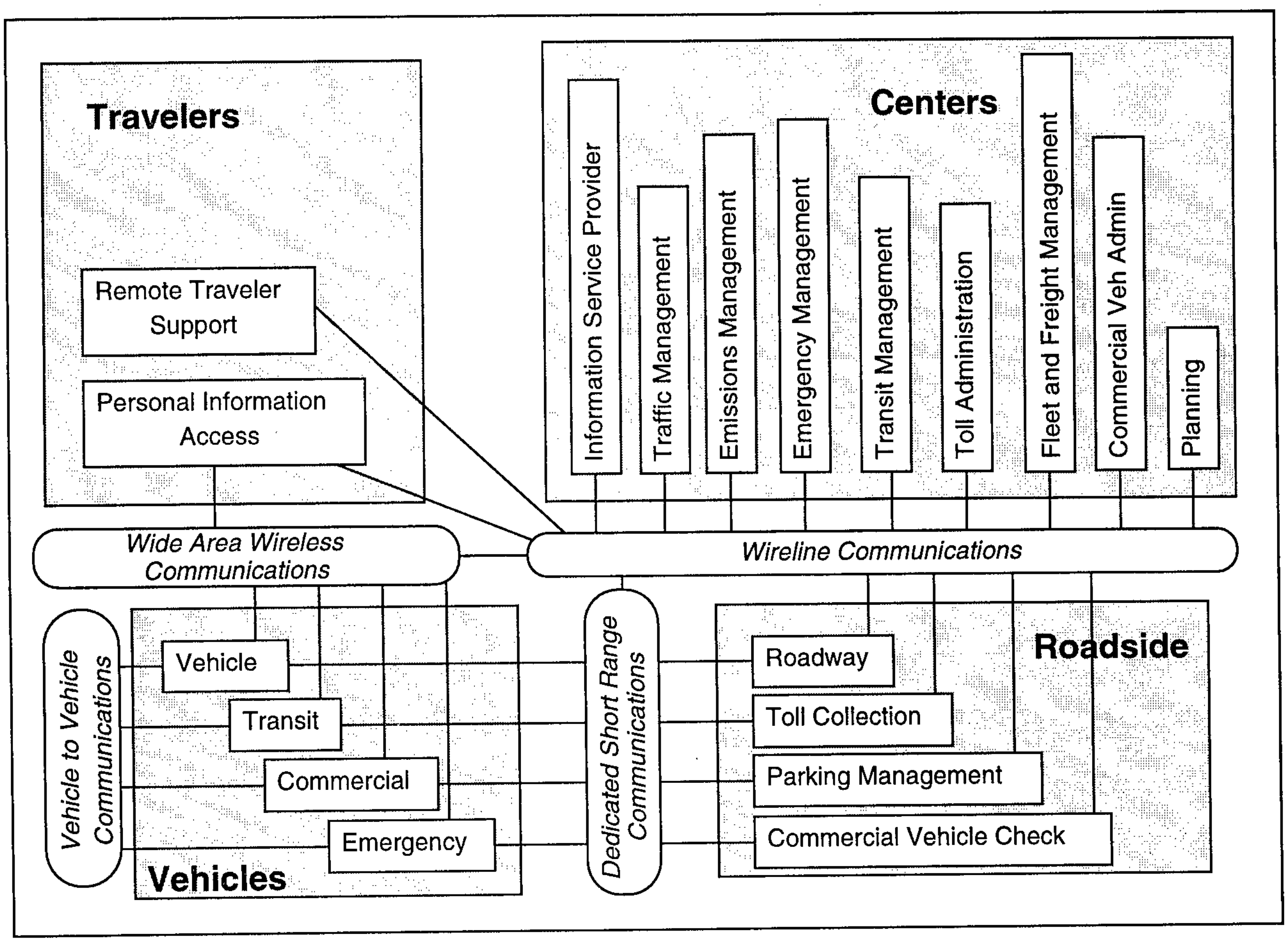


**Figure 2.4-4. National ITS Architecture Subsystems and Communications**

Within the National ITS Architecture, the domain of traveler information systems is primarily represented by functions within 10 of the 19 subsystems. These are listed below in Table 2.4-4.

The communications links include the equipment necessary for the various subsystems to exchange data to perform their transportation functions. It should be noted that the term "wireline communication" as used in the National ITS Architecture, refers to communication between stationary points. In this context, wireline communication may include wireless communication. These communications services may be provided by agency-owned communications plants (e.g. twisted pair, coaxial, fiber, or spread-spectrum radio), or may be leased from a communications service provider.

**Table 2.4-4. National ITS Architecture Subsystems Applicable to Traveler Information Systems**

| | |
|---|---|
| Personal Information Access Subsystem | Emergency Management Subsystem |
| Remote Traveler Support Subsystem | Roadway Subsystem |
| Information Provider Subsystem | Parking Management Subsystem |
| Traffic Management Subsystem | Vehicle Subsystem |
| Transit Management Subsystem | Transit Vehicle Subsystem |

A brief description of the Information Service Provider, Personal Information Access, and Remote Traveler Support subsystems follow. These are graphically depicted in Figure 2.4-5 and Figure 2.4-6 on the following pages.

Information Service Provider Subsystem. The term information service provider is introduced in the National ITS Architecture. The information service provider can be operated by a public or private sector organization; in many areas, both the public and private sector might be involved in the provision of traveler information. This subsystem provides the capabilities to collect, process, store, and disseminate traveler information to subscribers and the public at large. Information provided includes basic travel advisories, real time traffic conditions and transit schedule information, yellow pages information, ride matching information, and parking information. The subsystem also provides specific directions to travelers by receiving origin and destination requests from travelers, generating route plans, and returning the calculated plans to the users. The information is provided to the traveler through the Personal Information Access subsystem, Remote Traveler Support subsystem, and various Vehicle Subsystems.

Personal Information Access Subsystem. This subsystem accesses traveler information from the home, at work, and other locations frequented by the traveler using personal fixed and portable devices over multiple types of electronic media. Radio, television, personal computers, personal digital assistants, telephones, and any other communications-capable consumer products that can be used to supply information to the traveler are all encompassed by this subsystem definition. Sophistication ranges from simple receipt of broadcast advisories to advanced interactive capabilities which enable users to receive route plans and other real-time information tailored to their individual needs. Other available capabilities include Mayday and real-time reservation services.

Remote Traveler Support Subsystem. This subsystem provides access to traveler information at transit stations, transit stops, other fixed sites along travel routes, and at major trip generation locations such as special event centers, hotels, office complexes, amusement parks, and theaters. Traveler information access points include kiosks and informational displays supporting varied levels of interaction and information access. At transit stops, simple displays provide schedule information and estimated arrival time of the next vehicle. This basic information may be extended to include multi-modal information including traffic conditions and transit schedules along with yellow pages information to support mode and route selection at major trip generation sites. Personalized route planning and route guidance information can also be provided based on criteria supplied by the traveler.

The Information Provider, Personal Information Access, and Remote Traveler Support subsystems are equally applicable to roadway and transit information. Two illustrative examples are presented to reinforce the concepts discussed about transportation subsystems. The examples will show how systems are integrated to collect and disseminate various kinds of traveler information using a number of methods of distribution. More in-depth scenarios are described in Section 2.6.

*Please note that these two examples are not prescriptions for traveler information systems, but simply illustrate the concept of National ITS Architecture subsystems.*

### 2.4.3.1 Example Subsystems for Roadway Based Traveler Information

The first example shows the functions necessary to provide roadway-based traveler information. This example is shown in Figure 2.4-5. The Roadway subsystem collects traffic information (e.g. traffic speeds, congestion, and incidents). A traffic management center, through means of a traffic management system, uses the roadway information to monitor and control traffic. This information is also exchanged with an emergency management center. The traffic management center provides traffic and roadway closure information to motorists through variable message signs (VMS) and highway advisory radio (HAR), and provides updates to an information service provider which makes periodic radio broadcasts. Pre-trip and en-route travelers can receive traffic information through electronic connections to the traffic management center's and information service provider's computers. While it is not shown in this example, the remote traveler support subsystem may be included in a traveler information system for roadway data.

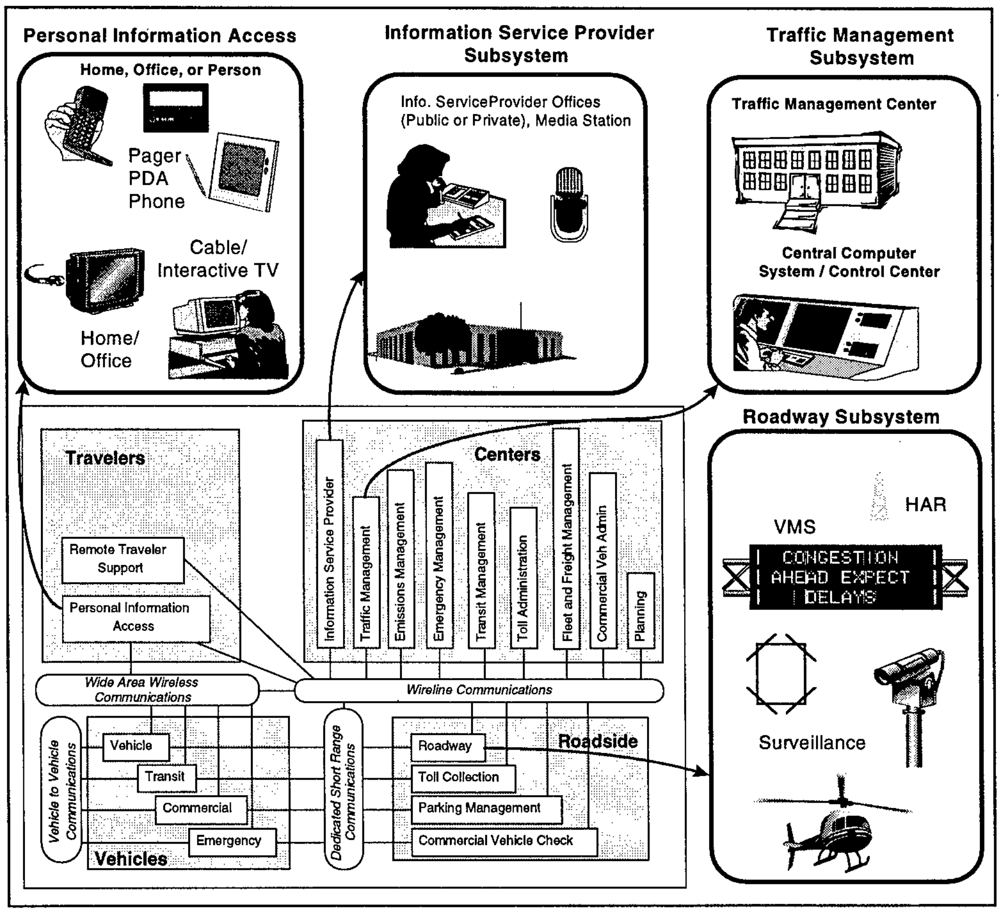


**Figure 2.4-5. Potential Subsystems for Roadway Traveler Information Example**

### 2.4.3.2 Example Subsystems for Transit Based Traveler Information

The second example shows the functions necessary to provide transit-based traveler information. This example, is shown in Figure 2.4-6. The example shows the roadway subsystem which monitors the location of transit vehicles, and a transit management center which uses the information from the on-board vehicle location system to monitor transit vehicle movements. The transit management center also controls a parking management system which monitors parking availability at a park and ride lot. Kiosks and rider information systems at transit stations (video monitors, public address systems) provide travelers information about transit and fare schedules, park and ride lot availability, and other trip planning information. While it is not shown in this example, the information service provider and personal information access subsystems may be included in a traveler information system for transit data.

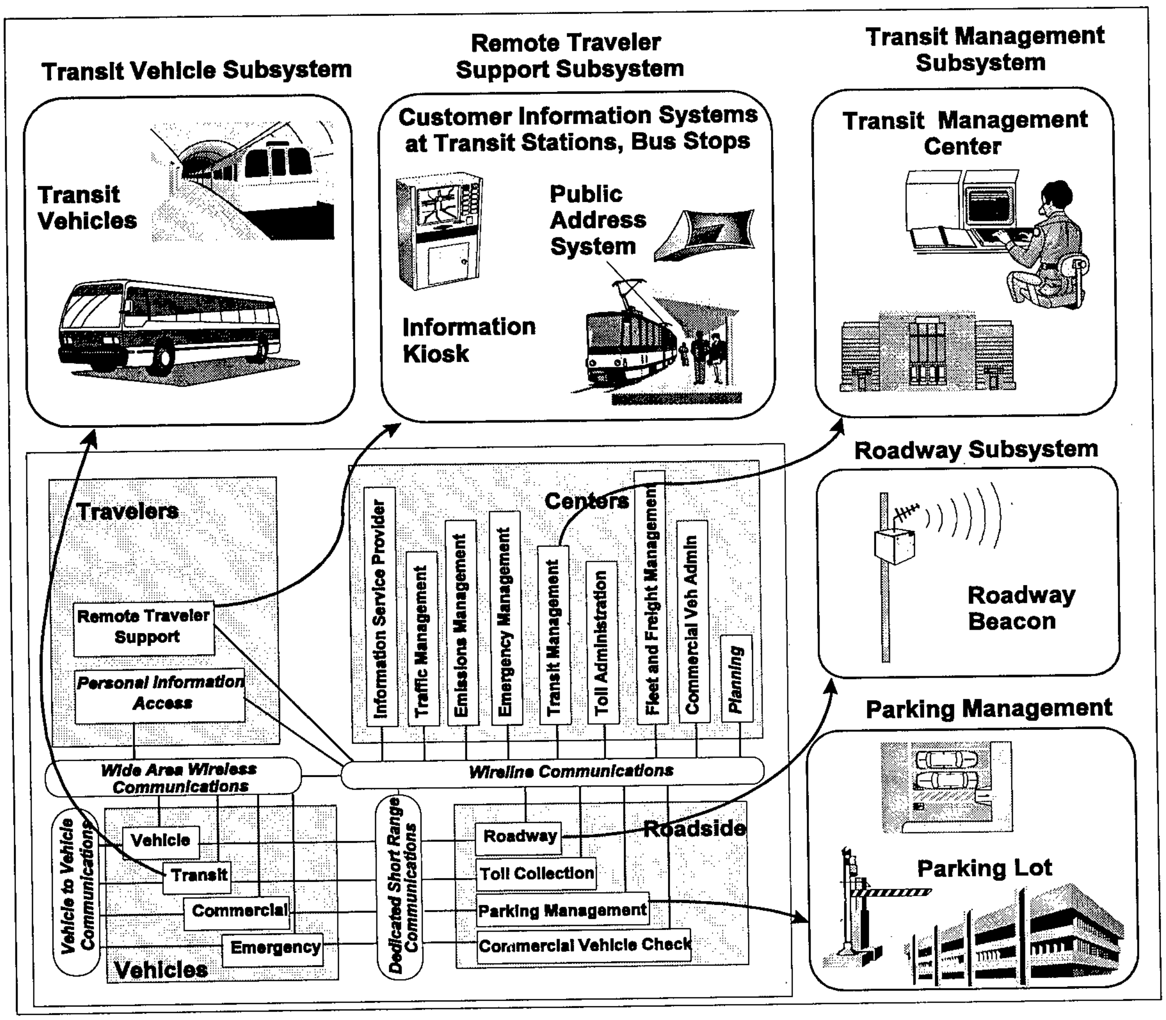


**Figure 2.4-6. Potential Subsystems for Transit Traveler Information Example**

An important concept to understand from the physical architecture is that of support for combining subsystems together (or functionality from multiple subsystems) in an actual implementation. This is particularly important for the "center" subsystems, which should not be immediately thought of as separate buildings. In simplest terms, the center subsystems are not "brick and mortar." Each subsystem is a cohesive set of functional definitions with required interfaces to other subsystems; subsystems are functionally defined, not physically defined. A regional implementation may include a single physical center that collocates and integrates the capabilities from several of the center subsystems. For instance, a single Transportation Management Center may include Traffic Management Subsystem, Transit Management Subsystem, Emergency Management Subsystem, and Information Service Provider subsystem capabilities. Conversely, a single subsystem may be replicated in many different physical centers in a complex metropolitan area system. For instance, the traffic management subsystem may be implemented in a traffic management center for freeway control in addition to several distinct city traffic management centers that cooperatively control the arterials. Figure 2.4-7 provides an indication of the range of ways that center subsystems may be implemented in physical centers.

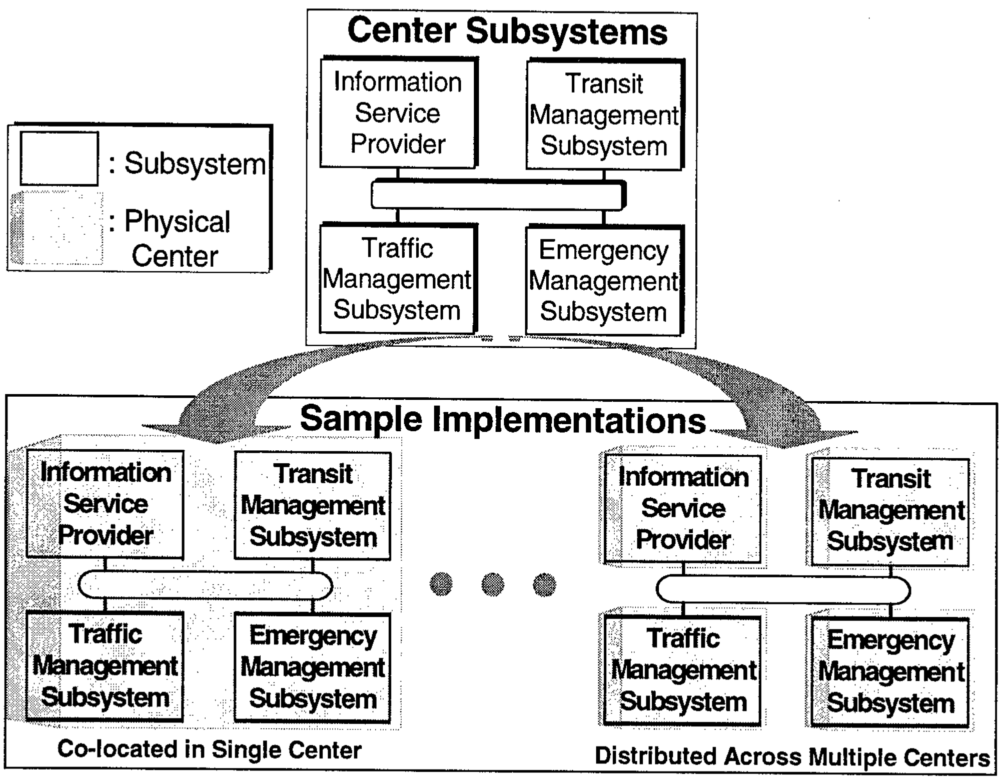


**Figure 2.4-7. Center Subsystems May Be Implemented In Various Regional Configurations**
(Source: National ITS Architecture Implementation Strategy)

### 2.4.4 Equipment Packages

*The logical and physical architectures contain all of the essential architecture elements needed to provide the user services (and their more detailed requirements).* Although the formal definition of the National ITS Architecture stops there, other categorizations of the architecture elements were made for the purposes of evaluation and to better understand the deployment implications. Sections 2.4.4 and 2.4.5 discuss the alternative views gained by grouping sets of key functionality together. These perspectives, which are grounded in (or tied back to) the formal definition, can be used as additional entry points into the National ITS Architecture.

The term "*equipment package*" was used in the National ITS Architecture development effort to group like functions (P-specs) of a particular subsystem together into an "implementable" package of hardware and software capabilities (e.g., roadway infrastructure, communications, transit stop systems, personal information devices, kiosks). The grouping of functions also took into account the user services and the need to accommodate various levels of functionality within them. The equipment packages are associated closely with market packages (which will be discussed next) and were used as a basis for estimating deployment costs (as part of the evaluation that was performed). The specific set of equipment packages defined is merely illustrative and is does not represent the only way to combine the functions within a subsystem. The National ITS Architecture has defined approximately 110 equipment packages in total. Equipment packages related to traveler information systems reside in multiple transportation subsystems of the National ITS Architecture (see Section 2.4.3).

An example of an equipment package that is relevant to traveler information is "Basic Information Broadcast," which is comprised of 11 process specifications (as shown).

**Basic Information Broadcast Equipment Package (part of the Information Service Provider Subsystem):**

This Equipment package provides the capabilities to collect, process, store, bill, and disseminate traveler information including traveler, transit, ridematching, traffic, and parking information. The traveler information shall include maintaining a database of local area services available to travelers with up-to-the-minute information and providing an interactive connectivity between, sponsors, and providers of services. The transit information shall include the latest available information on transit routes and schedules, transit transfer options, transit fares, and real-time schedule adherence. The traffic information shall include latest available information on traffic and highway conditions, and current situation information in real-time including incidents, road construction, recommended routes, current speeds on specific routes, current parking conditions in key areas, schedules for any current or soon to start events, and current weather situations. This Equipment package shall also provide users with real-time travel related information while they are traveling, and disseminate to assist the travelers in making decisions about transfers and modification of trips. These capabilities shall be provided using equipment such as a fixed facility with a communications system such as a data subcarrier multiplexing device.

This equipment package consists of the following P-specs:

1.1.4.3- Provide Media Operator Traffic Data Interface

4.1.8- Provide Transit Vehicle Operations Data Interface

6.2.1.3- Collect Transit Data for Advisory Messages

6.2.4- Collect Yellow Pages Data

6.2.1.5- Provide ISP Operator Broadcast Parameters Interface

1.1.4.6- Provide Traffic Data Retrieval Interface

1.1.4.5- Provide Media System Traffic Data Interface

6.2.1.2- Provide Traffic and Transit Advisory Messages

1.3.4.3- Provide Media Operator Incident Data Interface

1.3.4.5- Provide Media System Incident Data Interface

6.2.1.4- Provide Traffic and Transit Broadcast Messages

### 2.4.5 Market Packages

Some of the 30 user services are too broad in scope to be convenient in planning actual deployments. Additionally, they often don't translate easily into existing institutional environments and don't distinguish between major levels of functionality. In order to address these concerns (in the context of providing a more meaning evaluation), a finer grained set of deployment-oriented ITS service building blocks were defined from the original user services. These are called "*market packages*" in the documentation.

Market packages are defined by sets of equipment packages required to work together (typically across different subsystems) to deliver a given transportation service and the major architecture flows between them and other important external systems. *In other words, they identify the pieces of the National ITS Architecture required to implement a service*. As such, they are directly grounded in the definition of the Architecture. Most market packages are made up of equipment packages in two or more subsystems. Market packages are designed to address specific transportation problems and needs and can be related back to the 30 user services (reference Table 2.3-2 in the Implementation Strategy document) and their more detailed requirements.

For example, the functionality of the broad user service named "traffic control" was broken up into several market packages to allow for explicit consideration of:

- basic functions (such as surveillance, which is represented by the "network surveillance" and "probe surveillance" market packages),
- institutional settings (by separating control functions typically performed by different agencies into the "surface street control" and "freeway control" market packages), and

✦ functional levels of service (by including a "regional traffic control" market package that provides for coordination of control strategies across jurisdictions).

In addition, a "multi-modal coordination" market package was defined that is comprised of functionality for transit and emergency vehicle priority treatment at traffic signals.

Figure 2.4-8 provides an example of a market package related to traveler information systems and Figure 2.4-9 explains the basic elements of the market package diagrams. The Interactive Traveler Information market package (shown in Figure 2.4-8) contains elements that are likely to be present in many existing and future traveler information systems. The arrows represent information flows between elements. The gray boxes are transportation subsystems; white boxes are equipment packages. As will be shown in Section 2.6, costs are associated with the equipment, software, and communications within the equipment package and can be accumulated to determine the cost to deploy an entire market package.

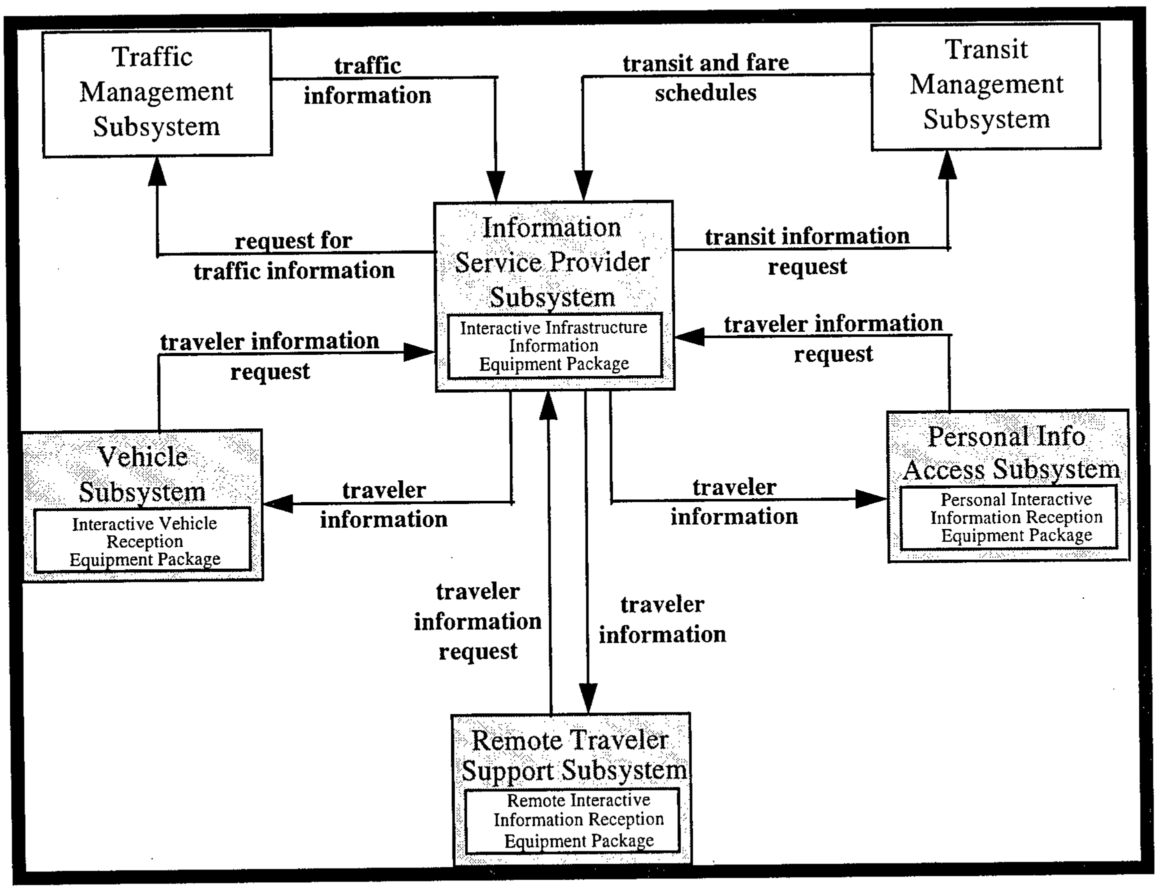


**Figure 2.4-8. Interactive Traveler Information Market Package (ATIS2)**
(Adapted From Appendix A of the Implementation Strategy)

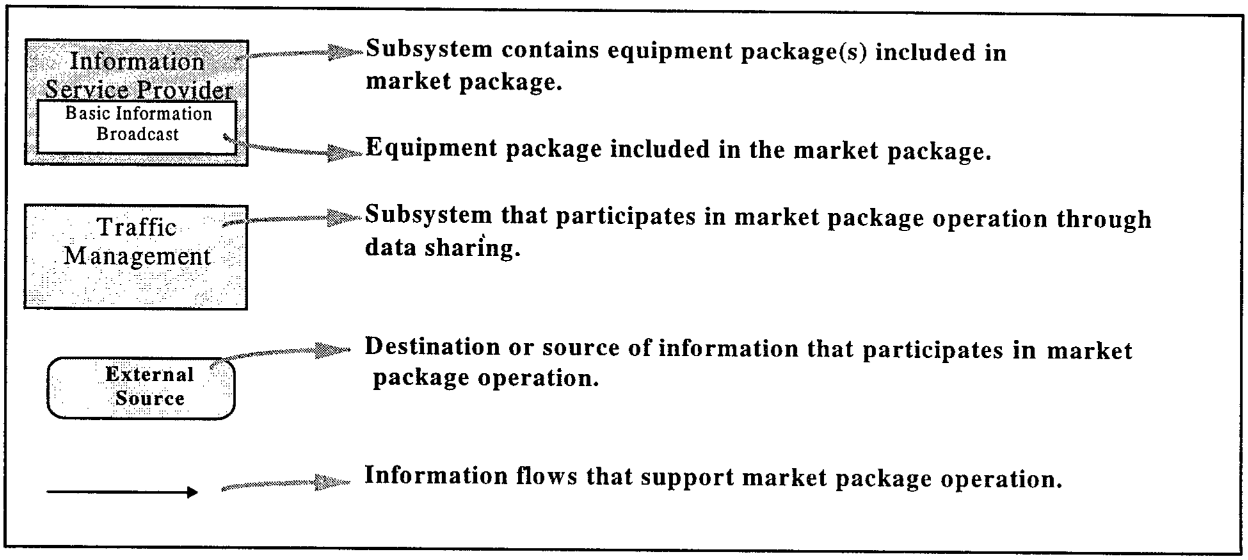


**Figure 2.4-9. Market Package Elements**
(Adapted From Appendix A of the Implementation Strategy)

The National ITS Architecture development effort identified a total of 56 market packages that reflect the current definition of ITS and the evolving technology market. Table 2.4-5 contains a complete listing of these, grouped according to their respective major application areas. As with equipment packages, the specific set of market packages defined is merely illustrative and does not represent the only way to combine the functions and equipment in order to provide ITS services. The market packages most closely related to traveler information systems are highlighted in the table.

A given market package may provide only part of the functionality of a user service (supporting multiple service levels), but often serves as a building block by allowing more advanced packages to use its components. Market packages also allow early deployments to be separated form higher risk services and can specifically address varied regional needs. Because they were evaluated during the development process, supporting benefits and costs analyses were conducted for the market packages which can also be accessed as a resource.

Market packages are not intended to be tied to specific technologies, but of course depend on the current technology and product market in order to actually be implemented. As transportation needs evolve, technology advances, and new devices are developed, market packages may change and new market packages may be defined.

In short, market packages provide another method for entering into the National ITS Architecture information and can be used as an alternative starting point for defining project functional requirements and system specifications. The important point to remember is that they provide a set of manageable, service-oriented views which allow the user to jump right into the physical architecture definition.

### 2.4.6 National ITS Architecture Documents

In summary, the National ITS Architecture provides a common structure for the design of ITS; it defines the functions that must be performed by components or subsystems, where these functions reside (e.g., roadside, traffic management center, or in-vehicle), the interfaces and information flows between subsystems, and the communications requirements for the information flows (e.g., wireline or wireless) in order to address the underlying user service requirements. Since the National ITS Architecture is also the foundation for much of the ongoing ITS standards work, consideration of the interface and information exchange requirements established by the Architecture today will likely facilitate or ease the transition to incorporating standards-compliant interfaces in the future (when approved standards are available).

**Table 2.4-5. ITS Market Packages**

| | |
|---|---|
| **Traffic Management** | **Advanced Vehicles** |
| **Network Surveillance** | Vehicle Safety Monitoring |
| **Probe Surveillance** | Driver Safety Monitoring |
| Surface Street Control | Longitudinal Safety Warning |
| Freeway Control | Lateral Safety Warning |
| HOV and Reversible Lane Management | Intersection Safety Warning |
| **Traffic Information Dissemination** | Pre-Crash Restraint Deployment |
| Regional Traffic control | Driver Visibility Improvement |
| Incident Management System | Advanced Vehicle Longitudinal Control |
| **Traffic Network Performance Evaluation** | Advanced Vehicle Lateral Control |
| Dynamic Toll/Parking Fee Management | Intersection Collision Avoidance |
| Emissions and Environmental Hazards Sensing | Automated Highway System |
| Virtual TMC and Smart Probe Data | |
| Standard Railroad Grade Crossing | **Commercial Vehicles** |
| Advanced Railroad Grade Crossing | Fleet Administration |
| Railroad Operations Coordination | Freight Administration |
| | Electronic Clearance |
| **Transit Management** | Commercial Vehicle Administrative Processes |
| Transit Vehicle Tracking | International Border Electronic Clearance |
| Transit Fixed-Route Operations | Weigh-In-Motion |
| Demand Response Transit Operations | Roadside CVO Safety |
| Transit Passenger and Fare Management | On-board CVO Safety |
| Transit Security | CVO Fleet Maintenance |
| Transit Maintenance | HAZMAT Management |
| Multi-modal Coordination | |
| | **Emergency Management** |
| **Traveler Information** | Emergency Response |
| **Broadcast Traveler Information** | **Emergency Routing** |
| **Interactive Traveler Information** | MAYDAY Support |
| **Autonomous Route Guidance** | |
| **Dynamic Route Guidance** | **ITS Planning** |
| **ISP-Based Route Guidance** | ITS Planning |
| **Integrated Transportation Mgmt/ Route Guidance** | |
| **Yellow Pages and Reservation** | |
| **Dynamic Ridesharing** | |
| **In-Vehicle Signing** | |

The following are brief descriptions of the documents produced under the National ITS Architecture Development Program that are referred to in subsequent sections. Paper copies of these can be obtained and used as reference documents. Another way to access them is via CD-ROM or on the Internet (see Section 5.1 of this document for information on how to obtain the paper copies, the CD-ROM, and the Internet addresses). The CD-ROM and the Internet sites will be more useful than hard copies when trying to access information rapidly. On the Internet, logical links (called "hyperlinks") between different parts of the architecture facilitate use of information for the type of exercises described later in this section. The CD-ROM also contains the underlying relational databases which define the Architecture (developed with Microsoft Access™), which can be useful for performing tailored searches or other advanced analyses. *It is important to remember that the key concepts and elements of the National ITS Architecture as presented in Sections 2.4.1-2.4.5 are interrelated and traceable in a variety of ways (forwards and backwards).*

Although the documentation at first can appear to be extensive, even overwhelming, keep in mind that only a portion of the information will apply to the specific needs of an agency at any point in time. Using the electronic tools with search capabilities and the linked HTML version of the National ITS Architecture, finding the relevant information becomes even more manageable.

U.S. DOT plans to update and maintain the National ITS Architecture over time to reflect changing needs and correct any deficiencies that may be found through the experience of users. Accordingly, critical portions of these documents, particularly those containing the Architecture definition, will be updated over time (e.g., an update is currently planned for 1998). *Therefore, while this document provides specific information and examples from the National ITS Architecture (January 1997 version) for illustration purposes, the reader should always consult and defer to the latest version of the National ITS Architecture.* See Section 5 for more information on how to access the National ITS Architecture.

It is important to keep in mind that several of the documents that were produced were done so for the purposes of evaluation; these documents can be used as additional resources (e.g., the Cost Analysis) but are peripheral to the fundamental definition. A first time interested reader should find the Executive Summary, Vision, and Implementation Strategy to be the most accessible starting points for looking into the documentation. A complete listing of the documents can be found in Appendix D.

Vision

The vision is the starting point for developing an architecture and is the component that drives everything else. The vision statement provides a description of the likely transportation system in the next 5, 10, and 20 years based on the National ITS Architecture. In the vision, the ITS User Services that the transportation system is to provide are identified in groups.

Mission

The Mission addresses the goals and objectives of a national intelligent transportation system. In the Mission, user service requirements are defined, and benefits that the system is expected to provide are identified. The mission definition ties the National ITS Architecture to the National ITS Program Plan developed jointly by US DOT and ITS America.

Logical Architecture

The Logical Architecture document contains three volumes: *Description* (Volume 1), *Process Specifications* (Volume 2), and *Data Dictionary* (Volume 3). These documents present a functional view of the ITS user services, contain diagrams that show processes and data flows among them, and define data elements, respectively.

Physical Architecture

The Physical Architecture document contains architecture flow diagrams that show data passing among physical subsystems, and presents characteristics and constraints on the data flows.

Traceability

The Traceability document shows how the National ITS Architecture satisfies the user service requirements. It contains tables that provide traceability of ITS user service requirements to National ITS Architecture elements, and traceability between logical architecture elements and physical architecture elements.

Theory Of Operations

This document provides a detailed narrative of how the architecture supports the ITS user services, described in the Mission Definition. It is a technical document, intended for engineers, operators, and others involved in detailed systems design.

Communications

The Communications document presents an analysis of the communications aspects of the National ITS Architecture. It presents a technology assessment that covers several potential communications technology alternatives. The alternatives are compared against ITS requirements. This document proposes quantitative data loading requirements for a hypothetical system design, and contains an extensive set of appendices that deal with a specific communications study.

Cost Analysis

The Cost Analysis provides typical unit costs for market packages and equipment packages. Methodologies are delineated.

Performance and Benefits Study

The Performance and Benefits Study documents the results of evaluations of several hypothetical ITS deployment scenarios. It also presents a discussion of the overall benefits of developing the National ITS Architecture.

Standards Requirements

The Standards Requirements document contains detailed information on requirements for 12 high-priority standards packages. Standards interface packages that apply to traveler information systems include:

- Digital map data exchange and location referencing
- Information Service Provider to Other Centers
- Information Service Provider Wireless Interfaces
- Traffic Management Subsystems to Other Centers
- Traffic Management Subsystems to Roadside Devices
- Dedicated Short Range Communications (DSRC)

Implementation Strategy

The Implementation Strategy document presents a process for implementing ITS services in a phased approach. The process is part of an overall strategy that includes recommendations for future research and development, operational tests, standards activities, and training.

The Implementation Strategy translates the National ITS Architecture to implementation through market packages. It identifies the market packages that provide certain ITS services and recommends a phased deployment of those market packages to provide the most needed and most feasible user services initially, and less needed/feasible user services at a later date. The Implementation Strategy considers several items and issues regarding deployment, such as legacy systems, politics, funding, market package synergy, technology requirements, and standards requirements.

## 2.5 Using the National ITS Architecture to Develop Traveler Information Projects

This section describes the specific ways that the National ITS Architecture can be used in each of the general steps of the project development process presented in Section 2.3, making use of the key concepts described in Section 2.4. This process addresses (1) needs or problem identification, (2) solution identification, (3) solution planning and design, and (4) funding, procurement, and implementation. Before discussing the specific ways it can be applied to the project development process, some additional context and general guidance is provided below.

## National ITS Architecture Application Guidance

The National ITS Architecture tools are intended to augment and support existing ITS project development processes, and should be applied with engineering judgment in that context. The National Architecture is not a process in and of itself. It contributes information and analysis to existing processes (e.g., systems engineering). By providing a source for critical information early in the development process, the National ITS Architecture can lower project risks and costs while also improving the potential that the resulting deployment will have long term utility and support regional ITS integration over time.

The National ITS Architecture tools are most applicable in the early stages of project development. They fully support the rapid definition of a starting point for project definition, with local requirements then driving the tailoring of that project for specific applications. Of course, the tools do not contain all the information necessary to fully design and implement ITS projects. While helpful information is sometimes available within the documentation (for example, in the evaluation documents), specification of issues such as performance requirements, design options, technology choices, existing system interfaces and constraints, detailed implementation and operational decisions, and which standards to use needs to be carried out at the local level. Awareness of how far into the project development process the National ITS Architecture tools apply is important to being able to make the best use of them.

The National ITS Architecture can be used to provide project developers with additional options to consider for information exchanges and functionality that may not have initially been conceived at the outset of the project. As such, its utility is likely to be greater for larger projects with a variety of possible interfaces. Using the National ITS Architecture should not be viewed as an all-or-nothing requirement; rather, the material can be used as is, tailored, or dropped, as appropriate for the situation. This will be discussed further in this section.

There are several ways to apply the National ITS Architecture; the most accessible of these methods will be presented in this section. *See Section 5 for more information on how to gain access to the various formats of the National ITS Architecture (including web sites).*

## Entry Points into the National ITS Architecture

The definition of the National ITS Architecture can be found in the logical and physical architectures. These architecture definitions exist in several formats, including paper documents, Microsoft Access™ relational databases, and a HyperText Mark-up Language (HTML) model, which provides access through a linked model. The databases and the linked HTML model are available on CD-ROM and the World Wide Web. The logical and physical architecture definitions represent a breadth and depth of information that can seem overwhelming to access and apply. However, there are tools to view the architecture definition that make the extraction of information more efficient. These maps and tables provide access or "entry points" to the details of the architecture in an organized fashion. Figure 2.5-1 shows the top-level of information shown for the linked HTML model, which provides easy access to most of these entry points. Some of the key entry points and their relevance to project development are discussed below.

## ITS Architecture Browsing Site

**January 1997 Edition**

This presentation of the National Intelligent Transportation Systems (ITS) Architecture Definition provides a hypertext view of the logical architecture, physical architecture, and implementation-oriented components of the architecture definition. This hypertext view provides access to all process specifications, data flows, subsystems, equipment packages, and terminators that make up the architecture definition. Your entry to the architecture may be through a number of different paths.

The National ITS Architecture was developed to support intelligent transportation systems extending to the year 2012. The architecture Vision provides a general forecast of the ways in which transportation improvements will be made over the next 20 years.

The architecture framework that supports this vision is made up of many physical entities (Subsystems and Terminators). By selecting a physical entity (either a subsystem or a terminator), you can browse through the process specifications that define each subsystem's functionality or the data flows that connect the subsystems.

Near term plans and planned deployments include the Intelligent Transportation Infrastructure and CVISN. The architecture structure for these near term deployments is provided in ITI and CVISN.

Another entry which is suitable for locally searching for data flows with particular text is a complete file of Logical Architecture Data Flows (Note - this file is very big (200k bytes)) or Physical Architecture Data Flows.

Yet another entry through the logical architecture is through the Pspec (Process specification) names.

Finally, a set of standards requirements packages has been created which bundle the dataflows into sets of interest to standards organizations. The launch point for these packages is: Standards Requirements packages (Cross references are provided for flows which reside in more than one package).

The entire set of architecture documents are available on the ITS America Web Site.

**Figure 2.5-1. National ITS Architecture Hypertext View**

Note to the reader: As the National ITS Architecture is updated and maintained over time, changes may be made to facilitate access to key information and allow greater flexibility for the user. Thus, some of the specifics shown in Figure 2.5-1 and the mechanics discussed in subsequent text boxes for accessing the entry points may become dated. For example, in future releases, it is likely that market packages will be given greater visibility at the top page level of the HTML model.

- *User Services* are what drove the definition of the National ITS Architecture. They represent high-level descriptions of the services to be provided by ITS, from the perspective of the user. The National ITS Program Plan provides detailed descriptions of the user services. User services can be related to general needs and higher-level goals and objectives. Traceability exists to map user services to the underlying architecture definition.

- User Service Requirements, as previously described in Section 2.4.1, are the "shall" statements that define the user services in detail and serve as the fundamental requirements of the National ITS Architecture. By selecting those user service requirements that apply to the definition of a specific system, traces can be made to the physical and logical architectures. The user service requirements are listed in Appendix A of the Traceability document on paper or CD-ROM.

- *Logical Architecture* describes "what" the National ITS Architecture must do to satisfy the User Services by defining required functions and dataflows. These functions and dataflows define the lower level details of the architecture. This tool is useful when defining the functions required to satisfy a service, requirement, or need. It leverages the extensive analysis already performed in the development of the National ITS Architecture. It provides process specifications that can be tailored to fit local requirements. The logical architecture is available on paper, CDROM, and the hyperlinked HTML model.

> In the HTML model, click on "hypertext view" from the top page, then "Process Specifications" (see Figure 2.5-1) in order to see a list of the p-specs, which are organized numerically according to their definition in the data flow diagram hierarchy. Or, you can click on "Logical Architecture Data Flows" in order to see the alphabetized list of logical data flows and get more information on them.

- *Physical Architecture Elements* are the subsystems and architecture flows that result from a partitioning of the logical architecture. These subsystems and architecture flows define a higher level of the architecture and can be aligned with high-level system functions such as "traffic management" or "information service provider." In this manner, a mapping at the physical architecture subsystem level can be developed that provides the links to the underlying logical architecture. The physical architecture is available on paper, CDROM, and the linked HTML model.

> In the HTML model, click on "hypertext view" from the top page, then "Subsystems and Terminators" (see Figure 2.5-1) in order to see a list of the subsystems, which are given alphabetically. Clicking on one of the subsystems gives lots of information about the subsystem, including a description, list of equipment packages it contains, corresponding process specifications, and an architecture flow diagram. Some of these can be further explored via additional links. You can also click on Physical Architecture Data Flows, as shown on Figure 2.5-1.

- *Market Packages*, as previously described in Section 2.4.5, represent slices of the National ITS Architecture that address specific services such as surface street control. These physical architecture subsets can be selected and aggregated to form a high-level architecture at the subsystem level. The market packages can be traced further to equipment packages and logical architecture functions. The market package definitions are available in the Implementation Strategy on paper and the CD-ROM, and also in the hyperlinked HTML model.

In the HTML model, click on "hypertext view" from the top page, then "ITI and CVISN" (see Figure 2.5-1) in order to see a list of the market packages, which are organized into early, additional, and advanced categories. Clicking on one of the market packages produces a wealth of information on relevant subsystems, equipment packages, architecture flows, related market packages, and evaluation information.

- *ITS Infrastructure Elements* are described in US DOT's Operation Timesaver initiative and define metropolitan, rural, and commercial vehicle infrastructure elements that form the foundation of ITS. These elements represent high-level service categories (e.g., traffic signal control systems, freeway management systems, transit management systems, multi-modal traveler information systems) that are mapped into the architecture. This mapping provides the supporting architecture for the ITS Infrastructure in terms of the logical and physical architecture.

Using the linked HTML model, a physical architecture flow diagram will be presented when one of the ITS Infrastructure elements is clicked on (click on "hypertext view" from the top page, then "ITI and CVISN" in order to see the ITS Infrastructure elements).

By using the CD-ROM with appropriate viewing software that can read ".pdf" files (such as the Adobe Acrobat® Reader), searches can be carried out on words of interest that might apply to a specific project or functional area. In addition, textual information can be copied (using the "select text" feature of the software) and pasted into a word processing application for further modification. Graphics information can also be downloaded (using "select graphics"), although it may not be as easy to modify these electronic tables or figures. Text and graphics information can always be printed and the information manually entered as inputs to other software programs.

## 2.5.1 Identification of Needs or Problems

As discussed in Section 2.3.1, most transportation needs and problems are identified through the planning process as part of the ongoing process of improving transportation systems at the local level. As such, the National ITS Architecture is unlikely to contribute much information to this initial step. However, it can assist agencies in identifying ITS goals and objectives that are specific to their needs. Both current and future needs should be identified. Goals and objectives identified in the National ITS Architecture (Mission Definition) that pertain to traveler information systems include:

- Increase operational efficiency and capacity of the transportation system
  - Increase operational efficiency
  - Increase speeds and reduce stops
  - Reduce delays at intermodal transfer points
  - Reduce operating costs of the infrastructure
  - Increase private vehicle occupancy and transit usage
  - Reduce private vehicle and transit operating costs
  - Reduce freight operating costs and increase freight throughput

- Enhance personal mobility and the convenience and comfort of the transportation system
  - Increase personal travel opportunities
  - Decrease personal costs of travel including:
    - Discomfort, stress, fatigue, and confusion
    - Safety and personal security
  - Increase sense of control over one's own life from predictable system operation
  - Decrease cost of freight movement to shippers, including:
    - More reliable "just-in-time" delivery
    - Reduce travel time and cost
    - Reduce driver fatigue and stress
    - Safety (e.g., from tracking hazardous material)
- Improve the safety of the nation's transportation system
  - Reduce number and severity (cost) of accidents and vehicle thefts
  - Reduce fatalities
- Reduce energy consumption and environmental costs
  - Reduce vehicle emissions and fuel consumption due to congestion
  - Reduce noise pollution
  - Reduce neighborhood traffic intrusiveness
- Enhance present and future economic productivity of individuals, organizations, and the economy as a whole
  - Increase sharing of incident/congestion information

The National ITS Architecture documentation includes a Vision Statement, which describes ITS capabilities now and into the future in magazine article style. The Vision can also serve to foster general ideas about the types of local needs and problems that ITS can be used to address.

The National ITS Architecture also includes data collection subsystems, such as the planning subsystem, to highlight the value of using ITS to collect long-term performance data on the transportation system. Collecting and using this type of information can enhance and augment the process of identifying needs and problems in the future.

| Useful National ITS Architecture Documents: Mission Definition, Vision Statement |
| --- |

## 2.5.2 Identification of Solutions

There are at least two major ways that the National ITS Architecture can be applied to the identification of alternative solutions to the given needs and problems, leading to the ultimate selection of a preferred solution. During this step, traditional solutions to the problem or combinations of traditional and ITS strategies may also be explored.

### 2.5.2.1 User Services

As discussed in Section 2.4.1, user services and associated user service requirements were fundamental to the National ITS Architecture development effort. These user services were designed to address surface transportation needs. Agencies may wish to review the list of user services in their search for potential solutions to the given needs and problems. A list of user services and those most relevant to traveler information systems was provided in Table 2.4-1.

The following is a summary of the top-level user service requirements most pertinent to traveler information functions:

The en-route driver information user service is designed to:

- ✦ Provide driver advisory information
- ✦ Provide an in-vehicle signing capability
- ✦ Provide user interface
- ✦ Provide short and long term capabilities

The route guidance user service is designed to:

- ✦ Provide travelers with directions to selected destinations
- ✦ Issue information such as mapping information and transit schedules in static mode
- ✦ Provide a real-time mode for issuing information reflecting current conditions
- ✦ Support two-way communications between the traveler and the infrastructure
- ✦ Provide a flexible user interface
- ✦ Support mobile systems

The traveler services information user service is designed to:

- ✦ Provide a "yellow pages" type of capability
- ✦ Provide an information receipt function
- ✦ Provide access to information from a variety of sources (e.g., local area information on lodging, food, gas, parking, hours of operation, tourist activities, special events, hospital information)
- ✦ Provide a variety of access methods

The pre-trip travel information user service is designed to:

- ✦ Assist travelers in making mode choices, travel time estimates, and route decisions prior to trip departure
- ✦ Provide travelers with information on available travel services
- ✦ Provide the capability for users to access information on the current conditions of transportation systems
- ✦ Provide a trip planning service
- ✦ Provide the capability for user access

The ride matching and reservation information user service is designed to:

- Provide travelers with information on rideshare providers
- Provide a rider request capability
- Provide a transportation provider service function for billing and reporting needs
- Provide an information processing capability for ride matching and clearinghouse needs

The en-route transit information user service is designed to:

- Provide travelers with real-time transit and high-occupancy vehicle information allowing travel alternatives to be chosen once the traveler is en-route
- Provide an information distribution function
- Provide information to fixed and mobile user interfaces
- Provide an information receipt function for acquiring relevant data
- Provide information processing to collect and integrate real-time transit operations data

Under this approach for this step, agencies should select those user services and user service requirements that are most relevant toward meeting the current and future needs previously identified. Those user services and user service requirements that remain in the preferred solution can be carried further into the next step of project development.

#### 2.5.2.2 Market Packages

Reviewing and selecting market packages is another convenient approach that can be taken for performing this step. As discussed in Section 2.4.5, market packages were defined in the National ITS Architecture development effort to serve as deployment-oriented ITS service "building blocks". In general, the market packages offer a finer grained set of options than do user services, offering more alternatives to choose from in this step of the process. In addition, evaluation information (such as costs and benefits related material) is more readily available for the market packages than for user services, which can provide added support to project planning. As shown in Table 2.4-5, the market packages identified in the National ITS Architecture that support traveler information functions include:

- *Network Surveillance* – This market package provides the fixed roadside surveillance elements that use a communications system to transmit surveillance data. It can be completely local, such as loop detection connected with signal control, or it can be CCTVs sending back images to traffic management centers. Surveillance enables traffic managers to monitor road conditions, identify and verify incidents, analyze and reduce the collected data, and make that data available to travelers and private information providers. Network surveillance is an important market package that directly or indirectly supports many ITS services.

- *Probe Surveillance* – This is an alternative surveillance approach in which the travel times of individual vehicles are tracked. Two general communications paths are possible: (1) wide-area wireless communications between the vehicle and a traveler information service provider can be used to transmit current vehicle location and status, and (2) a dedicated short range communications link between the vehicle and roadside can be used to provide equivalent information back to a traffic management system.

- *Traffic Information Dissemination* – This market package allows traffic information to be disseminated using roadway equipment, such as changeable message signs, or highway advisory radio. The emphasis is on provision of basic traffic information or other advisories by means that require minimal or no in-vehicle equipment to receive the information. This package provides a tool that can be used to notify drivers of incidents. Careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information.

- *Traffic Network Performance Evaluation* – This market package includes advanced algorithms, processing, and mass storage capabilities that support historical evaluation, real-time assessment, and forecasts of traffic network performance. This includes the prediction of travel demand patterns to support better link travel time estimation for route planning purposes.

- *Broadcast Traveler Information* – This market package provides the user with a basic set of traveler information services. It involves the collection of traffic conditions, advisories, general public transportation and parking information, and the near real-time dissemination of this information over a wide area through existing infrastructures and low-cost user equipment (e.g., FM sub-carrier, cellular data broadcast).

- *Interactive Traveler Information* – This market package provides tailored information in response to a traveler request. The user can request and obtain current information regarding traffic conditions, transit services, traveler services, ride share/ride match, parking management, and pricing information.

- *Autonomous Route Guidance* – This market package relies on in-vehicle sensory, location determination, computational, map database, and interactive driver interface equipment to enable route planning and detailed route guidance based on static, stored information. No communication with the infrastructure is assumed or required. Identical capabilities are available to the traveler outside the vehicle by integrating a similar suite of equipment into portable devices.

- *Dynamic Route Guidance* – This offers the user advanced route planning and guidance that is responsive to current conditions. The package combines the autonomous route guidance user equipment with a digital receiver capable of receiving real-time traffic, transit, and road condition information that is considered in providing route guidance.

- *Information Service Provider (ISP) Based Route Guidance* – This market package moves the route planning function from the user device to the information service provider. This approach simplifies the user equipment requirements and can provide the traffic manager with better information on which to predict future traffic and appropriate control strategies.

- *Integrated Transportation Management/Route Guidance* – This market package allows a traffic management center to continuously optimize the traffic control strategy based on near-real time information on intended routes for a proportion of the vehicles within their network. It represents an extension to the ISP-Based Route Guidance market package which improves the level of coordination between ISP and Traffic Management Subsystem so that the planned routes can be factored in to near-future traffic management strategies.

- *Yellow Pages and Reservation* – This market package enhances the Interactive Traveler Information market package by adding infrastructure provided yellow pages and reservation capabilities. The same basic user equipment is included; service or advertising fees should allow recovery of the ISP investment. This market package provides different ways for accessing information, either while en-route in a vehicle, pre-trip via wireline connections, etc.

- *Dynamic Ridesharing* – This market package enhances the Interactive ATIS with Infrastructure Driver and Traveler Information package by adding infrastructure provided dynamic ridesharing capability. The investment to the driver or traveler should not increase. If this service is provided by a private ISP, service fees may be required to allow for recovery of the ISP investment.

- *In-Vehicle Signing* – This market package supports local distribution of sign information to equipped vehicles for presentation to the driver. Sign information can include general advisories reflecting real-time information or simply replicate the information available on static signs.

- *Emergency Routing* – This market package supports dynamic routing of emergency vehicles and coordination with a traffic management system for special priority on the selected route(s). An emergency service provider provides the route planning function for the emergency fleet based on real-time traffic conditions and the emergency routes assigned to other responding vehicles.

For additional help in connecting needs and problems with market packages, the Implementation Strategy document contains a table that provides this kind of information. For illustration, the excerpt of this table, shown as Table 2.5-1, shows the market packages that best address the problems of traffic congestion and air pollution.

In addition, the Performance and Benefits Study contains tables that relate the ITS system goals to individual market packages (Table 5.3-1 of the document) and the likely benefits of each market packages (multiple tables in Section 5.2 of the document). Agencies can use these as an aid in determining which market packages best address local needs.

| |
|---|
| Useful National ITS Architecture Documents: Traceability Matrix, Implementation Strategy, Performance and Benefits Study |

**Table 2.5-1. Connecting Problems, Solutions, and the National Architecture**
(Excerpt from Table 4.2-1 of the Implementation Strategy)

| Problem | Solution | Conventional Approach | Advanced Systems Approach | Supporting Market Packages |
|---|---|---|---|---|
| Traffic Congestion | Increase roadway capacity (vehicular throughput) | • New roads<br>• New lanes | • Advanced traffic control<br>• Incident Management<br>• Electronic Toll Collection<br>• Corridor Management<br>• Advanced vehicle systems (Reduce headway) | • Surface Street Control<br>• Freeway Control<br>• Incident Management System<br>• Dynamic toll/parking fee management<br>• Regional Traffic control<br>• Railroad Operations Coordination<br>• Advanced vehicle longitudinal control<br>• Automated highway system |
| | Increase passenger throughput | • HOV Lanes<br>• Car Pooling<br>• Fixed route transit | • Real-time ride matching<br>• Integrate Transit and Feeder Services<br>• Flexible route transit<br>• New personalized public transit | • Dynamic Ridesharing<br>• Multi-modal coordination<br>• Demand Response Transit Operations |
| | Reduce demand | • Flex Time Programs | • Telecommuting<br>• Other telesubstitutions<br>• Transportation Pricing | • Dynamic toll/parking fee management |
| Air Pollution | Increase transportation system efficiency, reduce travel and fuel consumption | • More efficient conventional vehicles<br>• Vehicle emissions inspections<br>• Promotion of alternatives to single occupant vehicle travel<br>• Increased capacity to reduce vehicle delay<br>• Regulations | • Remote sensing of emissions<br>• Advanced traffic management to smooth flows<br>• Multi-modal pre-trip info<br>• Telecommuting<br>• Other telesubstitutions<br>• Transportation Pricing<br>• Alternative fuel vehicles | • Emissions and environmental hazards sensing<br>• Surface Street Control<br>• Freeway Control<br>• Regional Traffic control<br>• Interactive Traveler Information<br>• Dynamic Toll/Parking Fee Management |

## 2.5.3 Planning and Design of the Solution

Project planning and design, particularly in the early phases, is likely the most important step for applying the National ITS Architecture information. There are a variety of ways to apply the National ITS Architecture in this step; the most important of these are discussed below. By using the various entry points described earlier in Section 2.5, other methods for facilitating the design process can be explored. The overall goal is for agencies to harness the analysis work already performed and to have the opportunity to consider additional functions, interfaces, and information sharing possibilities beyond the initial project scope, which can be planned for now in anticipation of future needs.

The planning and design activities that are discussed in this section include:

- Determine Functional Requirements
- Identify Information Exchange Requirements
- Identify Standards

#### 2.5.3.1 Determine Functional Requirements

The National ITS Architecture can be used as an input to defining project or system functional requirements. This involves a more detailed look at the user service requirements or market packages carried through from the previous step. Potential approaches include:

- *User service requirements* - The user service requirements associated with the proposed solution can be evaluated for their applicability to the project. For example, they can be used to augment the functional specification that may be put out in an RFP for detailed design and procurement. Using the Traceability Matrix, the process specifications that are associated with the relevant (selected) user service requirements can also be analyzed. For those process specifications that are maintained in the system design, the data is available to relate those functions to the rest of the logical and physical architecture.

- *Market packages* - The high-level architecture defined using the market packages can be further refined by examining the logical architecture elements that support these subsystems and architecture flows. The linked model can provide the maps to the underlying functions and data flows of the logical architecture. The process specifications associated with the market packages can be tailored to satisfy more closely the local needs or requirements that the solution must address. As originally defined, the market packages may identify more subsystems, equipment packages, or terminators than are required to satisfy the identified needs. While this presents a chance to drop unneeded features, it should also be viewed as an opportunity to consider additional capabilities that may satisfy other needs at marginal cost. During the process of designing the project, expansion capability may also be identified that can be planned for in future solutions. See Section 2.5.3.4 for an example of how to aggregate and tailor market packages to meet local needs.

- *Physical Architecture Subsystems* - Even if the user service or market package approach isn't followed initially, agencies should be able to determine the relevant subsystems associated with a given project. Given a list of these subsystems, the physical architecture entry point can be used to determine the associated equipment packages, process specifications, and information flows. The underlying process specifications can be evaluated for their applicability and potential contribution to the functional needs of the given project (or future ones). This entry point is particularly useful for projects with a substantial amount of central equipment and software costs, such as a TMC upgrade.

For each alternative presented above, the National ITS Architecture material can be used as is, dropped, modified, or added to as appropriate to the situation. In most cases, additional performance requirements and other types of decisions will need to be included in the specification of a system before it can be procured (even if the detailed design work is to be put out for bid). It is important to recognize that the National ITS Architecture does not address reliability, availability, or maintainability. These and other operational and maintenance needs must be added to any requirements definition or system specification.

Unique local needs that are not covered as part of the 30 user services will also require the addition of subsystems or functions that are outside the National ITS Architecture. These types of elements may represent legacy system functions or portions of legacy systems. The addition of functionality, subsystems, and external interfaces (terminators) that are not part of the National ITS Architecture is part of the process of tailoring the solution architecture to satisfy the identified needs.

### 2.5.3.2 Identify Information Exchange Requirements

The physical architecture identifies the physical subsystems and data flows among subsystems that will support the communications requirements of a given project. It is important to identify physical data flows because they are the actual representation of communication ties among agencies and subsystems. Figure 2.5-2 illustrates a simplified physical architecture data flow diagram for traveler information, focused on the information service provider subsystem. Appendix C contains a more detailed listing and explanation of the physical architecture flows that are relevant to traveler information functions.

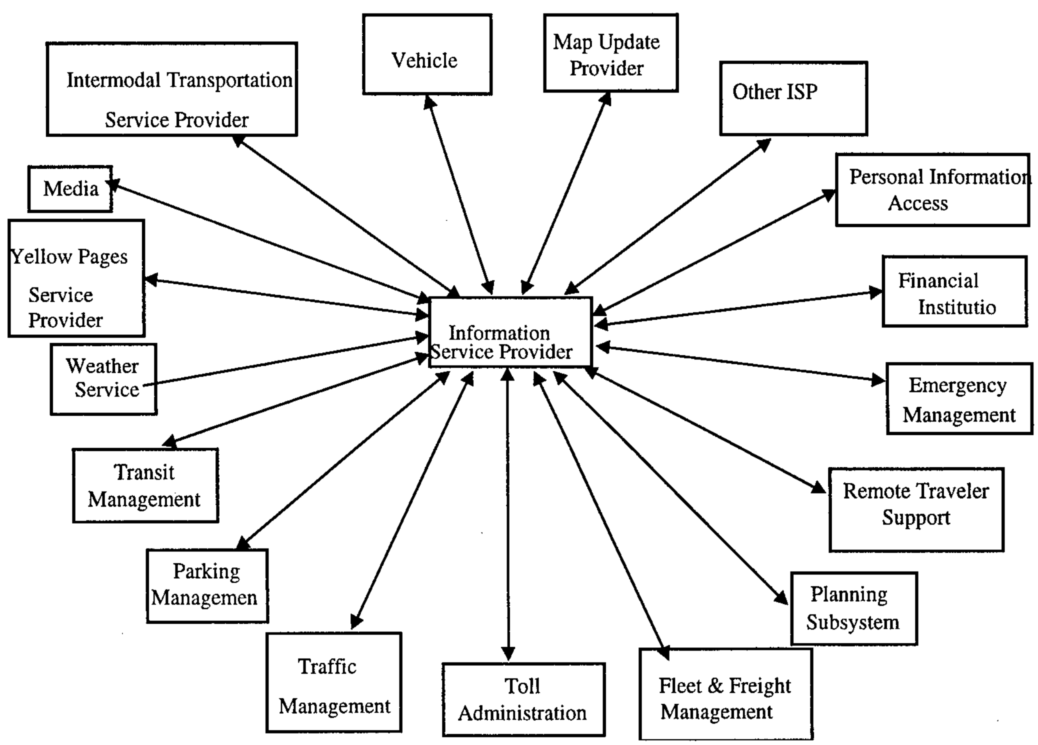


**Figure 2.5-2. Example Physical Data Flows for Information Service Provider**

In the process of specifying the information exchange requirements for the project, the underlying logical data flows associated with the identified physical information flows should be evaluated for their inclusion in the definition of communication messages. In cases where data flows are not currently available (but might be in the future), accommodation of extra message fields in the software development for the project should be considered. This will likely be done more economically if it is carried out now instead of having to modify the software later to handle the increased and changed needs for communications.

The Theory of Operations document can be used to obtain a better understanding of how the physical architecture elements work together to provide ITS services. For example, it provides diagrams and descriptions indicating the intended sequencing of messages for particular user services. These diagrams illustrate the sharing of information between subsystems which is relevant in determining the working relationships needed between different agencies for a given project (e.g., between a public agency and a private sector traveler information provider). This type of information can be invaluable in developing a concept of operations for a project.

During the process of analyzing the possible information requirements contained in the National ITS Architecture, information exchanges beyond what was originally planned may become desirable additions to the project. This could entail establishing working relationships and agreements with agencies that were not originally part of the project planning effort, which could lead to an expansion of the project steering team. The information exchanges identified in the National ITS Architecture can stimulate the discussion of operational roles and responsibilities and are therefore critical to establishing the operations requirements for the project.

#### 2.5.3.3 Identify Standards

The rapid pace of progress in technology will introduce many new systems and devices into transportation systems. As transportation systems incorporate advanced technology, there will be a need for standards to promote multi-vendor interoperability and ease of integration. With standards, it is simpler to share data and communicate between transportation systems, particularly between agencies within the same region. Without standards, it is more difficult to integrate transportation systems with each other, and consequently there is a danger of isolating systems and limiting their potential effectiveness in solving a region's transportation needs and problems.

One of the major reasons for developing the National ITS Architecture was to identify where standard system interfaces were needed. Because the National ITS Architecture is serving as the common foundation for the ongoing ITS standards development work, factoring it into your current system enhancements will facilitate the transition to a standard interface definition in the future. The Standards Requirements document contains detailed information on the requirements for 12 high-priority standards packages.

Agencies can take advantage of these standards as they emerge by specifying their use in procurement packages. Among the pertinent national ITS standards development activities in process are the ATIS data dictionary, ATIS message data flow, ITS data bus (IDB), and in-vehicle system interfaces. Appendix A contains sources for additional information on standards development activities that are relevant to traveler information projects.

Agencies should also keep in mind that a variety of existing communications and information-based standards, which may have been created for other reasons, are applicable to ITS projects and are being used in systems today.

#### 2.5.3.4 Market Package Aggregation and Modification Illustration

To illustrate some of the concepts of Section 2.5.3, this subsection illustrates the use of market packages as a way to create a high-level physical architecture that can be further tailored to address local requirements.

As market packages are selected to address the given problems and needs, they may be aggregated by connecting or overlapping duplicate subsystems. The subsystems are connected by architecture flows that define subsystem interfaces. The aggregation of market packages will result in a high-level physical architecture that has been extracted from the National ITS Architecture and will represent a starting point for refinement and tailoring to unique local needs or requirements. For example, the Surface Street Control and Incident Management System market packages might be found to be the most applicable solutions to the identified problem.

The aggregation of these two market packages would result in the architecture illustrated in Figure 2.5-3. This diagram shows the aggregation of the equipment packages (shown as white boxes inside the gray subsystems) and physical architecture flows (shown as arrows) of both market packages. Compared to the Surface Street Control market package by itself (which would only include two equipment packages in the traffic management subsystem and one in the roadway), the traffic management subsystem has accumulated more functionality in the aggregated market package since the equipment packages from the individual market packages for that subsystem have been aggregated as well. In addition, more architecture flows have been identified between the traffic management and roadway subsystems resulting in an expanded interface definition.

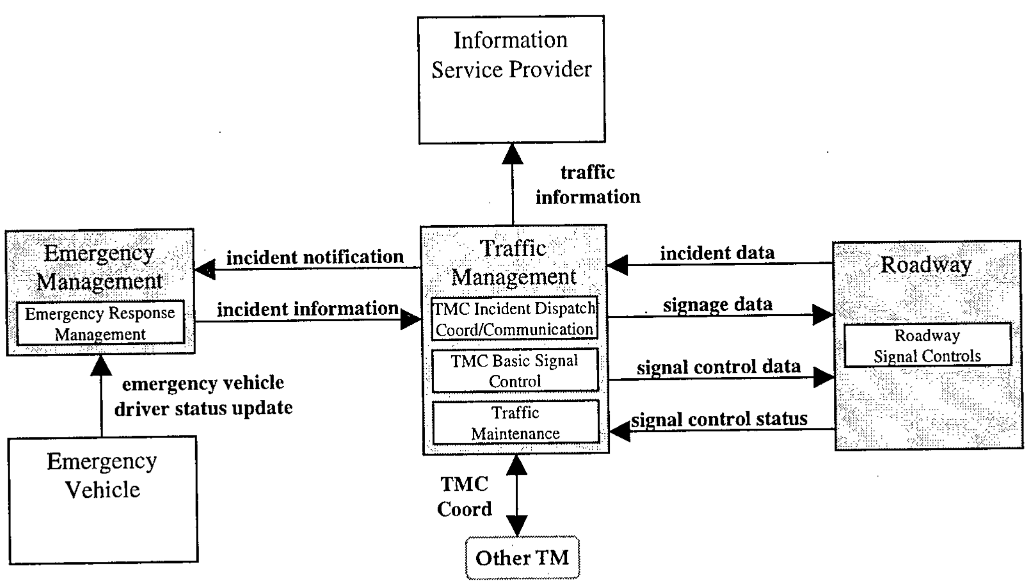


**Figure 2.5-3. Aggregation of Surface Street Control and Incident Management Systems**

The solution architecture should be analyzed to determine if it properly addresses the identified needs. The solution architecture may have more subsystems than are required or it may be missing subsystems or terminators required to satisfy the needs. If there are extraneous subsystems or architecture flows, they can be dropped from the architecture. For instance, if there was only one TMC in the area and no coordination was deemed necessary in the future, the TMC Coordination architecture flow and the 'Other TM' terminator would be dropped.

If a requirement is not satisfied by the architecture, subsystems and/or architecture flows should be added. The physical architecture should be reviewed for additional subsystems or terminators and their associated architecture flows to satisfy any missing elements in the solution architecture. For example, if there were an additional requirement that a transit management property be given direct traffic information on incidents, a subsystem would be added to include a transit management subsystem and a 'traffic information' architecture flow from the traffic management subsystem to exchange the information. Figure 2.5-4 illustrates this modification to the architecture.

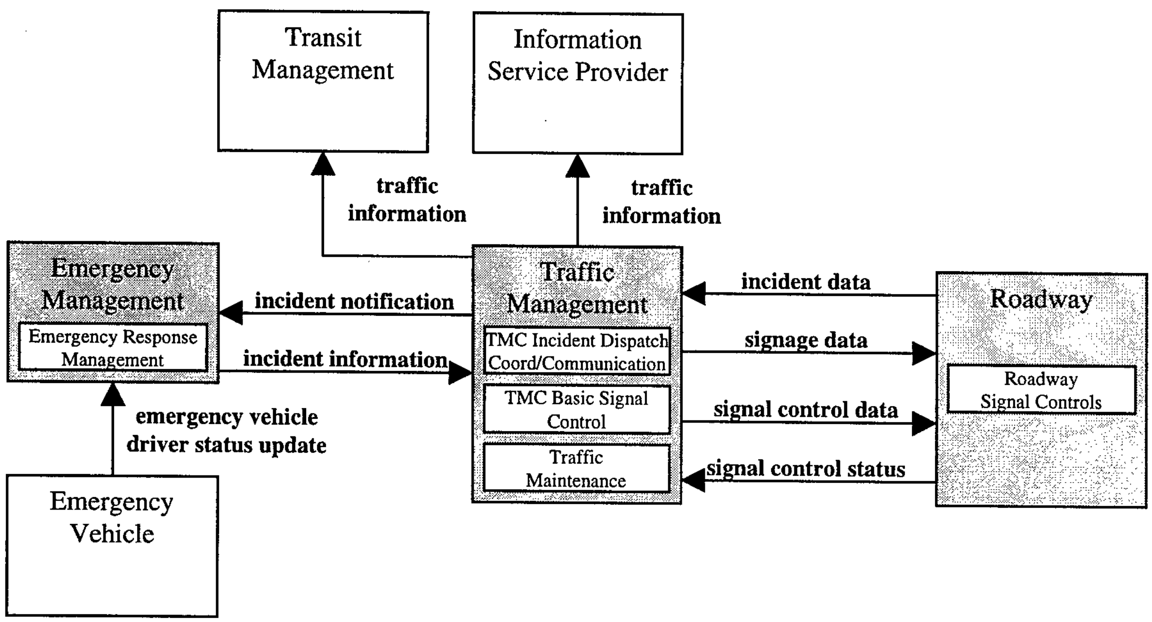


**Figure 2.5-4. Modification of Aggregated Market Package Architecture**

The high-level architecture defined using the market packages and physical architecture subsystems can be further refined by examining the logical architecture elements that support these subsystems and architecture flows. The process specifications can be tailored to satisfy more closely the local needs or requirements that the solution must address. The solution architecture will be refined to a point where it satisfies the identified needs in sufficient detail that design specifications can be generated as inputs to the final design of the solution.

Useful National ITS Architecture Documents: Logical Architecture, Physical Architecture, Traceability, Theory of Operations, Communications Document, Standards Requirements Document

### 2.5.4 Funding, Procurement, and Implementation

The National ITS Architecture material is most useful in earlier steps of the system or project development process. Nevertheless, it can also provide valuable information during this final step, particularly in the area of cost estimation. The evaluation documents and the Implementation Strategy can also be used as a general resource during this final phase of project development.

**Cost Estimates**

As a tool to assist in the estimation of costs for planning purposes, a series of spreadsheets that contain approximate non-recurring (initial capital investments) and recurring (operation and maintenance) costs of equipment packages was developed as part of the National ITS Architecture effort. These are provided in the Cost Analysis document. These costs are provided in 1995 U.S. dollars.

These costs should be applied cautiously and should not be used as a recipe for determining the actual costs of ITS deployments, since these costs vary substantially over time and from region to region. Consequently, current prices should be collected by anyone attempting to generate a detailed cost estimate for an ITS application. However, the spreadsheets can be useful in producing first order cost estimates for planning purposes. Moreover, they can be used to determine which factors affect the cost of a particular equipment package.

Useful National ITS Architecture Documents: Physical Architecture, Implementation Strategy, Cost Analysis

## 2.6 Traveler Information Project Application Scenarios

The National ITS Architecture can be used to identify the functions to be integrated into a new or existing traveler information system, and to determine what standards, information flows, and equipment/devices are needed to implement those functions. This section will step through two representative traveler information system ITS application scenarios to help illustrate how the National ITS Architecture can be used to design and deploy traveler information systems. The two scenarios are:

- Public-Private Traveler Information Center (Section 2.6.1)
- Transit User Information System (Section 2.6.2)

Each of the scenarios includes a brief presentation of each of the four general steps referenced throughout this section, but is tailored to illustrate different aspects of the previously presented guidance on applying the National ITS Architecture.

## 2.6.1 Public-Private Traveler Information Center Scenario (Using Market Packages)

One challenge facing transportation managers is that of establishing, operating, and maintaining, traveler information systems which will provide transportation users the kind of information which will influence the routes or modes these travelers take. Furthermore, in forever decreasing budgetary climates, establishing public-private partnerships to accomplish these goals is paramount.

*This scenario illustrates the use and tailoring of market packages and their supporting cost analysis and highlights the consideration of standards.*

### 2.6.1.1 Identification of Needs or Problems

A large multi-year freeway construction project is being planned. Because the freeway passes through a metropolitan area, it is anticipated that the construction project will create large-scale disruption of the transportation system. These are summarized below:

- Roadways will be closed and detours will be implemented.
- Buses will be re-routed, and occasionally schedules will be changed.
- The freeway, a route to a major metropolitan airport, will be affected – tourists and out of town travelers will be affected.

**Existing Systems**

The metropolitan region has a number of existing ITS systems. These systems and additional considerations associated with the development of the traveler information system portion of the construction project are discussed below.

Media Interface—Currently, the media interface to traffic-related operations is traditional face-to-face and voice telephone. Virtually none of the interaction with the media is automated.

Traffic Management Systems—The City currently operates a traffic signal control system with about 400 intersections, and has a traffic management center. The State district office operates a freeway management system (200 miles of freeway) which includes 6 variable message signs (VMS) and 6 closed-circuit television (CCTV) cameras located at major interchanges. In addition, police officers at the traffic management center help coordinate incident management activities.

Transit Management Systems—The County transit bureau operates a bus transit system of 100 buses and has recently started a project to implement an automated vehicle location (AVL) system for its fleet. The County transit bureau also has a new bus scheduling system.

Emergency Management Systems—A number of emergency management systems are in operation in the region.

**Objectives**

The primary objective of this effort is simply to minimize the impact of this construction on travelers. In order to meet this objective, an efficient means must be established for disseminating information between transportation systems and institutions and passing it on to travelers.

### 2.6.1.2 Identification of Solutions

The State Department of Transportation, responsible for the freeway system, has taken the lead to form a coalition of public and private agencies that will work together to maintain optimal performance of the transportation network during construction. Public agencies include: the City which manages the surface street network, the County which operates the bus transit service, the Airport Authority, and State, City and County emergency management services—law enforcement, fire and rescue, and emergency medical. Private agencies will be involved in the dissemination of traveler information—traffic reporting agencies, news media, and cable TV.

The coalition has decided to implement a public-private Traveler Information Center (TIC) to process and disseminate all transportation-related information. The TIC will be the information service provider and single collection point for transportation information. The TIC will provide information to the general public, travelers and businesses, and inform motorists, and the traveling public of transit schedule changes and route changes, and roadway closures and diversions. At the airport, kiosks will provide information on transit and traffic conditions to mitigate the impact to tourists and out of town travelers.

The TIC will be responsible for the Information Service Provider subsystem, the Remote Traveler subsystem, and the Personal Information Access subsystem functions. Afterwards, the system will form a basis for a regional traveler information system. This is shown in Figure 2.6-1.

The different entities and how each will interact with the TIC are addressed below:

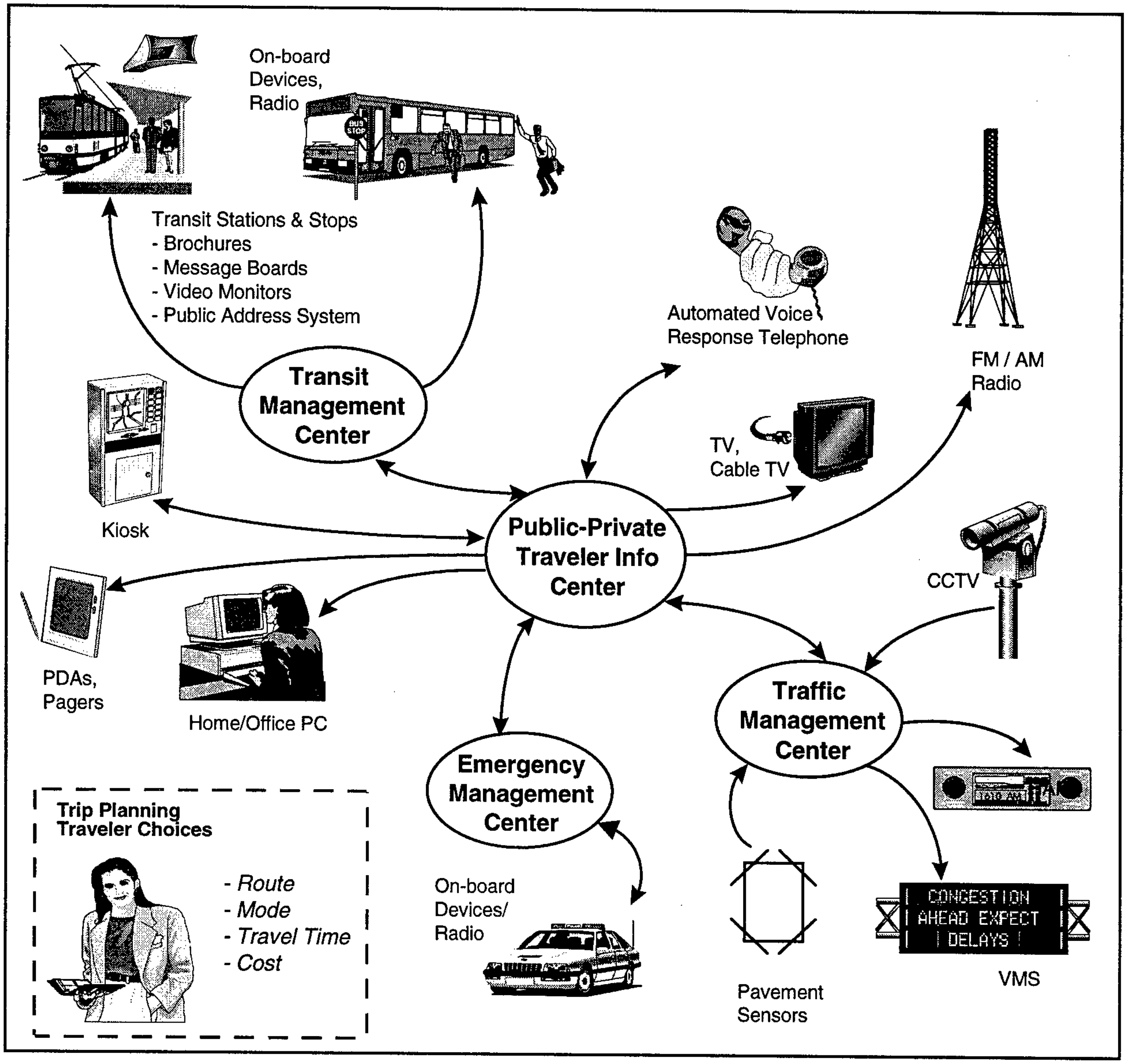


**Figure 2.6-1. Public-Private Traveler Information Center Scenario**

## Media Interface

In addition to electronic forms of communication, the public/private traveler information center will also be the primary interface for the news media—print, radio and television.

The traveler information center will:

- Publish brochures. The traveler information center will develop and publish brochures which will be distributed at local malls, transit stations, rest areas, and airports to inform the public of the project. These updates will include upcoming diversions, closures, etc.
- Interface with television media. Television stations have requested video from the traveler information center when it becomes available. In addition, a public access channel has offered air time for posting of traveler information and construction updates to the public.

- Interface with print media. The traveler information center will send weekly advisories to local newspapers to be included in the weekend, transportation or construction advisory sections of the paper.
- Make traffic, transit, and weather information available.
- Hold press conferences to inform the media and the public about the project, project schedule, project status, and potential benefits.

**Traffic Management Systems**

The traffic management systems will provide information on roadway closures, congestion, incidents, and diversion routes to the TIC. Variable message sign (VMS) coverage will be expanded to cover additional routes and be used to coordinate planned diversion routes. The traffic management center will also introduce highway advisory radio (HAR) to the region. HAR and portable VMS will be procured and used both during and after completion of the construction project.

The traveler information system will expand the roadway video surveillance system and make video available to emergency management, transit management, the TIC, and the media. Video from an additional 6 surveillance cameras will be installed as part of this project. Video images will be sent to the traveler information center where it will then be distributed to the traffic management center and transit management center. Provisions will be made to send existing camera video from the traffic management center to the traveler information center where it will be redistributed to others in the coalition. The media will use the video information for television traffic reports, and the transit and emergency management centers will use the information to assist in routing decisions.

**Transit Management System**

The County transit bureau scheduling system will be used during the construction project to determine optimal bus route changes and schedule modifications. This information will be made available to the TIC to support travelers.

**Emergency Management Systems**

The various emergency management centers want to maintain current levels of service and response times during construction. This can be accomplished if they are well informed of roadway incidents, street closures, and areas of traffic congestion. Emergency vehicle routing is key to response time performance.

**In-Vehicle Systems**

Vehicle communication alternatives will be studied during the project. This study was added to the project in response to the new bus location system being implemented, and interest on the part of a large car rental agency for dynamic route information (incidents, construction advisories, etc.). The addition of in-vehicle equipment will not be funded by the construction project.

**Personal Information Access Systems**

Paging and updates for personal digital assistants (PDA's) will be done from the traveler information center. Under this project only public agencies and private partners will receive paging information. In the future, the TIC hopes to develop a subscription based pager and PDA-based traveler information system.

**Remote Traveler Support Systems**

- Kiosk. The project will deploy up to 40 kiosks in malls, rest areas, transit stations, and at the airport.
- Home Computer and Internet. The traveler information center will manage a comprehensive Internet capability compatible with the information available on the kiosks so that travelers can access information from their homes and offices.

The State DOT and the other coalition members decided to review the list of market packages from the National ITS Architecture for their potential application to the development of the regional TIC. The following paragraphs show the market packages that were selected for future analysis.

**Broadcast Traveler Information (ATIS1)**

*ITS Elements: Traffic analysis, Pagers and PDAs, In-Vehicle Devices*

The Broadcast Traveler Information market package provides a basic set of traveler information services. It involves the collection of traffic conditions, advisories, general public transportation and parking information and the near real time dissemination of this information over a wide area through existing infrastructures and low cost user equipment (e.g., FM subcarrier, cellular data broadcast).

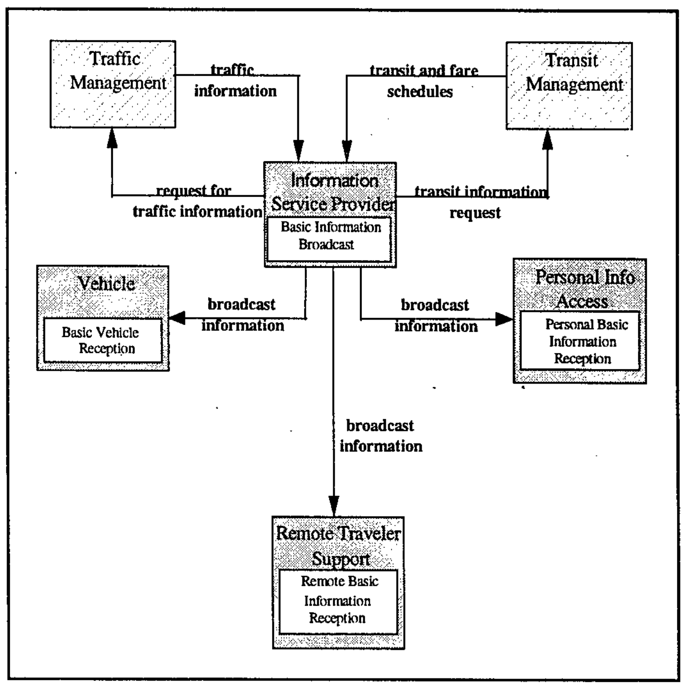


**Figure 2.6-2. Broadcast Traveler Information Market Package**

Interactive Traveler Information (ATIS2)

*ITS Elements: Kiosk, Traveler Advisory Telephone, Home Computer Access and Internet, Pre-trip planning*

The Interactive Traveler Information market package provides tailored information in response to a traveler request. The user can request and obtain current information regarding traffic conditions, transit services, traveler services, ride share/ride match, parking management, and pricing information. A range of two-way wide-area wireless and wire communications systems may be used to support the required digital communications between traveler and the information service provider. A variety of interactive devices may be used by the traveler to access information including telephone, kiosk, personal digital assistant, home computer, and a variety of in-vehicle devices. This market package was previously shown in Figure 2.4-8.

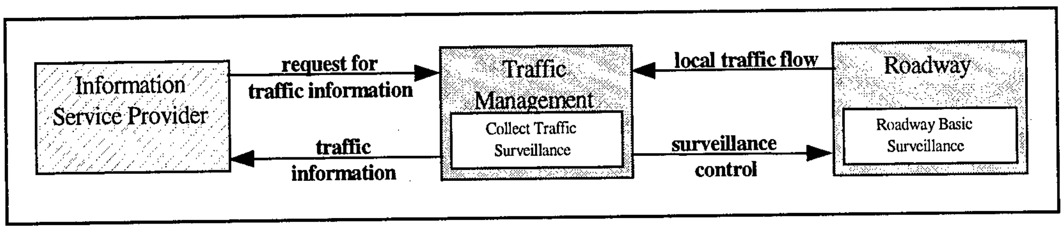


**Figure 2.6-3. Network Surveillance Market Package**

Network Surveillance (ATMS1)

*ITS Elements: CCTV and Vehicle Detection (e.g. Inductive Loops)*

The Network Surveillance market package can include local elements such as loop detection connected with signal control, or CCTVs sending back data to the traffic management centers. This enables traffic managers to monitor road conditions, identify and verify incidents, analyze collected data, and make it available to other transportation centers, information service providers, and the media.

**Incident Management System (ATMS8)**

*ITS Elements: Incident Information and Coordination between Traffic and Emergency Management Centers*

This market package provides traffic management center equipment that supports traffic operations personnel in developing an appropriate response in coordination with emergency management and other incident response personnel to confirmed incidents. The coordination with emergency management might be through a computer aided dispatch system or through other communication with emergency field personnel.

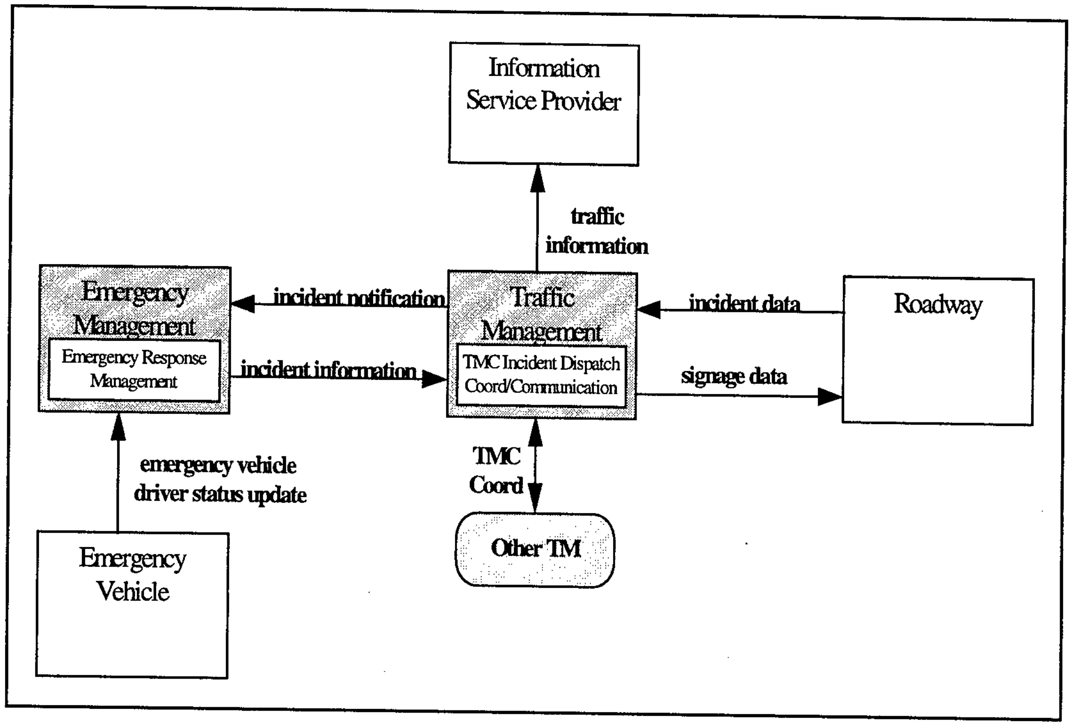


**Figure 2.6-4. Incident Management System Market Package**

**Traffic Information Dissemination (ATMS6)**

*ITS Elements: Variable Message Signs and Highway Advisory Radio*

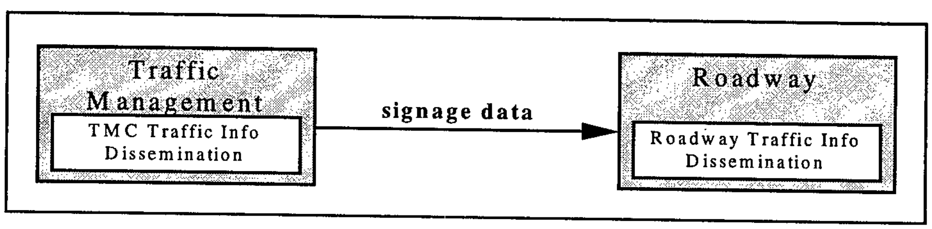


**Figure 2.6-5. Traffic Information Dissemination Market Package**

The Traffic Information Dissemination market package allows traffic information to be disseminated using roadway equipment like variable message signs or highway advisory radio. The emphasis is on provision of basic traffic information or other advisories by means which require minimal or no in-vehicle equipment to receive the information.

**Transit Vehicle Tracking (APTS1)**

*ITS Elements: Vehicle Tracking, Transit and Fare Schedule Information.*

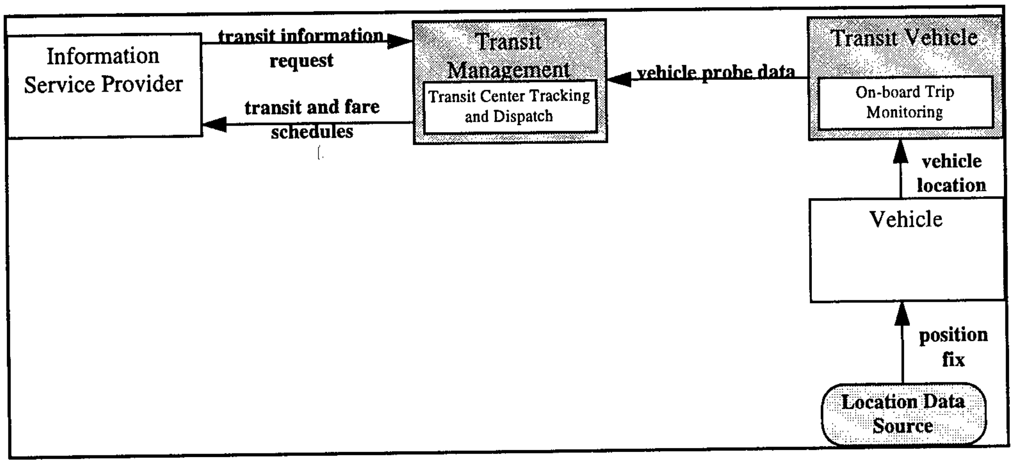


**Figure 2.6-6. Transit Vehicle Tracking Market Package**

The Transit Vehicle Tracking market package provides for an Automated Vehicle Location system to track the transit vehicle's real time schedule adherence and updates the transit system's schedule in real-time. The transit management center processes this information, updates the transit schedule and makes real-time schedule information available to the information service provider.

### 2.6.1.3 Planning and Design of the Solution

As part of the planning and design process, the State DOT and the other coalition members analyzed the market packages selected (Transit Vehicle Tracking, Traffic Information Dissemination, Incident Management System, Network Surveillance, Interactive Traveler Information, and Broadcast Traveler Information market packages) to determine the functions and flows needed to be included between the TIC and other components. This involved a review of the functionality (P-specs) of the applicable market packages and the contents of the applicable physical architecture flows (as shown in the market package diagrams). They had to tailor them to eliminate unnecessary functionality and data flows that were not going to be implemented (as discussed below). Additionally, flows that may be needed in the future were planned for, leaving in the necessary "hooks" for later implementation.

**Market Package Tailoring Illustration**

The following tables illustrate some of the modifications made during the process of analyzing the market packages in light of the existing system configuration and future plans of the transportation operating agencies within the region. The coalition did not find that there were many extraneous functions and information flows in the selected market packages. The following tables illustrate some of the modifications made during the process of analyzing the market packages.

**Functional Requirements Modifications (Example)**

| Subsystem | Equipment Package | Change | Reason |
|---|---|---|---|
| Information Service Provider | Interactive Infrastructure Information | HOLD P-spec 6.6.1 (Provide Multi-modal Route Selection) | Create the hooks for future rental car agency dynamic route guidance |
| Traffic Management | Collect Traffic Surveillance | ADD function: Provide CCTV surveillance video to ISP | Allows ISP to pass on live video to travelers through media interface |

**Information Exchange Requirements Modifications (Example)**

| Subsystem: From -> To | Physical data flow | Change /Explanation |
|---|---|---|
| Traffic Management -> Roadway | Signage data (MODIFY) | Use existing system protocols/message conventions |
| ISP -> Emergency Management | Incident notification (ADD) | Provide incident information from TIC to various EMCs. |

### Identifying Applicable ITS Standards for Traveler Information Systems

Among the standards development efforts relevant to Traveler Information Systems and to this scenario are the National Transportation Communications for ITS Protocol (NTCIP), the Transit Communications Interface Protocols (TCIP), and the Advanced Traveler Information System data dictionary and message set. Appendix A of this document includes information about these and other ongoing ITS standards development efforts. The ITS standards relevant to this scenario are briefly described below.

### National Transportation Communications for ITS Protocol (NTCIP)

The National Transportation Communications for ITS Protocol (NTCIP) is a suite of standards for data transmission between traffic management centers and field devices, and between traffic management centers and other transportation management centers. In this scenario, NTCIP will be used for communication between the traffic management center and highway advisory radio (HAR), variable message signs (VMS), and closed circuit TV (CCTV) controls. The NTCIP center to center protocol will be used to exchange information between centers.

### Transit Communications Interface Profiles (TCIP)

The TCIP standards development effort has been created to address the needs of the transit community. The primary goal of TCIP is to define the data interfaces among transit-related applications, and to facilitate the transmission of data between transportation departments, agencies, and management centers. TCIP will augment NTCIP with transit-related information. TCIP will define the information flows (message sets) needed to exchange transit information among roadside devices, transit vehicles, and transit operations centers.

In this scenario, TCIP protocols will apply to the transit management center to traveler advisory signs, and to the public/private traveler information center communication links.

**Advanced Traveler Information System Data Dictionary and Message Set**

This effort will define the data elements and messages related to traveler information systems. This includes kiosks, personal information devices, and trip planning. In this scenario these messages will apply to the communication links between the traveler information center and the traveler information display devices (visual and audible).

#### 2.6.1.4 Funding, Procurement, and Implementation

A phased approach has been selected which will permit early establishment of the TIC main functions. Future functions, such as subscription-based pagers and PDA-based traveler information systems will be implemented as funding permits.

**Cost Analysis**

The *Cost Analysis* document from the National ITS Architecture provides information that can help to generate an order-of-magnitude cost for this public-private traveler information center scenario.

As discussed previously, market packages are composed of equipment packages. As a tool to assist in the estimation of costs, the National ITS Architecture includes a series of spreadsheets that provide order-of-magnitude costs of each equipment package in 1995 U.S. dollars. These costs are divided into initial non-recurring costs (capital costs) and recurring costs (operations and maintenance). Moreover, these spreadsheets may be used to determine which factors affect the cost of a particular equipment package. Table 2.6-1 shows the cost spreadsheet for the illustrative implementation of the Basic Information Broadcast (ISP 1) equipment package.

## Table 2.6-1. Cost Spreadsheet for the Broadcast Information Broadcast Equipment Package

***Basic Information Broadcast (ISP 1)***

| | Equipment Description | Years to Replacement (Life Cycle) | Unit Price (Low) | Unit Price (High) | Quantity (Low) | Quantity (High) | Comparative Technology | Retail Price * | Unit Price | Quantity |
|---|---|---|---|---|---|---|---|---|---|---|
| Non-Recurring (Initial Capital Investment) | | | Introductory State * | | | | | | Steady State * | |
| | Two Processors (Servers) | 5 | 27 | 33 | | | Per Loral, Rockwell | | 27 | |
| | Workstations (5) | 5 | 13.5 | 16.5 | | | Experience in Similar | | 13.5 | |
| | Integration | 20 | 90 | 110 | | | Integration Projects | | 90 | |
| | | | | | | | | | | |
| | Database Software | 20 | 25 | 50 | | | Per Loral, Rockwell | | 25 | |
| | Traffic Analysis Software (includes some product development) | 20 | 250 | 500 | | | Experience in Similar | | 250 | |
| | Map Database Software | 2 | 15 | 30 | | | Integration Projects | | 15 | |
| | Communication Lines DS1 | 20 | 0.5 | 1 | | | Existing Technology | | 0.5 | |
| | Communication Lines DS0 | 20 | 0.5 | 1 | | | Existing Technology | | 0.5 | |
| | Communication Lines DS0 | 20 | 0.5 | 1 | | | Existing Technology | | 0.5 | |
| | Note : Software is off-the-shelf technology and unit price does not reflect product development, unless noted otherwise. | | | | | | | | | |
| Recurring (Operations & Maintenance) | | | Introductory State * | | | | | | Steady State * | |
| | Maintenance for Hardware Systems @ 2% of Capital Cost | | 0.81 | 0.99 | | | Estimate | | 0.81 | |
| | Maintenance for Software Systems @ 5% of Capital Cost | | 13.75 | 27.5 | | | Estimate | | 13.75 | |
| | Wireline Communication DS1 from Data Loading (see Common Equipment in Section 5.6) | | 4.8 | 8.4 | | | Current Price Structure | | 4.8 | |
| | Wireline Communication DS0 from Data Loading (see Common Equipment in Section 5.6) | | 0.6 | 1.2 | | | Current Price Structure | | 0.6 | |
| | Wireline Communication DS0 from Data Loading (see Common Equipment in Section 5.6) | | 0.6 | 1.2 | | | Current Price Structure | | 0.6 | |
| | Staff (2@50K to 75K +1@75K to 100K) | | 175 | 250 | | | Estimate | | 175 | |
| | FM Subcarrier Lease (10 to 20K per month) | | 120 | 240 | | | Estimate from Phase I | | 120 | |
| | | | | | | | | | | |
| | Note : Salary Costs are fully loaded prices (Base Salary, Overtime, Overhead, Benefits, etc.) | | | | | | | | | |

** All prices are in thousands of 1995 dollars.*

Estimates of cost and potential benefits are critical elements when trying to gain project approval. However, caution should be exercised in using these estimates. The user should understand the underlying assumptions upon which estimates are based, and that unit costs will vary by region. Consequently, current prices should be collected by anyone attempting to generate a detailed cost estimate for an ITS application.

### Cost Assumptions

- 2 permanent VMS and 2 portable VMS will be deployed.
- 2 portable HAR will be deployed.
- 6 additional Video Cameras will be deployed.
- 40 Kiosks will be deployed.
- 100 PDAs will be deployed.

- Vehicle tracking roadway infrastructure and on-board vehicle devices will not be part of the project.
- Software is off-the-shelf.
- Communications are leased from a communications service provider.
- Salary costs are fully loaded prices (base salary, overtime, overhead, benefits, etc.).
- Experience shows that to cover the costs for unaccounted items (customization, specialized consulting, inflation, etc.) the final cost figure may need to be adjusted (multiplier) by a factor of 1.25 to 1.5.

To generate cost, one should list the equipment packages associated with each market packages; then, using the *Cost Analysis* document worksheets, calculate order-of-magnitude costs. (All prices are in 1995 dollars. The costs shown in the tables below utilize the *high* worksheet unit price cost.)

A cost summary for this scenario is included in Table 2.6-2. Tables 2.6-3 and 2.6-4 are two examples of how costs are developed from individual equipment package worksheets.

**Table 2.6-2. Cost Summary for Traveler Information System Scenario**

| Item | Market Package / Equipment Package | Initial Capital Cost (Rounded) | Operational Cost Per Year (Rounded) |
|---|---|---|---|
| 100 PDAs Plus | **Broadcast Traveler Information Market Package (ATIS1)** | | |
| Route Guidance | Basic Information Broadcast Eq Pkg (ISP1) | $ 750,000 | $ 550,000 |
| | Personal Basic Information Reception Eq Pkg (PIA1) | $ 150,000 | $ 50,000 |
| 40 Kiosks Plus Pre-Trip Planning | **Interactive Traveler Information Mkt Pkg (ATIS2)** | | |
| | Interactive Infrastructure Information Eq Pkg (ISP6) | $ 650,000 | $ 200,000 |
| | Remote Interactive Reception Eq Pkg (RTS1) | $ 1,000,000 | $ 100,000 |
| 6 CCTV Plus Communications | **Network Surveillance Mkt Pkg (ATMS1)** | | |
| | Collect Traffic Surveillance Eq Pkg (TMS1) | $ 500,000 | $ 220,000 |
| | Roadway Basic Surveillance Eq Pkg (RS5) | $ 600,000 | $ 10,000 |
| 4 VMS & 2 HAR Plus Communications | **Traffic Information Dissemination Mkt Pkg (ATMS6)** | | |
| | TMC Traffic InformationDissemination Eq Pkg (TMS15) | $ 150,000 | $ 200,000 |
| | Roadway Traffic Information Eq Pkg (RS14) | $ 700,000 | $ 10,000 |
| Incident / Emergency Management & Response Plans | **Incident Management Systems (ATMS8)** | | |
| | TMC Incident Dispatch Coord/Comm Eq Pkg (TMS10) | $ 250,000 | $ 150,000 |
| | Emergency Response Management Eq Pkg (EM3) | $ 200,000 | $ 200,000 |
| Transit Interface Schedule Info. & Veh. Tracking | **Transit Vehicle Tracking Mkt Pkg (APTS1)** | | |
| | Transit Center Tracking and Dispatch (TRM7) | $ 1,800,000 | $ 350,000 |
| | On-board Trip Monitoring Eq Pkg (TRV7) | $ - | $ - |
| | ** Cost sfor vehicle tracking are not covered by project. | | |
| **Traveler Info. System Scenario** | Total Preliminary Cost | $ 6,750,000 | $ 2,040,000 |
| | **Total Estimated Cost (Inc. Adjustment Factor of 1.4)** | **$ 9,450,000** | **$ 2,856,000** |

Mkt Pkg = Market Package    Eq Pkg = Equipment Package

**Table 2.6-3. Cost for Interactive Traveler Information (ATIS2) Market Package**

| Capital Investment | Interactive Infrastructure Information Equipment Package | Cost |
|---|---|---|
| | - Additional Processor/Server | $ 16,500 |
| | - Workstations (2) | $ 6,600 |
| | - Integration | $ 110,000 |
| | - Trip Planning Software | $ 500,000 |
| | - Communication Lines (DS1) | $ 1,000 |
| | **Sub Total** | **$ 634,100** |
| **Operations and Maintenance / Year** | **Interactive Infrastructure Information Equipment Package** | **Cost** |
| | - Maintenance of Hardware Systems | $ 462 |
| | - Maintenance of Software Systems | $ 25,000 |
| | - Wireline Communication From Data Loading (DS1) | $ 8,400 |
| | - Staff | $ 150,000 |
| | **Sub Total** | **$ 183,862** |
| **Capital Investment** | **Remote Interactive Information Reception Equipment Package** | **Cost** |
| | - Software Upgrade and Integration to Existing Kiosks | $ 12,000 |
| | - Interactive Information Display Interface | $ 8,000 |
| | - Additional Interface to Communication Lines | $ 2,000 |
| | **Sub Total** | **$ 22,000** |
| **Operations and Maintenance / Year** | **Remote Interactive Information Reception Equipment Package** | **Cost** |
| | - Maintenance of Interface for Display | $ 800 |
| | - Wireline Communication (RTS to ISP included in RTS) | $ 1,200 |
| | - RTS to Map Update Provider Communication (DS0) | $ 1,200 |
| | - RTS to TRMS Wireline Communication DS3 from Data Loading | $ 72,000 |
| | **Sub Total** | **$ 75,200** |

## Table 2.6-4. Cost for Traffic Information Dissemination (ATMS6) Market Package

| **Capital Investment** | **TMC Traffic Information Dissemination Equipment Package** | **Cost** |
|---|---|---|
| | - Workstation (1) | $ 10,000 |
| | - Software | $ 22,000 |
| | - Integration | $ 110,000 |
| | - TMC to Event Communication Line (DS0) | $ 1,000 |
| | - TMC to ISP Communication Line (DS3) | $ 5,000 |
| | **Sub Total** | **$ 148,000** |
| **Operations and Maintenance** | **TMC Traffic Information Dissemination Equipment Package** | **Cost** |
| | - Operator | $ 110,000 |
| | - Maintenance | $ 7,000 |
| | - Shortwave Radio Access | $ - |
| | - Wireline Communication From Data Loading (DS0) | $ 1,200 |
| | - Wireline Communication From Data Loading (DS3) | $ 72,000 |
| | **Sub Total** | **$ 190,200** |
| **Capital Investment** | **Roadway Traffic Information Dissemination Equipment Package** | **Cost** |
| | - VMS | $ 120,000 |
| | - HAR | $ 20,000 |
| | - Fixed Fiber Optic Advanced Warning Signs | $ 15,000 |
| | - Fixed Fiber Optic Advanced Warning Signs at Remote EMS Location. | $ 22,000 |
| | - Tower Structures for VMS | $ 150,000 |
| | **Sub Total** | **$ 327,000** |
| **Operations and Maintenance** | **Roadway Traffic Information Dissemination Equipment Package** | **Cost** |
| | - VMS | $ 6,000 |
| | - HAR | $ 1,000 |
| | - Fixed Fiber Optic Advanced Warning Signs | $ 800 |
| | - Fixed Fiber Optic Advanced Warning Signs at Remote EMS Location. | $ 2,200 |
| | - Leased Line Costs Borne by TMCS | $ - |
| | **Sub Total** | **$ 10,000** |

### 2.6.2 Transit User Information System (Using User Service Requirements)

In this scenario, the County transit agency is working together with the City traffic operations center to utilize AVI/AVL transit probe data to implement a transit signal priority system as well as to enhance transit user schedule adherence information on the dial-in automated phone lines and transit user kiosks.

Transit vehicle priority provides real-time coordination between the surface street traffic management system and the transit management system. Integration of these two systems can reduce overall delay, improve the consistency of transit travel times and headways, improve traveler mobility, and increase economic productivity through ridership. The most obvious benefit, however, is to travelers on buses who will experience more consistent travel times on routes, and fewer delays at stops and transfer points. Benefit to the traffic signal control agency comes in the form of additional surveillance data, including route travel times and vehicle probe data.

Signal priority for transit vehicles can be of the greatest benefit to buses that are behind schedule, providing a way for a bus to make up time along a route. When a bus is behind schedule, it can request priority—extension of the green phase—allowing passage through the intersection.

In this scenario, the County transit agency is responding to a noticeable decline in transit ridership over several years. Inherent with this decline is an increase in arterial traffic delays and congestion. The City operates a Traffic Management Center containing a centralized traffic signal control system. Currently, the City's traffic signal control system operates independently of the County Transit Management System, i.e., it is wholly self-contained and does not communicate with any other agency transportation management system. County Transit is proposing several small projects to the City in hopes of integrating the transit signal priority into the City signal control operations. A joint working group of City traffic signal and County transit engineers has been formed to develop a solution that meets the needs of both team members.

*This scenario illustrates the use of user service requirements as an approach for guiding the development of functional requirements for a system.*

#### 2.6.2.1 Identification of Problems and Needs

The first job of the joint working group was to identify and refine all of the relevant transportation needs, objectives or problems.

**Existing Systems**

The County transit agency currently has a previously installed automatic vehicle identification and location system. The AVI/AVL system communicates bus identification to the roadside reader over a DSRC link. Currently, this information is communicated solely to the transit management center over dedicated land lines for the purpose of tracking the location of fleet vehicles. No further processing of the location data is performed. The City operates and coordinates the traffic signals throughout the City. Signal control is largely based on time-of-day plans and coordination plans are determined by network sections or corridors. At many intersections, individual signal timing adjustments are made locally depending on demand. The City traffic signal system and the County transit systems do not currently communicate with each other.

**Objectives**

The County transit agency wants to accomplish several objectives through several small projects. Working with the City traffic operations department, they hope to get a large return on their investment (through increased ridership) by taking advantage of integration benefits. The joint working group identified the following needs:

- The County must know real time location of its fleet of transit buses.
- The County must process bus location information to determine link travel times.
- County transit must disseminate real time schedule information to potential transit users through a series of user kiosks deployed at key transit locations, employment sites, and activity centers throughout the County.
- County transit must disseminate pre-trip travel information to potential users' homes and workplaces through an Internet web site.
- In order to improve travel times, reduce inconsistent transit service and thereby increase ridership, County transit must integrate AVL probe information with the City-operated transit signal priority system.
- The City wants the link travel times provided by transit in order to optimize the traffic signal operations.

### 2.6.2.2 Identification of Solutions

The joint working group's aim was to utilize much of the existing infrastructure from the AVL and traffic signal control systems. Coordination of the transit priority system with the traffic signal system is successful when the respective facility managers are aware of traffic conditions on the transportation network as well as transit schedule adherence, and they coordinate a timely response according to those conditions. Coordination between the two networks will involve using the field devices (AVL and signal controllers) on their respective systems to implement cooperative responses.

One approach to satisfying the needs of both team members is to tie AVI/AVL readers to selected traffic signals. In addition to this integration of traffic and transit systems, the roadside AVI/AVL readers will be upgraded to process identification information. The identification and time information will be processed at the transit management center to determine the County transit bus probe vehicle speed and link travel time. This information will be passed from the transit management center to transit users in the form of schedule adherence and expected travel time and arrival time data through a series of transit kiosks and an Internet site. The County transit management center will also pass probe data to the City traffic signal control operations in order to allow adjustments to signal operations.

The joint working group agreed to investigate the **Pre-Trip Travel Information, Traffic Control, Ride Matching and Reservation, and Traveler Services Information** user services to determine if their underlying requirements and physical and logical architecture definition could be used to support the planning and design of the project.

**Other Considerations**

The joint working group also identified several capabilities that might be included in the future.

- Inclusion of private automobiles into the mix of probes for determining travel link times.
- Capability to provide this information to the operations centers of other agencies.
- Potential for all transportation information (including transit-specific information) to be passed to an ISP for processing and dissemination. This would reduce the need for transit to purchase and maintain separate kiosks around the region and allow the information to be provided in a variety of other ways to travelers.

The County transit and City traffic agencies have agreed to investigate the use of ITS standards for communications.

### 2.6.2.3 Planning and Design

At this point, the County, as the lead in the project, procured the services of a consultant to plan, design and implement the solutions identified above. The joint working group asked the consultant to use the selection and tailoring of user service requirements as way to guide the development of functional requirements for the project. The Travel and Transportation Management user services that apply to this scenario are Traffic Control, Traveler Services Information, Ride Matching and Reservation, and Pre-Trip Travel Information. A Functional Description document was prepared from the objectives.

**User Service Requirements Illustration**

User services are defined in the National ITS Architecture Traceability document. As an example, a list of requirements from Appendix A of the Traceability document that defines the "Pre-Trip Traveler Information" user service in detail is provided below with the specific requirements selected to be applied in this design shown as bolded. Similar tables were produced for the other two user services that were investigated. Appendix B of the Traceability document was then used to select the process specifications (P-specs) that correspond to the selected user service requirements. These were used in the preparation of the Functional Description document, along with many additional locally derived requirements and operational concepts forwarded from the joint working group.

The physical data flows needed to implement the necessary portions of the Pre-Trip Travel Information user service were selected from Appendix A of the Physical Architecture document and were incorporated into the procurement specification by the consultant. An example of this is also provided below.

**1.1** PRE-TRIP TRAVEL INFORMATION (EXCERPT)

**1.1.0** Pre-Trip Travel Information (PTTI) [provides the] capability to assist travelers in making mode choices, travel time estimates, and route decisions prior to trip departure. It consists of four major functions, which are, (1) Available Services Information, (2) Current Situation Information, (3) Trip Planning Service, and (4) User Access. Information is integrated from various transportation modes and presented to the user for decision making.

...

**1.1.1.1 PTTI shall provide users with available services information that is timely.**

**1.1.1.1.1 PTTI shall provide users the latest available information on transit routes.**

**1.1.1.1.2 PTTI shall provide users the latest available information on transit schedules.**

**1.1.1.1.3 PTTI shall provide users with real time schedule adherence information.**

**1.1.1.1.4 PTTI shall provide users the latest available information on transit transfer options.**

**1.1.1.1.5 PTTI shall provide users the latest available information on transit fares.**

**1.1.1.1.6 PTTI shall provide users information on accessing ridematching services.**

**1.1.2 PTTI shall provide the capability for users to access information on the current condition of transportation systems.**

**1.1.2.1 PTTI transportation services current situation information shall be provided in real-time.**

**1.1.2.1.1** Real-time information provided by PTTI shall include the current condition of any incidents.

...

**1.1.2.1.4** Real-time information provided by PTTI shall include any currently recommended alternate routes.

**1.1.2.1.5 Real-time information provided by PTTI shall include the current speeds on specific routes.**

**1.1.2.1.6** Real-time information provided by PTTI shall include current parking conditions in key areas.

...

**1.1.3 PTTI shall include a trip planning service.**

**1.1.3.1** PTTI trip planning service shall provide the users with information needed for planning an upcoming trip.

...

**1.1.3.1.3 Based on user specified parameters PTTI shall provide users with real-time travel conditions for time of inquiry and estimated conditions for estimated time of travel.**

**1.1.3.1.4** Based on user specified parameters PTTI shall provide users with one or more alternate itineraries in addition to the primary calculated itinerary.

...

**1.1.3.3.2** PTTI shall consider predicted travel conditions when calculating a trip itinerary.

**1.1.4 PTTI shall provide the capability for user access.**

**1.1.4.1 PTTI shall provide the capability for users to access the system from multiple distributed locations.**

**1.1.4.1.1 PTTI shall provide the capability for users to access the system from their homes.**

**1.1.4.1.2 PTTI shall provide the capability for users to access the system from their place of work.**

**1.1.4.1.3 PTTI shall provide the capability for users to access the system from other major trip generation sites.**

...

**Physical Data Flows Required Selected from Appendix A of Physical Architecture. (Example)**

| |
|---|
| Transit Vehicle to Transit Management: vehicle probe data |
| Transit User to Remote Traveler Support: traveler information request |
| Transit Vehicle Subsystem to Roadway Subsystem: local signal priority request |
| Information Service Provider to Remote Traveler: traveler information |
| Transit Management to Remote Traveler Support: transit and fare schedules |

**Applicable Standards - Transit Communications Interface Profiles (TCIP)**
The TCIP standards development effort has been created to address the needs of the transit community. The primary goal of TCIP is to define the data interfaces among transit-related applications, and to facilitate the transmission of data between transportation departments, agencies, and management centers. TCIP will augment NTCIP with transit-related information. TCIP will define the information flows (message sets) needed to exchange transit information among roadside devices, transit vehicles, and transit operations centers.

In this scenario, TCIP protocols will apply to the transit vehicle to transit management center, and to the transit management center to traffic management center communication links.

**Advanced Traveler Information System Data Dictionary and Message Set**
This effort will define the data elements and messages related to traveler information systems. This includes kiosks, personal information devices, and trip planning. In this scenario, these messages will apply to the communication links between the transit management center and the traveler information display devices (transit information kiosks).

**2.6.2.4 Funding, Procurement and Implementation**
In consultation with the joint working group, the consultant then completed preparation of the design Plans, Specifications, and Cost Estimates (PS&Es). The City and County have decided to implement a transit vehicle probe system and will use TCIP as a standard for communicating information between AVL and the traffic signal control systems. The County will fund the development and installation of transit kiosks and an Internet-based application. It should be noted that Information Service Provider functions are being formed by the County transit agency. However, the open design of this installation opens the door for future applications where an ISP could take over traffic information dissemination responsibilities for the entire region. Figure 2.6-7 depicts the integration of the two systems which will enable the solutions identified by the joint working group.

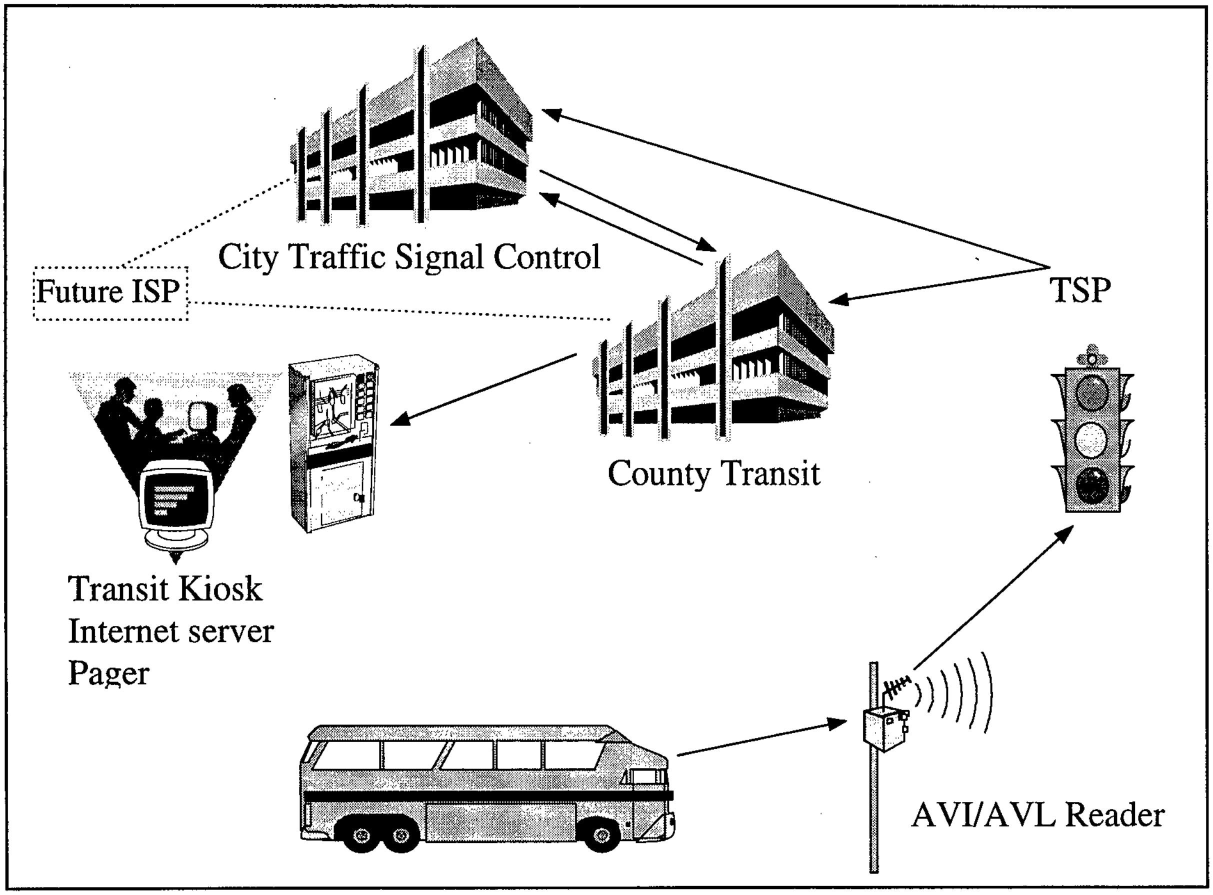


**Figure 2.6-7. Transit User Information System Scenario**
(TSP = Transit Signal Priority, ISP = Information Service Provider)

## 2.7 Summary

This section presented the key concepts of the National ITS Architecture and discussed in some detail how it can be applied to traveler information project development activities. Two traveler information project application scenarios were presented which used realistic examples to illustrate these methods.

**Some of the key themes of this section include:**

- The key concepts and elements of the National ITS Architecture as presented in Sections 2.4.1-2.4.5 are interrelated and traceable in a variety of ways.
- The National ITS Architecture tools are intended to augment and support existing ITS project development processes, and should be applied with engineering judgment in that context.
- There are many ways to apply the National ITS Architecture to the project development process.
- The National ITS Architecture tools are most applicable in the early stages of project development.
- The National ITS Architecture can be used to provide project developers with additional options to consider for information exchanges and functionality that may not have initially been conceived at the outset of the project.
- Using the National ITS Architecture should not be viewed as an all-or-nothing activity; rather, the material can be used as is, tailored, dropped, or added to as appropriate for the situation.
- The National ITS Architecture is available in several formats, including paper documents, Microsoft Access™ relational databases, and a linked HTML model, which provides access through a linked model.
- Several entry points or methods are also available which make accessing the applicable information more convenient.

A summary of how the National ITS Architecture can be used to support project development activities and the most relevant resource material is provided below:

### Identification of Needs or Problems (Section 2.5.1)

- ✓ The National ITS Architecture can assist agencies in identifying ITS goals and objectives that are specific to their needs.
- ✓ The Vision Statement can also serve to foster general ideas about the types of local needs and problem that ITS can be used to address.

Useful National ITS Architecture Documents: Mission Definition, Vision Statement

**Identification of Solutions (Section 2.5.2)**

- ✓ Agencies can use two major approaches for identifying possible solutions that are supported by the National ITS Architecture.
  - ✦ User Services
  - ✦ Market Packages
- ✓ Evaluation and Implementation Strategy documents have supporting information that can be referenced.

Useful National ITS Architecture Documents: Traceability Matrix, Implementation Strategy, Performance and Benefits Study

**Planning and Design of the Solution (Section 2.5.3)**

- ✓ The National ITS Architecture can be used as an input to defining project or system functional requirements. Potential approaches include:
  - ✦ *User service requirements* - The user service requirements associated with the proposed solution can be evaluated for their applicability to the project.
  - ✦ *Market packages* - The high-level architecture defined using the market packages can be further refined by examining the logical architecture elements that support these subsystems and architecture flows.
  - ✦ *Physical Architecture Subsystems* - Agencies can determine the relevant subsystems associated with a given project and use this as an entry point to accessing the underlying architecture definition.
- ✓ The physical architecture can be used to support the definition of the information exchange requirements for a given project.
- ✓ The Standards Requirements document contains detailed information on the requirements for 12 high-priority standards packages, which can be helpful towards the identification of standards for a given project.

Useful National ITS Architecture Documents: Logical Architecture, Physical Architecture, Traceability, Theory of Operations, Communications Document, Standards Requirements Document

**Funding, Procurement, and Implementation (Section 2.5.4)**

- ✓ The Cost Analysis can be used to help estimate planning-level costs for the project. These costs should be applied cautiously and should not be used as a recipe for determining the actual costs of ITS deployments.
- ✓ The evaluation documents and the Implementation Strategy can also be used as a general resource during this final phase of project development.

Useful National ITS Architecture Documents: Physical Architecture, Implementation Strategy, Cost Analysis

# 3. Regional ITS Planning

Just as individual highways fit into a larger regional transportation system, traveler information systems should fit into a larger regional transportation management context. Because the sharing of information between agencies and the coordination of operations are central characteristics of ITS, a regional approach is particularly desirable. Regional ITS planning activities and investment decisions should be carried out within the framework of the overall transportation planning process and need to be viewed in that context.

**Why is regional ITS planning a good idea[1]?**

- It provides a mechanism for bringing stakeholders together to address transportation operations and management issues of mutual concern.
- It promotes greater consideration of systems management and operations as part of a region's overall approach to meeting transportation needs.
- It facilitates decisions on which ITS services and strategies apply to local needs and transportation problems.
- It allows agencies to coordinate efforts such that future projects will be compatible, resulting in cost savings and easier integration of systems over time.
- It facilitates reaching agreements between agencies on future operational strategies and information exchanges to be pursued.
- It fosters consideration of and attention to detail which is required to ensure coordinated and cost-effective operation of ITS.
- It provides an opportunity to coordinate long term implementation of ITS and establish general deployment strategies and priorities.

The National ITS Architecture provides an excellent departure point for those engaged in a regional ITS planning process. The results of this process will set forth how individual transportation management systems operated by different agencies in different jurisdictions should work together to provide better transportation management and information services to the traveling public. These activities provide a framework for thinking about the needed relationships among institutions, as well as technical issues such as the information needs of each transportation operating agency, the sources of that information, and how that information can best be exchanged between the different agencies.

[1] **Adapted from "Integrating Intelligent Transportation Systems within the Planning Process: An Interim Handbook," TransCore, August 1997, pages 2-8 and 5-2.**

The processes discussed below provide a way of approaching regional ITS planning in a systematic way, using material from the National ITS Architecture as a guide and departure point. Use of these or similar processes in regional ITS planning, and following the processes discussed in Chapter 2 to develop individual projects, allows for sensible evolution of an improved regional transportation management system that will accommodate emerging national standards and best practices.

Ideally, the planning activities discussed in this section would be carried out prior to the implementation of individual projects as discussed in Section 2. Projects that are developed after regional ITS planning decisions have been made can be designed to implement a portion of the overall ITS strategy and can make use of the information exchanges already decided upon. However, regional ITS planning activities do not always occur prior to the implementation of specific projects. Projects that are implemented without the guidance of regional ITS planning can still make use of the National ITS Architecture as described in Section 2.

This section is not intended to cover all aspects of the transportation planning process and the activities and products which comprise it. For further information on how ITS should be included within the planning process, refer to the Interim Handbook on Integrating Intelligent Transportation Systems within the Planning Process (TransCore, August 1997).

Regional ITS planning can be done using a two-phase approach: 1) concept planning, and 2) implementation planning. The material that follows discusses the activities that are involved in each of these steps and points out where National ITS Architecture material can be helpful. For completeness, short sections are then provided for project deployment and evaluation, which are necessary to implement and monitor the effectiveness of the initiatives decided upon in the planning process.

## 3.1 Concept Planning

Concept planning addresses the questions of what transportation management systems and improvements are needed in the region, and how individual systems can be integrated so that individual agencies can do a better job of providing services to the public. Concept planning supports the development of a consensus for a regional transportation management strategy. A useful analogy is to think of it as a strategic plan. Strategic plan development is typically a participative process that results in a vision and strategy for the future for an organization. Similarly, regional ITS concept planning should result in a vision and strategy that reflects the needs of the various stakeholders in a region, and builds upon systems and relationships already in place.

Concept planning should consider the problems as well as the existing transportation goals and objectives of a region as determined through the transportation planning process, and use these as a basis to compile a set of relevant ITS or transportation management goals, objectives, and solutions. It may be advisable to revisit some of the assumptions in the existing plan, however, to see whether new players can be identified who have a stake in ITS, and to broaden the definition of transportation needs to account for the expanded capabilities of ITS. This periodic review and revision fits with the overall regional transportation planning process.

Typical steps involved in concept planning include:

- Stakeholder identification
- Identification of existing ITS or transportation management functions
- Identification of regional needs
- Identification of needed ITS or transportation management functions and improvements

Products of concept planning may include:

- A mission statement
- A vision statement
- Needed transportation management functions and improvements
- Assessment measures
- A strawman regional architecture

### 3.1.1 Stakeholder Identification

The list of stakeholders will naturally include all of the traditional transportation management agencies in a region, including the state highway or transportation department, county and city operating agencies, and public transportation agencies. The Metropolitan Planning Organization (MPO) is clearly also an important stakeholder. Effective transportation management planning also includes consideration of the views of other agencies, such as emergency service providers (ambulance, fire, police) and private traveler information service providers.

Concept planning provides stakeholders with a process for identifying transportation problems as well as potential ITS or transportation management solutions to the problems. Identifying what is needed before determining how to do it is an important aspect of both planning and systems engineering. Looking at needs from the perspectives of different stakeholders is necessary to ensure that the total requirements of a regional transportation management system are considered as the system concept emerges and projects are planned and implemented.

### 3.1.2 Identification of Existing ITS or Transportation Management Functions

This is a comprehensive inventory of existing and planned projects/systems in a region. Information sharing or integration with other systems, whether existing or planned, should be identified. Existing systems may be characterized by:

- The services provided
- The stakeholders involved and their responsibilities

- The technologies in place
- The control and communications structure within the system.
- The opportunity to include infrastructure into planned traditional transportation improvement projects (e.g., incorporating conduit into roadway re-construction jobs)
- Information flows, including both information sources and recipients
- Operating characteristics and responsibilities

### 3.1.3 Identification of Regional Needs

Regional transportation problems and needs that can potentially be addressed through ITS or transportation management solutions should be identified in the form of concise statements, such as reduce accidents at freeway ramp entrances, or improve detection of ice on bridges. These needs should be developed in the context of the needs, goals, and objectives already developed as part of the region's transportation planning process, because these have already been agreed on by the region's transportation stakeholders.

Specific objectives and measures of effectiveness (MOEs) can also be identified at this stage for use in future performance assessment. MOEs may be either qualitative or quantitative. Each objective identified through the concept planning process should have at least one MOE associated with it. The relative weights to be put on the MOEs by the various stakeholders may be quite different. The explicit assessment of these weights can form the basis for consensus building among the stakeholders to develop common goals and cooperative programs.

### 3.1.4 Identification of Needed ITS Functions and Improvements

Once needs have been determined, solutions can be identified. These solutions, or services, should be detailed enough to be useful in defining projects, identifying their interdependencies, and in guiding regional ITS architecture development. To facilitate the latter, the information sharing possibilities associated with each service should be identified. As defined in Section 2.5, ITS user services and market packages are useful categorizations that help identify transportation management solutions.

### 3.1.5 Concept Planning Products

As a method for documenting the outcome of the various steps discussed above, possible products from a concept planning effort include: a mission statement, vision statement, a regional ITS improvement plan, and a strawman architecture. As steps in regional ITS planning, these products begin to document the big picture of the future to guide future ITS project plans and implementations.

A *mission statement* is a concise, unambiguous statement of the primary goal or goals of the regional system. It should be brief, only a few paragraphs in length.

| Useful National ITS Architecture Document: Mission Definition |
|---|

A *vision statement* contains narrative text providing a non-technical description of the system concept from the viewpoint of various key user groups. It describes what the system will be like in the future, ranging anywhere from a 5- to 20-year period. It may highlight specific areas, such as information and communications; public transit; commercial vehicles; cooperation and coordination of systems; demand management; freeway management; incident management; and emergency services. A vision statement should use layman's language understandable to all stakeholders and may include magazine-style vignettes to convey descriptions of future scenarios for the general public.

| Useful National ITS Architecture Document: Vision |
| --- |

*A regional ITS improvement plan* can be in the form of tables that depict the region's transportation management goals, objectives and assessment measures; existing ITS functions or services that address these goals and objectives; new services or improvements to be provided; and the information sharing characteristics of each.

| Useful National ITS Architecture Documents: Mission Definition, Implementation Strategy, Traceability |
| --- |

A *strawman architecture* is a concept that helps to spur communication among those involved in the development of the regional transportation management system. It provides a starting point for discussions, development, and definition. This can take many forms, but typically represents an informal, immature view of the final implementation. It is based on experience and expertise gained from earlier system implementations, as well as current and future system requirements determined through the concept planning process.
A strawman architecture may illustrate:

- Transportation agencies and service providers involved with ITS deployment
- Applicable communications (center-to-center, center-to-roadside, center-to-vehicle, and vehicle-to-roadside) required to facilitate effective ITS
- Field ITS devices, both existing and planned

Figure 3.1-1 shows an example of a portion of a strawman regional architecture.

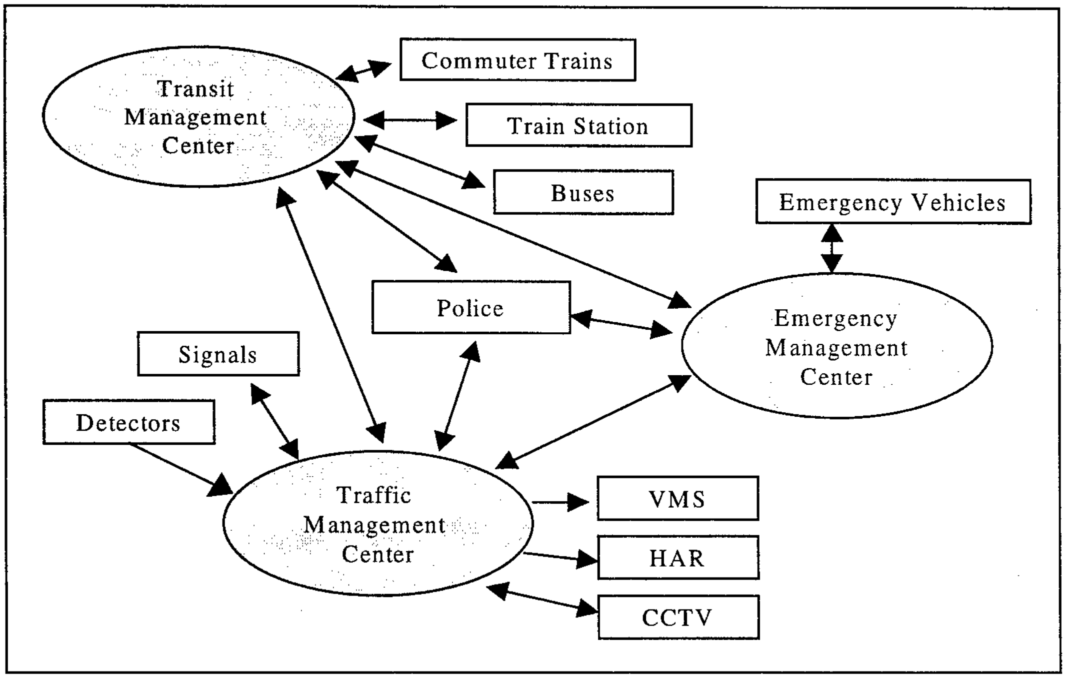


**Figure 3.1-1. Example Strawman Regional Architecture**

| Useful National ITS Architecture Documents: Physical Architecture, Implementation Strategy |
|---|

## 3.2 Implementation Planning

Implementation planning addresses the questions of how the stakeholder organizations in a region can organize to implement the results of the concept planning process. Just as strategic plans typically spawn an action plan, so should a regional ITS concept planning process lead to regional ITS implementation planning.

The steps involved in a typical implementation planning process may include:

- Stakeholder identification
- Development of a regional ITS architecture
- Identification of operational requirements
- Linking regional implementation plans with the region's transportation plan
- Time phasing of projects
- Developing regional technology agreements

The results of implementation planning will provide a roadmap for how to deploy an integrated, multi-modal transportation management system for a region. By identifying needed interfaces among systems in a region, agencies and service providers can incorporate them into their system requirements to accommodate integration with future ITS applications and systems. This prevents time-consuming and costly retrofits that might otherwise occur.

### 3.2.1 Stakeholder Identification

The development of an implementation plan should be supported by the same stakeholder organizations involved in concept planning. However, the representatives of these organizations that should participate in this stage will typically be individuals knowledgeable about the operations of the different transportation systems in the region. A structure that involves a steering committee, consisting of senior representatives from stakeholder organizations, and a technical committee, consisting of experienced operations personnel from these organizations, will serve the implementation planning process well.

Active participation during this stage is critical. Support will be needed for inclusion of ITS projects in the region's capital plan and, most importantly, to achieve buy-in to the operational concepts being formulated.

### 3.2.2 Development of a Regional Architecture

A regional architecture is a framework that provides a top-down approach for defining a regional transportation management system. A regional architecture will foster a logical and organized approach to regional ITS implementation and operation.

Regional ITS architecture development should build from the results of concept planning. The architecture should meld existing systems and services with new systems, services and improvements identified during concept planning. The regional architecture should:

- Identify the different transportation management systems in a region and how they will interact
- Allow multiple agencies, service providers, and users to communicate
- Show the responsibilities of the different organizations and service providers involved in the system
- Identify communications and data flows among participants
- Support development of open systems (i.e., systems with interfaces that use standard or known communications protocols)
- Incorporate the use of existing or planned systems
- Enable synergy among the different systems
- Allow for accommodation of new technologies in the future
- Provide a framework for multiple design choices
- Minimize ambiguity of system design

- Provide structure for future planning and growth
- Facilitate future system compatibility and interoperability

The architecture should identify all important physical transportation subsystems (by stakeholder/ agency) and external system interfaces and should show information flows between them. A functional description of each of the subsystems should also be developed. The architecture representation(s) should reflect both the existing and the proposed future ITS situation.

Using the logical and physical architecture concepts discussed in Section 2 and in the National ITS Architecture documents will assist agencies in the process of developing a regional architecture. Figure 3.2-1 shows how the physical architecture diagram from the National ITS Architecture can be used as the starting point for a depiction of a regional physical architecture.

The process of implementation planning will require that more detail on the interface requirements for each of the participating agencies be specified. Figure 3.2-2 shows an example of how the overall interface requirements vary among the four traffic management systems in a hypothetical region called Anytown. The architecture flows that are allocated are associated with the Network Surveillance, Regional Traffic Control, and Traffic Information Dissemination Market Packages. As can be seen, no two agencies have precisely the same set of allocated architecture flow requirements since each agency has individual needs and resources for ITS applications. Developing this level of detail will enable each participating agency to view how they fit into the overall transportation management picture in the region.

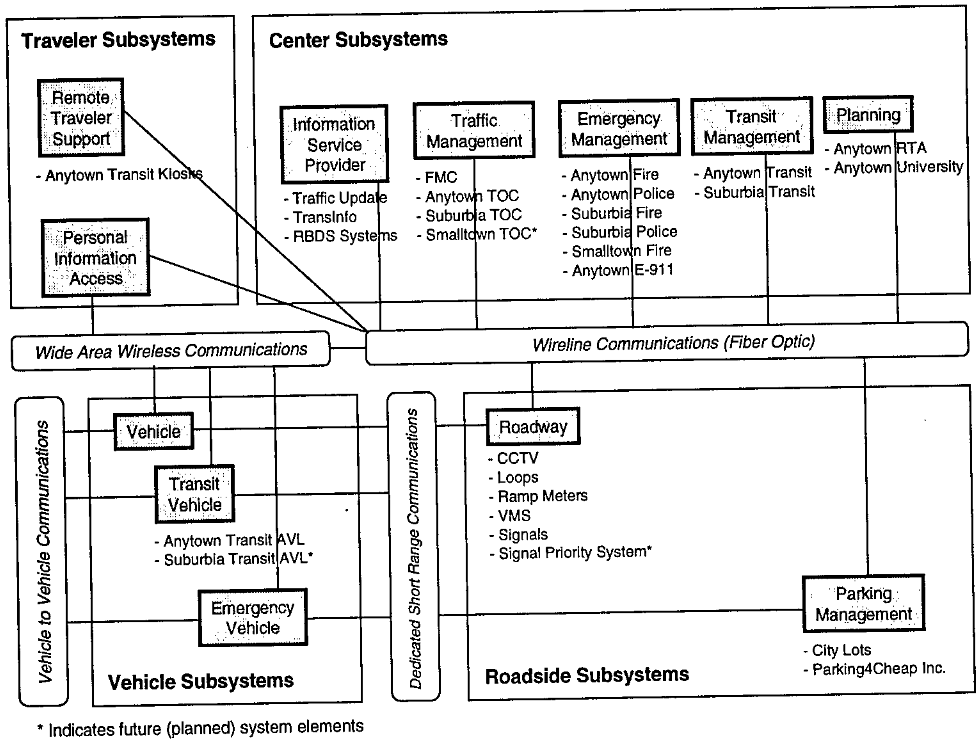


**Figure 3.2-1. Example Regional Physical Architecture**

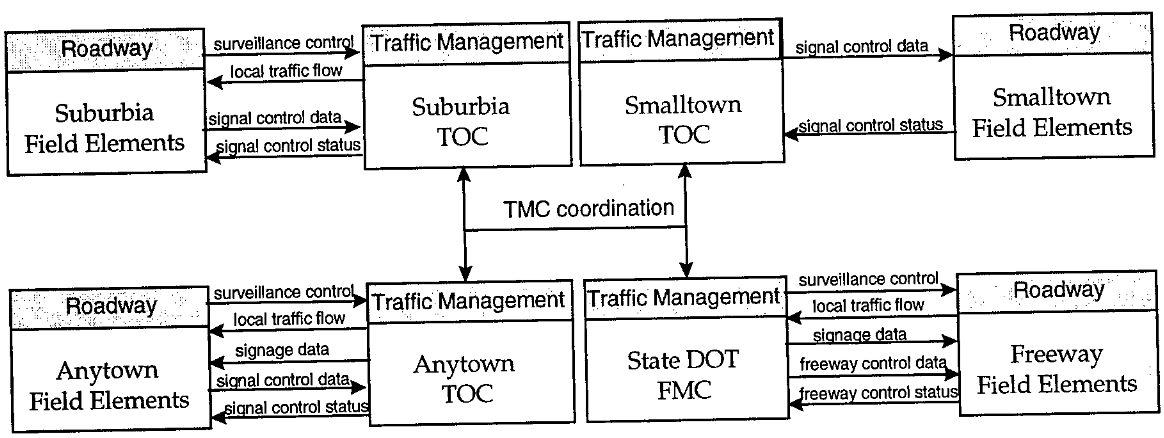


**Figure 3.2-2. Regional Traffic Control Architecture Flows Applied in the Anytown Region**

There are several ways to define the regional architecture at the appropriate level of detail by using the National ITS Architecture information as a starting point. One potential method is illustrated below:

## Using the National ITS Architecture to Guide Regional Architecture Development

1. Determine the general subsystems from the National ITS Architecture which roughly correspond to regional stakeholders or service providers and populate with actual agency names. More than one agency may be identified for each subsystem at this point. Figure 3.2-1 provides an example of this initial step. (Step 4 handles the case where stakeholders or systems don't map to - or are not addressed by - the National ITS Architecture)

2. Create a top-level physical architecture based on the identification of major information flows (architecture flows from the National ITS Architecture) between stakeholders that are consistent with the existing systems and the regional ITS improvement plan. This can be accomplished in several ways, depending on the extent of existing ITS services and information sharing and the level of detail and organizational approach of the regional ITS improvement plan. Two potential ways to do this are:

   (a) Look at the relevant interfaces contained in the physical architecture to determine and document the architecture flows which roughly correspond to the regional ITS improvement plan. Combine these into a single representation.

   (b) Determine which market packages most closely represent the existing ITS situation and the regional ITS improvement plan. Use the market package diagrams to identify and document the most relevant subsystems, architecture flows, and important external interfaces. Combine and consolidate these diagrams into a single view.

3. Reevaluate the physical architecture carried over from the previous step. Delete or modify the portions of the National ITS Architecture (information flows, subsystems, or external interfaces, or functions) which upon further review don't apply to the region or are not consistent with the regional ITS improvement plan.

4. Incorporate any auxiliary specific local requirements or issues (information flows, subsystems, external interfaces, or functions) which are not addressed by the National ITS Architecture that exist or are a part of the regional ITS improvement plan.

5. Add detail or create diagrams that show the interactions and information exchanges of specific agencies within the region, in accordance with the operations requirements or concept of operations (roles and responsibilities) decided upon. (See 3.2.3 for more discussion of operations requirements.) Figure 3.2-2 provides an example of this step.

6. Document the major functions carried out in each subsystem.

Useful National ITS Architecture Documents: Logical Architecture, Volumes 1 and 3, Physical Architecture, Implementation Strategy, Cost Analysis

### 3.2.3 Operations Requirements

A critical part of implementation planning is the identification of operational requirements of the planned systems prior to implementation. Development of operational requirements requires forward thinking by agencies and service providers. Issues to be addressed may include: the roles and responsibilities of the different organizations, development of a concept of operations, identification of funding requirements, interactions during incidents or special events, and other operations and maintenance (O&M) considerations. This includes establishing requirements or agreements on information sharing and traffic device control responsibilities and authority (e.g., deciding if back-up control capability is desired given a loss of power or failure condition). These decisions will be factored into the regional architecture and will also flow-down through ITS deployment projects as they are phased in.

Because many ITS services and strategies involve communication and coordination, this step of planning for operations cannot be overlooked. In the case of ITS, much more is involved than just thinking about how an individual project is to be operated and maintained (by a single agency) after it is constructed. The importance of this planning is that a shared operational concept will be established that will facilitate the future working relationships between agencies and service providers.

The concept of regional transportation management can significantly impact the O&M activities of agencies and traveler information service providers. In some cases, it may increase operations and maintenance costs with the introduction of additional equipment and new technology. Increased costs may arise from the need for additional staff (or staff training) to operate the systems and additional (and potentially more expensive) maintenance for these new systems. The increased investment in operations and maintenance should eventually result in lower user costs due to improved system efficiency.

Identification of O&M requirements is crucial to the success of a project. The development of O&M requirements should involve those most knowledgeable about these issues, namely the personnel responsible for day-to-day operations and maintenance activities in the different agencies.

The Theory of Operations document can be used to illustrate the sharing of information between subsystems which is relevant in determining the working relationships needed between different agencies in order to implement the planned ITS improvements. This type of information can be invaluable in developing an overall concept of operations.

| Useful National ITS Architecture Document: Theory of Operations |
|---|

### 3.2.4 Linkage to the Transportation Plan

Implementation planning describes how a regional transportation management system will evolve. Vital to this characterization is how to package this gradual evolution in terms of projects and funding. The transportation planning process addresses the relative priority of investments in various transportation improvements, and it is imperative that relevant information from implementation planning be considered as part that process. Potential opportunities for leveraging resources, such as adding ITS surveillance and communications infrastructure to facility reconstruction or capacity expansion projects already planned, should also be explored.

It is important that reasonable estimates of the benefits and costs of specific ITS or transportation management improvements be provided so that these improvements can be considered fairly as part of the transportation planning process. The National ITS Architecture development effort produced information that can assist that process.

#### 3.2.4.1 Benefits

The National ITS Architecture also contains material that identifies the likely benefits of integrating market packages and the context where these benefits may accrue. Tables showing the likely benefits and context where benefits may accrue for each market package are provided in the Performance and Benefits Study and the Implementation Strategy. Additional resources for ITS benefits information are listed in the References section.

| Useful National ITS Architecture Documents: Performance Benefits Study, Implementation Strategy |
|---|

#### 3.2.4.2 Costs

As a tool to assist in the estimation of costs, the National ITS Architecture documentation contains a series of spreadsheets. Although these should not be used for actual project cost estimation purposes, they are useful to help agencies estimate ballpark costs for planning purposes. Examples of how these spreadsheets can be used to estimate costs of market packages were provided in Section 2.6.

| Useful National ITS Architecture Document: Cost Analysis |
|---|

<u>Financial Opportunities and Constraints</u>

Linkage with the capital plan will also require analysis of revenue sources and benefit streams associated with the regional system implementation. This step is where the potential role for public/private partnerships can be considered and weighed.

The physical architecture identifies the interconnections among different transportation subsystems and can assist agencies in determining common components of systems. This may point out opportunities for sharing resources. Common examples include a communications infrastructure, surveillance devices, and traveler information systems. An individual agency may be able to reduce costs by sharing these components while minimizing capital and operating costs.

| Useful National ITS Architecture Document: Implementation Strategy |
|---|

### 3.2.5 Time Phasing

Because it is unlikely that an entire regional transportation management system will be deployed under a single project, implementation planning should also address prioritization and time phasing of projects. This can be based on a number of criteria such as political issues, cost, amount of impact, and user visibility. The first components that should be implemented are generally those that:

- Fulfill common functions such as surveillance and communications
- Have the potential to provide early visible benefits to the user such as reliable traveler information

Projects need to be defined in sufficient detail so that benefits and costs can be reasonably estimated. Other elements of the candidate project definition include identification of funding sources, both for capital and recurring operations and maintenance costs, and identification of potential implementation impediments.

### 3.2.6 Regional Technology Agreements

A review and assessment of existing and emerging technologies should also be conducted to allow agencies to make good choices among the different technology or deployment options. For example, regional choices on technologies or standards may be required for the telecommunications infrastructure, electronic toll tags, traveler information message formats, signal controllers and interfaces, electronic fare media, and specialized mobile radio systems.

Standards should be identified to provide for interoperability of systems and interchangeability of components. Identification of standards should consider the current status of ITS standards development activities, and determine how and when these can best be incorporated into the designs of the regional system and individual projects. Establishing regional agreements prior to the issuance of national standards allows for compatibility of systems to be realized sooner at the local level. After national standards are completed for various interfaces, the regional stakeholders are likely to want to eventually transition to them (although not all interfaces will be the subject of a national standards activity and regional standardization may be sufficient in some cases). The benefits of using national standards include:

- Compatible and interoperable ITS deployments
- Lower deployment risks, thus stimulating public and private interest in ITS
- Reduced product costs by providing an incentive for multiple suppliers
- Widened markets for suppliers

Standards development is an ongoing process. As agencies and vendors become educated in the implementation of standards, the risk and cost associated with system integration should be reduced.

It is sometimes difficult to identify which standards exist and are relevant. The following four-step process is recommended for choosing the appropriate standards:

1. Develop the regional architecture. Major interfaces and the interface requirements will be defined as part of this step.

2. Review publicly available information on ITS standards to determine the status of standards work that is of interest. (See Section 5 for more details on where to find this information).

3. Talk to the organizations involved in relevant standards work, such as AASHTO, the Institute of Transportation Engineers, the Society of Automotive Engineers, ITS America, and other standards developing organizations.

4. Select the standards that specify each of the major interfaces of interest.

Regional technology agreements may also specify design options to be followed. Tables provided in Section 4.5 of the National ITS Architecture Implementation Strategy outline some of the major design options for each of the market packages.

| Useful National ITS Architecture Document: Implementation Strategy |
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## 3.3 Project Deployment

Regional concept and implementation planning leads to project deployments that fit within a regional transportation management context. Material in the National ITS Architecture documents also provides agencies with insight on deployment issues, as discussed previously in Section 2.

Project deployment includes detailed design development, procurement, and implementation. Deployment may also be linked with other capital improvements, such as including conduit for communication links in roadway re-construction projects. Some helpful project deployment hints are provided in Section 4 of this document.

## 3.4 Evaluation

Evaluation involves measuring and documenting the quantitative and qualitative impacts and benefits that are derived from the proposed implementations. An ongoing evaluation process should be developed that allows for assessment of progress against the measures of effectiveness developed in the concept planning stage.

It can be very difficult to measure quantitative benefits of many ITS services and improvements because of the uncertain nature of travel demand on any given day at any given time. Consequently, qualitative and anecdotal measures can be very useful in illustrating the benefits of many ITS services, especially to agency decision-makers and political representatives.

| Useful National ITS Architecture Documents: Performance and Benefits Study, Evaluation Results |
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# 4. Lessons Learned / Best Practices

This section provides some advice from experience on how to best develop and implement advanced traveler information projects from agencies that have developed and implemented ITS projects, or are currently developing or implementing ITS projects. Information contained in this section was derived from phone interviews, focus group sessions, site visits with agencies, and from the experiences of several consultant organizations. The lessons learned and best practices in this section are not intended to be guidance or direction from DOT, but are provided as helpful information.

## 4.1 Coordination and Teamwork

Teamwork and coordination, involving all stakeholders, plus selecting and empowering the right kind of program manager and staff, may very well be your key to success.

| *Coordination and Teamwork may be your Key to Program Success* |
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### 4.1.1 Regional Coordination

Advanced traveler information systems must be cooperatively defined and operated in a coordinated manner with other transportation operating agencies in the same and neighboring jurisdictions, with transit operating authorities, with emergency services providers, and with other entities whose operations may be impacted by the operation of the traveler information system. Information sharing with these agencies will be critical to providing information needed by travelers in your region. This will call for use of the team approach, involving as many of the stakeholders as possible, in the development of the program and individual projects, and a building of trust and working relationships throughout the process, all of which must be carried forward into the actual operation of the system if full benefits to the public are to be realized.

**Some key lessons and best practices:**

- Include all stakeholders in regional planning and project development phases of ITS programs, including traveler information projects.
- Determine interest of private parties for participation in a traveler information system venture. To ensure fairness, an RFI to determine interest may be needed. The RFI must query interest, resources, experience and skills covering both the capital acquisition and the operation and maintenance phases. It should solicit recommendations on characteristics of a possible public-private partnership and should provide reasonable bounds on the parameters and expectations of any public-private partnership for the traveler information system.
- Identify an ITS advocate in every key agency as a means to facilitate inter-agency cooperation.
- Foster inter-jurisdictional, inter-agency, and inter-departmental cooperation.

- ✦ Try to identify representatives for each major stakeholder at three levels, policy, management, and technical, to participate in those levels of stakeholder participation. Policy level is needed for top level steering. The management and technical representatives are needed to participate in regional planning with a decision making body and technical support committees. This involvement is a key to success of regional coordination.

- ✦ Address information-sharing issues up front. Partners' roles and responsibilities need to be clearly defined early in the planning stage.

- ✦ The private sector generally needs to see a good potential for a reasonable return on its investment in order to make a long-term commitment.

- ✦ Direct focus at current and potential ITS projects rather than at broad ITS themes.

- ✦ Keep open lines of communication between all stakeholders during every project phase.

- ✦ Involve police and other public safety agencies early in the planning/development process.

- ✦ Visit traffic operations centers and traveler information centers in other metropolitan regions to learn about the benefits of ITS projects. Use the information gathered to get buy-in from agency decision makers and other stakeholders. Even better, get the decision makers to make the visits and see the benefits for themselves.

- ✦ Address the region's needs in ITS projects, rather than just deploying technology for technology's sake.

- ✦ Perform public outreach. Emphasize the cost savings, travel time savings and safety improvements benefits of ITS projects to justify ITS to the public. Consider outreach activities to educate individuals/agencies on becoming informed consumers of ITS and the benefits that they can bring to transportation systems in their region by means of:

    - Training courses
    - Awareness seminars
    - Workshops
    - One-on-one support
    - Experience sharing
    - Guidance documentation
    - Conference/committee meeting presentations

- ✦ Prime considerations when deciding to deploy ITS include the competitive advantage it offers in attracting new business, expanding current business, or improving the quality of life of a region's constituents.

- Share the cost of ITS project staff, facilities, and equipment with other ITS stakeholders in your region. The term for this is "Resource Sharing." The potential benefits to all ITS transportation stakeholders will help encourage this resource sharing.
- Consider the time required to get a Memorandum of Understanding (MOU) developed and signed by all major stakeholders in any planning. Legal issues take a considerable amount of time to resolve.

It is important to appreciate the fact that ITS deployment programs differ in many respects from the traditional highway and street projects which state and local DOT's have for many years developed, constructed, and maintained. It follows that the *process* through which ITS programs are developed must also differ from that which has been used in the past.

> *An open development process, involving all stakeholders, featuring the team approach and leading to the building of consensus, trust, and good working relationships, is essential.*

This building of consensus, of trust, and of working relationships will all take special effort on the part of those developing the program; it will consume more staff time and will significantly lengthen project development time. However, it is essential for success. As noted in Sections 1 and 2, use of the National ITS Architecture tools can help to offset the additional time by savings in staff time and project development time.

### 4.1.2 The Program Development Team

It is important that support for ITS traffic management programs be built and maintained as the development process moves along. This support will be vital as various approvals are sought including approval to include the program as a part of the Regional and State Transportation Improvement Plan, approvals for funding, and approvals of individual projects. That support will also be vital as the program moves forward into procurement, through system integration and into actual operation, for highly successful operation will only be achieved through a spirit of cooperation and accommodation, through the coordination of activities of the many operating entities. And the best way to develop and to maintain that support is through a continued involvement of the many stakeholder entities throughout the entire development process. This group of stakeholders can be referred to as the Program Development Team.

> *Develop a broadly based Program Development Team involving as many stakeholders as possible. Keep the Team actively involved throughout the development of the program; let the Team share in the ownership, the responsibilities, the credit associated with the program.*

The role of the team in the development of the program is a critical consideration. Let the team members help in shaping the program; let the team members be a part of moving the program forward; let the team members feel a sense of ownership of the program and a responsibility for the program; let the team members share in taking credit for the success of the program.

**Some key lessons and best practices:**

- Involve the public and private stakeholders throughout the program development process, although staff should become more technical or more detail oriented as work progresses from concept planning to implementation phases.
- Form separate, but coordinated groups within the Program Development Team to address planning, design, procurement, and operations.
- Carefully define group charters and objectives to heighten productivity and speed results.
- Share project successes and credit for successes.

### 4.1.3 The Program Manager

Many operating agencies that have successfully deployed and operated ITS programs have attributed much of their success to a common key point, the presence of a "champion" - a person who fully understands the benefits that can accrue from the program, one who is fully committed to the program, one who is willing to "go the extra step" to see the program fully deployed and operational, and one who is skilled in convincing others of the value of the program.

**Some key lessons:**

- Ensure continuity of project management.
- Select a well-qualified program manager.

The program manager should have a background in transportation engineering and in traffic management. Training in systems engineering and program management disciplines would be beneficial. He/she should possess both communications and people skills, as well as being computer literate. It is important that the "champion" hold a relatively high position within the organization with direct access to a decision-making level of authority, and be respected both within and outside of the organization.

*Assign a well-qualified "champion" as Program/Project Manager.*
*Program management continuity will be crucial to program outcome.*

### 4.1.4 Staffing the Program

Selection of the key staff to support regional transportation planning and to perform the project development work is very important. Some of these must be staff that have basic transportation management experience and may be trained to achieve some basic knowledge of National ITS Architecture application.

**Some key lessons and best practices:**

- ✦ Address staffing issues early. Prior to the start of an ITS project, ensure that adequate, technically qualified staff are available to work with the project manager.
- ✦ Involve a responsible point of contact in the personnel organization that governs hiring as early as possible.
- ✦ Do not underestimate the time requirements involved in the training of public agency staff.
- ✦ Involve operations and maintenance personnel in all phases of ITS project planning and deployment so that their roles, responsibilities, and needs are accurately defined and addressed.
- ✦ Include procurement personnel at the beginning of the project. Procurement is as important a phase of the project development as the design and build phases.
- ✦ Involve legal staffs early in the process to prevent fatal flaws such as non-conformance with federal, state, and local laws and regulations.

## 4.2 Project Development Process

Fundamental steps used by transportation agencies in the formulation and implementation of projects involve assessing problems or needs, the search for and selection of a solution, design of the project, and finally, the funding, procurement and implementation. These are the same process steps described in Section 2.

### 4.2.1 Identification of Needs or Problems

In developing any ITS project, one must keep in mind the age-old axiom: Let the problem drive the solution.

**Some key lessons and best practices:**

- ✦ Get ITS buy-in early from upper management (agency decision makers) and mid-level management (project implementers). In particular, apprise them of the needs or problems being addressed
- ✦ Gaining consensus on the project definition, users, user needs, and user requirements can take several passes.
- ✦ Consider use of focus groups to help determine users, user needs, and technologies involved.

- ✦ Do not rush the project requirements phase. A one-month delay early in the project (during the requirements definition phase) may prevent a one-year or several year delay, resulting from incomplete requirements and specifications, in the future.

- ✦ Gaining consensus on the project definition, users, user needs, and user requirements can take several passes. Take the time needed to review important project requirements. Allow the engineering consultant or support contractor at least two reviews (one draft, one final) to develop the user requirements/equipment specifications. Allow sufficient time for a comprehensive review between draft and final versions of specifications and requirements.

A thorough analysis of the operational problems being experienced needs to be made early in the process. The exact nature, the magnitude, and the extent of the problem; and the conditions that are causing the problem, need to be fully understood before even beginning to consider the solutions.

*Use a needs-driven approach in developing the program and always LET THE PROBLEM DRIVE THE SOLUTION.*

This needs-driven approach becomes particularly important in ITS projects. It has been noted all too frequently that, in the consuming drive to bring high technology systems to the transportation scene, the process has been reversed, resulting in an approach in which one finds high technology "solutions" in search of a problem. This can result in a high cost project that falls short of doing the job that needs to be done.

### 4.2.2 Identification of Solutions

As a first step in the development of solutions, key individuals involved with the program should become thoroughly knowledgeable on what solutions (generically) have worked for others. It is also important that staff be aware of those which have <u>not</u> worked and why they have not worked. There are several ways to do this and possibilities include: communicating with other agencies who are operating ITS applications, attendance at Federal Highway Administration and Federal Transit Administration courses, a review of the literature, attendance at seminars, workshops and conferences covering the subject, and seeking advice from your FHWA Division or FTA Region Offices. Courses may be provided as part of the ITS professional capacity building program: see the Office of Traffic Management and ITS Application web page at <http://www.fhwa.dot.gov/hst/pcb/itscord1.htm>. Whatever the means, getting key project staff "up-to-speed" on ITS applications to traveler information systems and how they may help transportation management problems is a critical activity that must be carried out.

The project staff that are knowledgeable of ITS traveler information systems and the support these systems provide for solutions to transportation management, including traffic signal control, problems must be engaged in identification of the more favorable traveler information solutions to the transportation problems being addressed. From this list of solutions, the trade-offs of costs and benefits plus any other impacts and considerations of the solutions such as impact on maintenance and operations staffing and costs, should be addressed and recommendations prepared. The recommendations coming out of this activity will be a key input to transportation planning process, see Section 3.

**Some key lessons and best practices:**

- ✦ One method recognized as a way for agencies to get over resistance towards ITS technologies was to provide upper management with real examples of successfully deployed ITS projects. Example projects presented to this audience should relate the unique transportation challenges that are experienced by the given region. It is critical that initial ITS project deployments be those that will provide immediate, visible, and significant benefits. Failure to deploy ITS projects that provide these types of benefits will greatly increase the challenges of securing funds for future ITS projects. It is also important that ITS projects to be deployed relate directly to the transportation goals of the region, rather than just deploying technology for the sake of technology.
- ✦ Outreach to the public was also identified by another agency as an important component of the program. The agency indicated that emphasizing cost related benefits of ITS projects is the best way to win public support.
- ✦ Complex projects require flexibility by all parties, and participation by all parties is critical to success.
- ✦ Consider operational and maintenance impact as well as capital cost and potential benefits.
- ✦ In developing traveler information systems, one of the most important areas to focus on is Consumer Acceptance, involving the following factors:
  - Traveler information must be timely, accurate, relevant, and reliable.
  - Most traveler information consumers would be unwilling to directly pay for traveler information alone, unless it offers a significant improvement over the traveler information that would be available free-of-charge.
  - Many TIS consumers find traveler information an attractive feature when it is bundled with for-pay services (e.g., stock quotes, weather, sports scores, yellow-pages information, etc.).
  - Travelers are generally more interested in having traveler information for long-distance trips or for travel in unfamiliar areas.
  - Travelers are generally less interested in having traveler information for local or familiar trips. However, travelers are interested in avoiding any extended delays or other inconveniences.
  - Travelers are generally more interested in having en-route information than in having pre-trip information.

### 4.2.3 Planning and Design of the Solution

Detailed design of the project should proceed based upon those system characteristics which have been defined in the solution definition and analysis. During the project design phase, as the full implications of using specific hardware/software systems come more into focus, it may be necessary to rethink some of the decisions made in prior planning. It is fully appropriate—in fact, it should be viewed as a responsibility—to make trade-offs and appropriate changes in the project at this point in the project development process. Some of these trade-offs will be in traveler information system configuration alternatives as described in Section 2.

There are two general approaches which have been taken by agencies in deploying ITS projects, and thus, in the defining of the project to be implemented: (1) the full deployment approach in which the entire system is deployed under one construction contract, one design-build contract, or one system manager contract and (2) a staged project approach in which separate contracts are awarded for the construction of a number of stand-alone subsystems, which when completed, will comprise the comprehensive ITS system.

The "Full Deployment" procurement approach generally requires funding for the deployment of the traveler information system in its entirety under one contract, but the contract could be a series of separately priced options. This approach will generally produce the entire system as a whole, rather than as the combination of a series of individually contracted sub-systems. With one contractor having responsibility for the entire system, the integration problems should be minimized, thus helping to ensure interoperability. The traveler information system must be integrated with a number of other systems in the region in order to establish the necessary information base.

Under "Staged," "Incremental," or "Evolutionary" approach, a series of projects, each consisting of a stand-alone subsystem capable of delivering benefits, are constructed under separate contracts over a period of time. Each subsequent sub-system is integrated with those which have preceded it, evolving into the comprehensive system. For example some of the information sources, the information analysis, and the traveler information distribution methods could be phased in over time and the implementation of some value added features could also be phased in over time. One of the major areas that must be addressed up front is definition of the communications facility or capability that will handle the long-term needs of the traveler information system. The greatest risk of the staged project approach has to do with those problems associated with the integration of new systems with those which are already on-line, and with the assignment for accountability of that function. When the traveler information system can't be integrated with a vital transportation information source, and one or both systems have to be modified, the costs may increase substantially. However, there may be advantages. Available funding levels may be less of a problem, as capabilities to match available funding levels can be spaced out over a period of time. There is the opportunity to select "winners," those projects on which there is a high probability of success, as early projects with very visible benefits. However, the evolutionary approach delays the full benefits needed to attract and build a sound customer base for the traveler information services and products.

**Some best practices for defining the project:**

- One method recognized as a way for agencies to get over resistance towards ITS technologies was to provide upper management with real examples of successfully deployed ITS projects. Example projects presented to this audience should relate to the unique transportation challenges that are experienced by the given region. It is also critical that initial ITS project deployments be those that will provide immediate, visible, and significant benefits. Failure to deploy ITS projects that provide these types of benefits will greatly increase the challenges of securing funds for future ITS projects. It is important that ITS projects to be deployed relate directly to the transportation goals of the region, rather than just deploying technology for the sake of technology.
- Outreach to the public was also identified by another agency as an important component of the program. Agencies have indicated that emphasizing travel time, safety, and cost related benefits of ITS projects is the best way to prove the worthiness of ITS to the public.
- Complex projects require flexibility by all parties, and participation by all parties is critical to success.
- Local ITS planning (e.g., Early Deployment Plans) must be integrated into a larger regional transportation planning process (e.g., Statewide Transportation Improvement Plan) as part of the ITS mainstreaming process, see Section 3.
- Have a firm idea of what you want the system to do in terms of needs, expectations, functionality, performance, and capabilities. Examine previously deployed systems to help identify needs relative to local or regional problems.
- Plan for an open, modular system.
- Foster ITS awareness, in particular, with regard to integrating the TIS with many other systems.
- Knowing exactly what the system should do will also strengthen the justification for the system when it is presented to decision-makers for approval.
- Design the system to meet identified needs and capabilities by analyzing the system to determine if it is really what the agency needs. Solicit input from all project stakeholders in order to obtain multiple views/various perspectives of the system. Take adequate time to design the system so that it fully meets the needs of the consumer.
- Implementing ITS does not require an agency to change or modify any legacy systems and/or equipment, nor does it mean that an agency has to lose its current investment in a present transportation solution.
- The planning process, which currently tends to be focused in the transportation community on capital improvements, must be modified to consider day-to-day operations and funding required to carry them out.
- Be realistic about your capabilities and get help accordingly. Use integrators and consultants to assist in the project.

- ✦ Conduct a communications study to make sure that future requirements are accommodated by the system design (i.e. number and type of devices: computers, cameras, etc.). Communications analysis can easily be overlooked when most of the design discussions center around the central computer/traffic management center/traveler information center needs and field element considerations. Overlooking the importance of communications can be a costly mistake for replacement of inadequate communications.

- ✦ Do not rush the project planning, requirements, and specification phases. To avoid delays during the development and installation phases, define the project requirements clearly. Also design to the needs that have been defined. Always keep the needs that have been defined and approved through the planning phases sharply in focus. Initial traveler information system deployment should address services and products appealing to the largest group of consumer and must provide realizable benefits to those consumers. Initial failures resulting in rejection and criticism by consumers will be hard to overcome.

- ✦ In order to ensure the reliability and functionality of enabling technologies, it is recommended that the agencies developing ITS applications fully investigate previous applications of candidate technologies in real world applications. These investigations should include discussions and/or site visits to agencies that have previously deployed the technologies. It is also important that these investigations be carried out independently of any vendors.

- ✦ Evaluation Design:

  - Demonstrable benefits are critical to participants in order to demonstrate their return-on-investment for both Public and Private Partners. This could be essential for obtaining support for future related projects. Measurable benefits to the traveler are necessary for growing the traveler information customer base. In most cases, the customer perception of being benefited through avoidance of significant delay may be valuable, but difficult to quantify.

  - The evaluation process should be initiated during the project planning phase. Evaluation contractors should be brought on-board early.

  - In order to be effective, the evaluator must be given the opportunity to influence the system design so that the system will accommodate the measurements needed to conduct the requisite analysis. Benefits analysis usually must involve before and after data.

  - The evaluator should be under direct contract to the lead agency or partner.

  - When reasonable, ensure that national goals as well as local goals and objectives are evaluated.

- ✦ Avoid closed proprietary systems (whenever possible). Instead, use an open systems architecture to:
  - Promote interoperability.
  - Promote modularity.
  - Support one product from multiple vendors.
  - Accommodate diverse geographic settings and variations in local environments.
- ✦ Use standards (whenever possible) to promote interoperability and prevent obsolescence.
- ✦ Use the National ITS Architecture as a design framework to:
  - Coordinate design with other ITS systems.
  - Accommodate future applications/interfaces between TIS and other systems/subsystems.
- ✦ Define functional requirements and performance standards for all system components.
- ✦ Vendors should furnish all of the necessary system documentation including detailed functional requirements; system design reports; system configuration diagrams; interface specifications; product/hardware/software documentation; test specifications and test procedures; and operator manuals, user guidelines, and Standard Operating Procedures (SOPs).
- ✦ Material presented on an in-vehicle display should be consistent with the corresponding material displayed on road signs.
- ✦ Build only what you can realistically maintain. During the design and build phases of the project, make sure you keep an eye on realistic maintainability/reliability expectations. The system's final state should be defined and the system developers should stay focused on the requirements of the final product, not just the next deliverable.

It is essential that ITS systems be designed to do the job needed to solve the local and regional transportation problem, to provide for compatibility of operation with a variety of other systems being operated by other transportation-related entities, to provide for interoperability with those other systems, and to be designed so that they can be reasonably modified and/or expanded in the future.

## 4.2.4 Funding, Procurement and Implementation

### 4.2.4.1 The Schedule

The schedule must be well thought out, be realistic, clearly show task inter-relationships, and be in a form which can be easily communicated and understood. It must have the commitment of the project team. It should be used on a continuing basis as one of the most powerful tools in managing the project. All reasonable steps should be taken by all parties to adhere to the schedule. It should be up-dated and adjusted when slippages do occur.

**Some key lessons and best practices:**

- ✦ Do not adopt an optimistic schedule.
- ✦ Define frequent and realistic milestones to use in assessing progress against the schedule.
- ✦ Unambiguously define all milestones.
- ✦ Define each milestone so that reaching it is clearly identifiable.
- ✦ Make reasonable efforts to keep the project on schedule. However, never cut schedules for reviews of design documentation, for preliminary and final design review presentations by the contractor, for system integration, or for thorough testing, in the factory, at the first field site and at every field site. When needed to preserve these critical activities, extend the schedule.

#### 4.2.4.2 Funding the Program

Obtaining funding for the project is one of the most critical responsibilities of the project manager and his/her higher management. It is essential that he/she "think funding" from the inception of the program, seeking out every opportunity to secure funding from a variety of sources for the various elements of the overall program. One goal should be to secure funding from a number of sources—the more the better—for the commitment of funding assures that there is a support for the overall program from that funding source. For traveler information systems projects, it is important to further leverage public funds with private party funds for capital, operating and maintenance costs.

**Some key lessons and best practices:**

- ✦ Commitment of capital funding as well as operations and maintenance funding from private sources, through public/private partnerships or other arrangements, thus leveraging the public funds, further strengthens any ITS program insofar as competing for funds from public sources. Also, the higher the federal match and the private partner investment, the more likely the project will be included in the capital improvements program.
- ✦ Share your funding experiences for design, construction, operations and maintenance.
- ✦ Share your experience using Federal-aid funding for operations cost and how to work with your metropolitan planning organizations (MPOs) to get their support.
- ✦ Shortages of funding are common, as a result of stiff project competition (primarily traditional non-ITS projects); budget cuts; capital vs. operations and maintenance budgets; and operations and maintenance cost increases.
- ✦ Maintain a realistic assessment of funding.

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| *Develop a broad-based funding package, with funding coming from as many sources as possible.* |

It is important that the project get into the programming process as early as possible in the project development phase, in order that funding will, in fact, be available at the time the project is ready for construction. While many ITS projects in the past were funded without going through the Transportation Improvement Planning (TIP) process (since they were funded as under a research or operational test environment), steps should be taken to have the project included in the TIP, in order to ensure eligibility for funding. Projects need to be entered into the programming stream to obtain funding from other sources.

*Identify funding sources, and carry projects into the programming processes at the earliest possible stage of project development. Secure approvals for staffing levels to operate systems and for funding to cover other on-going operating and maintenance cost.*

#### 4.2.4.3 Agency / Contractor Interaction and Other Issues

Many agencies strive to keep the contractor "at a distance" which would work well in a perfect world where requirements are perfectly described and understood and where the contractor's design is perfectly described and understood. Lacking this perfect world, developing a cooperative working relationship between agency and contractor is most likely to yield a system that meets agency requirements. In such a relationship, it is appropriate that rules be established to limit information going to the contractor from agency staff and other agency representatives to "interpretations of the requirements," and within the contract scope. Included must be the admonition that only through contracting officer direction may the scope of the contract be changed.

**Some key lessons and best practices:**

- Don't simply take a vendor's or contractor's advice or word on the capabilities of a system or piece of equipment. Ask them: "Has the (system/software/equipment) been used in a traveler information system application before? Has the (system/software/equipment) been used to perform this (task/function) before?" Be sure to obtain references as to where these applications were and what agencies were involved and then talk to those references.

- Make sure the company from which you are purchasing services or equipment from is financially sound. Check business and technical references. Talk to others in the field who have done what you are planning to do.

- Maintain focus on the system's final configuration definition. Keep the system developer's focus on the requirements of the final product, not just the next deliverable.

- Take the time needed to review important project requirements. For larger projects, allow the contractor/equipment vendors at least two passes (one draft, one final) to develop the user requirements and the equipment and software specifications. For smaller projects, one pass may suffice. Arrange in the contractor's work statement for audio/visual presentations of the draft and final designs to agency staff, plus other agency representatives and project stakeholders. This is helpful in identifying requirements misinterpretations.

- Allow sufficient time for a comprehensive review of draft and final versions of test specifications and test procedures.

- When significant amounts of software development are involved, arrange to have one or two key staff and expert software engineer representatives sit in on the contractor's internal software design walk throughs, since these cover how the system will work in some detail and may highlight misinterpretations.

#### 4.2.4.4 Managing the Program

There are many lessons that have been learned on ITS projects and on other kinds of projects, including those from program management efforts of other civil and defense agencies. Although most ITS projects are much smaller in scope than most defense projects, many of the lessons apply. Most of the system engineering tools that other agencies have used are beyond the scope of this document, but guidance on courses or seminars that describe application of system engineering tools to ITS projects is available from the FHWA Division or FTA Region Offices.

**Some key lessons and best practices:**

- Look for success stories in the ITS field prior to starting your ITS project. Learn from projects related to what you are trying to do—what are the benefits? Was it cost effective? Also check out the benefits reference documents. This will help you to support your project as it develops.

- Provide upper management and decision makers with real examples of successfully deployed ITS projects. This is a way for agencies to overcome resistance to ITS technologies. Example projects should relate to the unique transportation problems in your region.

- Use the design/build process to get systems operating early whenever appropriate. However, be cautious about using a design/build process that involves any significant amount of development, see also Section 4.3.2 on *Selection of the Contracting Approach*. It is also important to separate the design aspects of the project from the build by thorough review of all design aspects of the project as milestones separating the phases. The review time required for a design should not be underestimated.

- Manage project and system expectations. They need to be realistic and achievable with available funding, time (schedule), and staffing.

- Emphasize consensus and coordination as keys to project success.

- Exceeding the costs estimated for software development is highly probable and a major problem in the industry. Cost overruns are common in ITS projects. Agencies need to be prepared for these overruns by developing contingency plans. Contractors can only base realistic software development cost on accurate, detailed requirements specifications.

- Use technical proposals and preliminary and final design reviews to achieve compatible agency and contractor interpretations of requirements as early as possible. Differing interpretations will yield false starts and wasted effort, time and money.

- ✦ Share your successes, and share credit for your successes.

- ✦ Schedule project activities (e.g., meetings, teleconferences, etc.) with a great deal of flexibility to ensure stakeholder participation/consensus.

- ✦ As unanticipated problems occur, the schedule slips, staff once available become unavailable, budgets appear inadequate—a few words of advice:

  - Take a step back and take a look at the big picture to reassess where the project stands. Back away from trying to cope with numerous details and topics with which you may not be completely familiar.

  - Revisit your project plan. To help bring the project back on track, all parties involved will need to be honest about achieving project expectations, and about assessing what can be realistically accomplished with available resources.

  - Be reasonable about deliverables, schedule, scope, and requirements.

  - Focus on the system features that will bring the most benefit. Consider dropping less significant aspects of the project unless needed as basic building blocks for more desirable features.

  - Focus on what has been accomplished so far, rather than on how much is left to do. Other staff may need reassurance. Positive motivation can be very helpful to your team, and help you get through a crisis.

  - Create an environment that encourages solutions, rather than focusing on problems. Establish an environment in which your agency, the equipment vendors, and other contractors can cooperate to complete the project successfully.

- ✦ Document control is very important. Track and control project documentation. Use a numbering scheme, such as PROJECT-TASK-YEAR-DOCUMENT NUMBER-REVISION LEVEL.

- ✦ It is critical that initial ITS project deployments provide immediate, visible and significant benefits. Failure to do this will make it harder to secure funds for future ITS projects.

- ✦ Learn and share lessons from all projects. Create an environment where engineers from different backgrounds and projects have an opportunity to share their experiences with each other—begin a "brown bag" lunch program or project/technologies discussion group.

- ✦ Establish well-defined roles and responsibilities for all staff members early on. Match the project assignment to the appropriate staff. Determine staff expertise required and methods to retain key individuals/positions.

- ✦ Follow successful management techniques used elsewhere on projects of a similar nature.

#### 4.2.4.5 System Integration and Testing

Being very thorough in the integration and testing of your system will be as important, perhaps more important, than anything else you do on the project, including writing complete and accurate specifications. System integration and testing will be needed at different levels. During development, integration and test will be accomplished the first time and must be very thorough, testing against every requirement. Keep in mind that each requirement must be defined such that it is verifiable, otherwise it is a useless requirement. This testing may include rigorous testing, analyses and demonstrations. After passing development testing verifying that each requirement is met, acceptance testing in the field need not test every requirement, but must ensure that the deliverable is acceptable.

**Some key lessons and best practices:**

- Integration of existing/working technologies is hard enough without introducing new and untried technologies.
- Systems can be built incrementally, however, any necessary communications equipment needs to be in place for integration with prior and future increments.
- Integration needs to be done in a controlled environment (e.g. design or factory acceptance tests) to isolate problems and system bugs. Interfaces with some devices may have to be emulated for early integration efforts.
- It is important that all requirements be verified on the completed system wherever possible, since the integration of units and subsystems into the full system may produce interactions that disable or change some functionality or cause some performance requirement to no longer be satisfied.
- Do integration in steps – add one component at a time. Do not wait until the end of the project to integrate all of the system components, since it would be extremely difficult to isolate problems. Integration and testing can easily take 30-40% of the time and resources of a project.
- Take the time to thoroughly debug and test a few units in the field prior to deploying a large number in the field. Require contractors to successfully conduct acceptance tests on each major deliverable, witnessed by the agency's representatives prior to acceptance by the agency.
- When changes are made in some area of a design, keep in mind that there may be both desirable and undesirable consequences of the change that may ripple through the design, and testing must ensure that the device, unit, or subsystem still functions properly after the change.
- Use trained agency staff in hands-on roles for operational and maintenance testing, particularly final development test in the factory and final acceptance test at the few field sites. This must be written into the contract since contractors will otherwise not allow non-contractor staff to touch their equipment. Although the contractor may resist giving the agency staff any hands-on involvement prior to final acceptance, if those agency staff can break the system by using it, this must be found out before the contractor receives final payment and walks away.

### 4.2.5 Operations and Maintenance

As mentioned in several places above, the importance of operations and maintenance can not be over stressed. Operations and maintenance must be included in all phases of any ITS project from planning through design, integration and test, and into field implementation and beyond.

**Some key lessons and best practices:**

- Involve operations and maintenance personnel in requirements reviews, specification reviews and in preliminary and final system design reviews to keep them involved and to get their buy-in to the system.
- Secure/budget adequate operations and maintenance resources (e.g., staff, funding, time/schedule, etc.).
- Train system operators and maintenance personnel on the appropriate system operations and maintenance aspects in order to ensure successful system operations.
- Perform operational and maintenance training early. Use those trained staff in hands-on roles for operational and maintenance testing, particularly in final acceptance tests. This is an important training experience for those staff.

## 4.3 Procurement and Contracting

Transportation agencies face many impediments in the procurement and contracting of developing projects, as procedures, controls and measures which have been put into place over the years for construction projects have had to be accommodated. However, there is some relief for these impediments. This section sheds some light on the more common problems that have been experienced, and some of the solutions that have been developed.

### 4.3.1 Autonomy in the Procurement Process

In some agencies, it has been the practice to clearly separate the procurement function from those who will use the goods or services procured. This autonomy in the procurement process is seen as providing certain assurances relative to the proper expenditure and management of public funds. However, because of the technical complexity of most ITS systems, and the need for these systems to be interoperable, technical and operational advice is critical in making wise procurement decisions.

Transportation management agencies should balance the need for autonomy in procurement with the obvious need for those with the technical and operational knowledge of ITS systems to participate in the procurement process. A sufficient degree of autonomy can be maintained while still involving technical staff, by adopting a team approach to procurement, which would include technical advisers and budget and procurement personnel. By bringing both sides together, each can gain a better understanding of the knowledge each brings to the discussions.

*It is crucial in ITS procurements that technical/operational, budgetary, and management elements be involved in proposal evaluation with each presenting its findings to a selection board. Bids from contractors that are not judged responsible companies able to perform or with technical proposals that are not technically acceptable should be rejected.*

This will allow the technical advisers to make recommendations on the extent to which or even whether the types of technology and systems available will meet agency needs, and the procurement specialists to outline budget, financial, and procurement restrictions that may impact how the type of technology or service is to be procured.

### 4.3.2 Selection of the Contracting Approach

There are several possible public-private partnership models that might be chosen for the traveler information system procurement and of course this would influence the contracting approach to be used. In some models, the private partner might handle the contracting. In other models, the major public agency might do the contracting for traveler information system development and deployment. There are some excellent courses that have been developed that touch on this, including; *Innovative Finance Strategies for Deploying ITS* and *ITS Public/Private Partnership* (see the references for further information). It has been demonstrated on a few major projects that having the private partner handle the procurement can significantly speed up project deployment. The material below is applicable to public agency procurement.

The selection of a particular contracting arrangement for deploying ITS systems may be critical to the successful deployment of an ITS system, and, ultimately, to it's successful operation. Three contracting approaches have been used by public agencies for the deployment of ITS transportation systems. These three are discussed below. The use of each has met with varying degrees of success. See also a paper on innovative contracting for ITS projects [Innovative Contracting Practices for ITS, April 1997] and another paper on procurement regulations and contracting options [FHWA Federal-Aid ITS Procurement Regulations and Contracting Options, August 1997] both available on the FHWA ITS web page. This contracting options paper, available in hardcopy from NTIS or electronically from the Turner Fairbanks Highway Research Center web page, is a valuable resource. Figure 1 of that paper identifies four basic contract types, their possible application, and their approval requirements. Three of those approaches are discussed below.

<u>Conventional PS&E/Contract Bid Approach</u>

In this approach, the designer develops specifications for both software and hardware, and these are included in the PS&E (Procurement Specification and Estimate) package and RFP (Request for Proposal). A contract for the construction, hardware, and software to deploy the system is then let in the manner of a conventional highway contract. This contracting approach may be appropriate for procurement and contractor installation of field devices and hardware. However, for design, development, integration and system engineering services, this approach has resulted in some problems in the past.

Hardware/software incompatibilities have arisen, and these systems have not performed as anticipated. In some cases, major modifications in hardware and/or software was called for in order to produce working systems. Resolution of issues relative to the accountability for these deficiencies, and of the responsibility for the development and deployment of corrective measures have proven to be particularly difficult in many cases. In general, this approach does not work well for technology acquisition.

System Manager Approach

Under the system manager approach, a consultant is engaged to develop the software and hardware specifications for the ITS system, and to produce a PS&E for the project. Contracting for the system manager's services falls under the Engineering and Design Services contract category which includes services like program and construction management, engineering, design, and surveying. Using the PS&E developed by the system manager, a contract for furnishing and installing hardware, and for other required items is let, using traditional contracting procedures as in the contract-bid category of contracting. Here, a key difference comes into play: the software/hardware consultant's responsibilities carry into the deployment phase of the system under this approach. The consultant is responsible for the final design and development of software and for integrating it with the hardware as it is installed, and for providing documentation and training to operating staff in the use of the integrated system. Several advantages to the system manager approach have been noted:

- The process includes competitive bidding, with all of its benefits, for the furnishing and installing of hardware, and for facility and electrical construction.

- Access to those developing the system software, and agency control over system development, are greatly facilitated. If the control system hardware is included with the software bid, a hardware contractor who does not produce software could win the bid. The hardware company will subcontract the software to a software company. The client then has very limited access and control over the system development and may not be able to ensure that the system meets its requirements.

- The system manager approach gives the flexibility to incorporate the latest technologies into the system, as well as to provide integration with other ITS systems including traffic control systems which may be operating on local and regional roadway networks. It is important to avoid the low-bid syndrome, where the software is designed to do the absolute minimum required to meet the specifications rather than take advantage of the latest thinking and processes in a rapidly evolving technological market.

Design/Build Approach

In this approach, a contractor is selected based on the contractor's qualifications and an assessment of the contractor's ability to perform followed by competitive negotiation. This single competitive contract is then awarded for design and construction of the project. This differs from the design-bid-build approach in that design-bid-build uses two sequential competitively awarded contracts, the first for design and the second for construction. The design/build approach traditionally combines the procurement procedures employed with the traditional engineering and design services contracts with those used in the traditional construction contracts, and thus embodies characteristics of both. These procedures may include pre-qualification, competitive sealed bidding, and award criteria based on price and other factors. It may be useful to require separate detailed technical proposals and cost/business proposals and evaluate technical proposals first. Then the predetermined selection criteria would include evaluation of the offerors' technical proposals that have been found to be acceptable, by a predefined set of criteria. This approach will provide indications of the each offeror's skills, understanding, and approach to the project. The negative is that the project requirements must be spelled out in the RFP so that the offerors can respond to them.

The design/build approach relies on the contractor to develop a design and then to build the project. The agency's role is to monitor the contractor's work. Generally this has worked for roadways and structures. However, it may have significant problems when applied to technology acquisition depending on contract type (e.g., fixed price or cost type) and the nature of the relationship between the agency and contractor. If the agency has a hands-off approach to contract management, the contractor may design and build much of the system based on incorrect interpretations of requirements. Some of the work may be found to be unacceptable. Partnering of the agency and contractor so that requirements are properly interpreted and the design is reviewed by agency representatives and found acceptable, before construction and implementation work proceeds, can lead to positive results. However, if the entire contract is a fixed price type, the contractor has an incentive to interpret requirements, produce a design, and build the system to minimize the contractor's cost. A way to address this issue is to have the agency more directly involved in the clarification of requirements during contract performance. This, in turn, may increase the contract scope. Also, if the contractor subcontracts the software to be designed and built by another contractor, there may be lack of visibility into the software development process. This is likely to result in a lack of agency knowledge and control of the software and an unacceptable system.

FHWA established Special Experimental Project No. 14 , Innovative Contracting Practices (SEP-14) to enable agencies to implement and evaluate innovative contracting practices that maintain competition advantages while striving for quality and timeliness. Included under SEP-14 are Experimental Design-Build and Non-Experimental Cost-Plus-Time contracting innovations. Federal-aid funds may be used in design-build contracts when awarded with competitive bidding procedures and subject to FHWA approval under SEP-14.

*Give full consideration to the use of the System Manager Approach when deciding upon the contracting arrangement to use.*

### 4.3.3 Procurement Rules and Regulations

Although federal legislative requirements mandating the use of low bid procurements have been relaxed in recent years, many states still require its use for procuring many services and equipment. In addition, it is still the preferred method for acquiring construction services in the public sector. But there can be problems with accepting low bids for ITS systems and devices.

**Some key lessons about low bids:**

- An important problem with low bids: the equipment and software are frequently designed to do the absolute minimum required to meet the specifications rather than take advantage of the latest advances in technology.
- The design of the system provided by a low bidder may have many misinterpretations of the requirements with major cost increases for the corrections thus allowing the bidder to bid very low, with later scope increases. Specified requirements must be accurate and thorough. Even then a low bidding contractor will find ways to reduce costs by not meeting requirements or by misinterpreting requirements.
- Often systems that are low bid have limited expansion capabilities. These limitations are frequently not discovered until control elements are expanded or modified at a later date.
- As upgrades to the system hardware and software are needed in later years, there may be design problems that require very expensive redesign and expansion of the system.

Traditional transportation procurement approaches will usually not provide the flexibility necessary for acquiring ITS projects. In an effort to provide greater flexibility to state and local governments in their procurement procedures, the U.S. Office of Management and Budget established the Common Rule governing grants administration. The rule provides that states will spend and account for grant funds according to their own laws and procedures. While some procurement methods have very specific federal rules to be followed (particularly procurements for architect/engineering services for construction projects), there is considerable flexibility in most other procurement models.

Project team members should work together to select the most appropriate procurement mechanism, contracting lead agency, and contracting approach for any particular project. In selecting the procurement and contracting approach, the most favorable alternatives need to be compared side-by-side listing all pros and cons of each. Decisions relative to project team members, as well as procurement-related issues, need to be made early in the project development process since many facets of the project will be impacted by these decisions.

## 4.3.4 Procuring Software

Procuring software has always been complex and care must be exercised to control the risks inherent in this activity. There are many important topics to be informed of on software acquisition. As of 1998, U.S. DOT is preparing an ITS software acquisition guidance document. Some of the key topics covered include the following, all of which are important:

- Acquisition approaches
- Consideration of commercial-off-the-shelf (COTS) software with its pros and cons
- Importance of requirements
- Acceptance criteria

- ✦ Intellectual property rights
- ✦ Schedule issues

The document is built around people, management, and system themes that encourage partnering between the agency and software contractor to ensure understanding and translation of requirements into software.

Using "off-the-shelf" software packages and systems are often touted as low risk, but may or may not reduce risk. Making major changes to an existing software system may be quite difficult. Nevertheless, agencies should familiarize themselves with the different product offerings before issuing procurement documents since it may be possible to meet requirements while saving time and money. A key point - careful consideration should be given to requirements that might involve extensive new software development or extensive product offering changes because of the risk implications.

Some further considerations involve right of use for agency funded copy-righted software and source code and other supporting software and tools to ensure ability of continued use of their investment.

- ✦ New software, which is developed for the project needs to be copyrighted, and ownership details need to be worked out ahead of time with the contractor. These arrangements need to be made prior to start of the software development phase. It is important for agencies that are implementing traveler information systems to have rights over the software that is delivered. Such rights would allow the agency to use, amend and expand the TIS without reliance on the vendor.

- ✦ The rapid rate of change in current technologies leads to many companies either changing the business they are in, being absorbed by others if successful, or going out of business when unsuccessful. Agencies need to protect themselves and their investment in the software. They need to ensure that all source code, development tools, operating systems and associated software are delivered. In addition, it is wise to make precise copies of the installed system to ensure that not only the code but also the correctly configured version of the operating systems are archived. Vendors often provide a basic platform that requires modification for each specific client. Vendors are likely to require some limitations on the delivery of all their source code. Such limitations can be:

    - Geographic - The system cannot be used outside a specific area.
    - Temporal - The product is licensed for some duration.
    - Functional - The product is only warranted until recompiled.

  These limitations need to be the subject of contractual discussions between the agency and the vendor.

### 4.3.5 Procuring Telecommunications

Just as transportation is the backbone of our communities, serving to move people and goods from point to point, telecommunications is the backbone of ITS, serving to move information among detectors, transportation management centers, and field devices. Telecommunications is vital and expensive. A new telecommunications system can be the highest cost item in an ITS deployment project. A telecommunications analysis including the three steps below should support telecommunications decisions:

- Requirements Definition
- Definition of Network Options
- Cost Analysis

The *Requirements Definition* step is the most important. Good decisions can only be made if care is taken during this step of the analysis. The product of requirements definition is a reasonable estimate of how much information needs to be moved from point to point throughout the system in its future fully deployed state. To do this, a rigorous estimation process that focuses on <u>needs</u> rather than <u>possibilities</u> must be followed. This must be supported by an understanding of the types of devices to be installed, where they will be, how many there will be, message sizes and frequencies, etc. Also, the region's plan for locating and communicating among transportation management centers must be understood. Perhaps the most fundamental question in requirements definition is whether the telecommunications system will serve the needs of a single agency, multiple transportation agencies in a region, or multiple government agencies within a jurisdiction or region. The latter two raise issues about ownership and cost participation, but should be considered from a good public policy perspective. The video requirement should be carefully considered. Among the questions to be critically examined: Who needs to see what images? How many images need to be seen at one time? What will the information be used for? Using the video images for commercial television broadcasts may imply need for higher quality than if they are only to be used to view incident scenes. Use of compressed digital video should always be explored, since recent improvements in compression algorithms produce images that approach the quality of full motion video transmissions. If the only use is to view incident scenes, transmission of lower quality, freeze-frame/slow-scan images may be adequate, and require much less communications capacity. For more information, reference the ITS JPO Telecommunications Resource Guide, Tab A, Telecommunications in Transportation, a Summary of Key Issues and Tab B, A Case for ITS Telecommunications Analysis.

The *Definition of Network Options* step involves defining different telecommunications network structures or architectures. For example, the information that needs to be passed back and forth will be very different if processing is distributed rather than centralized. Within the context of these different network structures or architectures, ownership and leasing options should be explored. Thinking broadly in terms of providing a telecommunications service rather than building a telecommunications infrastructure will open the door to consideration of a number of different options, including combinations of leased and owned infrastructure. This may also include resource sharing opportunities, in which access to public right-of-way is exchanged for a share of the telecommunications capacity being installed in the right-of-way. [Final Report on Telecommunications Shared Resources: Legal and Institutional Issues, 1997].

In the final *Cost Analysis* step, the cost implications of the different alternatives are detailed and compared. Ownership options involve higher installation and maintenance costs, which must be compared against the terms of the available leasing arrangements. Short term leasing deals, on the order of from five to ten years, may enable agencies to possibly obtain more favorable terms in the future, and also enable agencies to take better advantage of technological advances than they typically would be able to with a publicly owned system or longer term leasing deal.

A final but very important point is that typical transportation agency personnel seldom have the experience needed to support informed decisions about these issues. It may be imperative that this

# 5. How Can I Find Out More?

Information on traveler information systems, Intelligent Transportation Systems (ITS), the National ITS Architecture, and ITS Standards may be found at the locations described below. Additional helpful references are listed in the References section. You should also know that most Federal reports may also be obtained through:

National Technical Information Service (NTIS), Technology Administration, U.S. Department of Commerce, Springfield, VA 22161

Phone: (703) 605-6000; Fax: (703) 321-8547

World Wide Web at **<http://www.fedworld.gov/ntis/ntishome.html>**

## 5.1 Traveler Information Systems

Because traveler information systems involve relatively new and evolving technologies, few written materials are available for further reference. However, during the past few years, a number of traveler information demonstration projects have been launched throughout the country. Information on these projects is being made available on the World Wide Web; listed below are representative examples of such projects, as well as internet addresses where more detailed information can be obtained.

**ITS Online**
ITS Online is a website devoted to the discussion of ITS. Several user forums are maintained, including commentaries and discussions on traveler information. ITS Online can be found on the web.

World Wide Web at **<http://www.itsonline.com>**

**Metropolitan Model Deployment Initiative**
These model deployments are showcases of the measurable benefits of taking an integrated, region-wide approach to managing transportation and providing traveler information services. The model deployments bring increased levels of service to the traveling public through the integration of several key systems, including: traffic signal control; transit, freeway, and incident management; emergency services management; regional multimodal traveler information services; and electronic toll collection and fare payment. In addition to introducing the public to the benefits of ITS products and services, the sites serve as "showcases" for local decision makers across the U.S. The model deployment sites serve as "laboratories" for conducting rigorous evaluations of the benefits of integrating intelligent transportation infrastructure in a metropolitan area.

World Wide Web at **<http://www.its.dot.gov/mdi>**

### Atlanta Traveler Information Showcase

The Atlanta Traveler Information Showcase (also called the Georgia DOT Navigator) was launched in conjunction with the 1996 Olympics. A primary purpose was to provide traveler information using a variety of technologies, including personal communication devices, in-vehicle navigation devices, cable TV, on-line services, and interactive kiosks. Further information on the Traveler Information Showcase may be found on the web.

World Wide Web at **<http://www.georgia-traveler.com>**

### ADVANCE

The Advanced Driver and Vehicle Advisory Navigation Concept (ADVANCE) project was launched in 1991 as a major test of dynamic in-vehicle route guidance system in the Gary-Chicago-Milwaukee corridor. Current and future expansions of the project include the provision of centralized travel information. More information on the ADVANCE project may be found on the web.

World Wide Web at **<http://www.ais.its-program.gov>**

### Operational Field Test Summaries

A variety of information is available on the ADVANCE traveler information system and the Atlanta Driver Advisory System (ADAS) and Kiosk field operational tests plus several other traveler information field operational tests on the Turner Fairbanks Highway Research Center World Wide Web site at:

**<http://www.tfhrc.gov/its/optests/atmsatis.htm>**

This web site has links to summary information on these operational tests in Microsoft PowerPoint briefing slide formats.

### TravTek

TravTek was an operational field test of some advanced traveler information system and advanced traffic management system technologies. TravTek provided some models and evaluation results which are very important to those considering or seeking to implement traveler information systems. Some important TravTek reference documents are identified in the References section of this paper. Very briefly, the TravTek project was a joint venture of a public / private partnership that proved to be successful, due in part to dedication of the partners to fulfilling their obligations to the project.

### Other Examples

The following is a list of other intelligent transportation infrastructure upgrade projects, operational tests, or corridor related activities which apply state-of-practice and advanced technology in traveler information and traffic management. They serve as relevant examples of how advanced technology can be applied to support these applications within metropolitan areas. Many of these projects include multiple infrastructure features and thereby serve to amplify the approaches for and benefits of integrating these features within the metropolitan area:

- ***TravInfo***
- ***TransCal***
- ***Swift***
- Minnesota ***Guidestar*** Projects
- ***Houston Intelligent Transportation System (HITS)*** including the Houston Transportation and Emergency Management Center
- ***Montgomery County Traffic Management Center***, Montgomery County, Maryland

For detailed information and contacts for these and many other projects, please see the U.S. DOT publication, ***Intelligent Transportation Systems Projects,*** which is updated and reissued annually.

## 5.2 How Can I Find Out More About ITS?

Contact the agencies listed below:

First verbal contacts should be to your local Federal Highway Administration Division Office or Federal Transit Administration Region Office. This should include queries relative to areas such as program, technical and policy. This office will work with you to schedule courses, seminars and possibly workshops on ITS topics.

**ITS Joint Program Office**
Federal Highway Administration, U.S. Department of Transportation, 400 Seventh Street SW, Washington, DC 20590

Phone: (202) 366-9536; Fax: (202) 366-3302

World Wide Web at **<http://www.its.dot.gov>**

This U.S.DOT ITS web page also provides links to numerous other sources of ITS-related information. With the wealth of information of all types on ITS available via the Internet, it is becoming important that the key staff involved in any ITS activity have access to Internet.

**Office of Traffic Management and Intelligent Transportation Systems Applications**
Federal Highway Administration, U.S. Department of Transportation, 400 Seventh Street SW, Washington, DC 20590

World Wide Web at **<http://www.fhwa.dot.gov/hst/its.htm>**

**Turner Fairbanks Highway Research Center**
Federal Highway Administration, U.S. Department of Transportation, 6300 Georgetown Pike, McLean, VA 22101

World Wide Web at **<http://www.tfhrc.gov>**

**Office of Mobility Innovation, Advanced Public Transportation Systems Division**
Federal Transit Administration, U.S. Department of Transportation, 400 Seventh Street SW, Washington, DC 20590

Phone: (202) 366-4991

World Wide Web at **<http://www.fta.dot.gov/library/technology/APTS/t_its.htm>**

**Other sources include:**

**ITS America**
400 Virginia Avenue SW, Suite 800, Washington, DC 20024

Phone: : (202) 484-4847

World Wide Web at **<http://www.itsa.org>**

## 5.3 How Can I Find Out More About the National ITS Architecture?

**Where do I look for Information?** Again, first verbal contact should be with your FHWA Division or FTA Region Office.

**Information on the National ITS Architecture is available at the following locations:**

**National ITS Architecture Team**
The National ITS Architecture documentation and the linked HTML model are available on the World Wide Web at

**<http://www.odetics.com/itsarch/>**

**ITS Joint Program Office, Federal Highway Administration, U.S. DOT**
Documents that may be obtained from the Joint Program Office include:

- *The National ITS Architecture for ITS: A Framework for Integrated Transportation into the 21st Century*
- *Building the ITI: Putting the National ITS Architecture into Action*

These documents are available on the World Wide Web at **<http://www.its.dot.gov>**

This site also provides a variety of very informative information, like an overview of what ITS is, a large glossary, several other very informative reports.

**Contact your FHWA Division or FTA Region Office to inquire about training:**

A course from the Federal Highway Administration on *Using the National ITS Architecture for Deployment*; this course has been prepared by the National ITS Architecture team and is informative about the

Architecture and how to use it, with practical interaction between students and the Architecture products on CD-ROM. Additional courses may become available.

**ITS America**
World Wide Web at ..... <**http://www.itsa.org/public/archdocs/national.html**>

Hard copy versions of the National ITS Architecture documentation may also be purchased from the ITS America Bookstore. Specific National ITS Architecture volumes are available.

Phone: (202) 484-4584 or 1-800-374-8472

The National ITS Architecture is also available on CD-ROM and includes an easy to use browser and search facility.

**Exploring The National ITS Architecture On Your Own:**

- ✦ Read the Executive Summary first. Then read the Implementation Strategy—start with Chapter 4.
- ✦ Use the CD-ROM in concert with a "File Find" utility. Some "File Find" utilities will search the written material in a document for specific words. This will allow you to search the entire National ITS Architecture for specific information.
- ✦ Use the Market Packages as guides to the rest of the material in the National ITS Architecture or use them as a starting point. You can think of them as high-level ITS system designs which can be implemented as a project or sub-project.
- ✦ Read Sections 2.4 and 2.5 of this document for more details on how to explore the material.

## 5.4 How Can I Find Out More About ITS Standards?

**How can I find out the status of ITS standards development?** Again, first verbal contact should be with your FHWA Division or FTA Region Office.

**Detailed information on ITS Standards is available at the locations listed below:**

**National Transportation Communications ITS Protocol (NTCIP)**
Contact the NTCIP Coordinator at the **National Electrical Manufacturers Organization (NEMA)**

Phone: (703) 841-3231; Fax: (703) 841-3331

World Wide Web at <**http://www.ntcip.org/standards**>

Copies of NTCIP standards may be purchased from NEMA. Those NTCIP standards currently available include:

- ✦ NTCIP Overview (NEMA TS3.1) - This publication provides an overview of the concepts and protocols for the NTCIP series of standards, which can be used to implement a working NTCIP-based transportation control system. This standard encompasses roadside device control, data collection, data routing, and file transfer services using various communication system topologies.

- Simple Transportation Management Framework (NEMA TS3.2) - The Simple Transportation Management Framework (STMF) describes the framework used for managing and communicating information between management stations and transportation devices. It covers integrated management of transportation networks, networking devices and transportation specific equipment attached to NTCIP-based networks.

- NTCIP Class B Profile (NEMA TS3.3) - This communications protocol standard can be used for interconnecting transportation and traffic control equipment over low bandwidth channels. This standard establishes a common method of interconnecting ITS field equipment such as traffic controllers and dynamic message signs (DMS), defines the protocol and procedures for establishing communications between those components, and references common data sets to be used by all such equipment.

- Global Object Definitions (NEMA TS3.4) - The messaging between transportation management and field devices is accomplished by using the NTCIP Application Layer services to convey requests to access or modify values stored in a given device; these parameters and their values are referred to as objects. The purpose of this standard is to identify and provide those object definitions that may be supported by multiple device types (e.g., actuated signal controllers and variable message signs).

- Actuated Controller Unit Object Definitions (NEMA TS3.5, ASC) - This standard defines objects which are specific to actuated signal controller units.

- Object Definitions for Dynamic Message Signs (NEMA TS3.6, DMS) - This standard contains object definitions to support the functionality of Dynamic Message Signs used for transportation applications.

There are a total of sixteen of the NTCIP standards, ten more than listed above. For more information about NTCIP standards, please refer to Appendix A.

**Transit Communications Interface Profiles (TCIP)**
Further information can be obtained from the following source:

World Wide Web at **<http://www.tcip.org>**

**ITS America**
ITS America, 400 Virginia Avenue SW, Suite 800, Washington, DC 20024

Available on the ITS America web page are descriptions of the ITS standards, the standards development activities and the status of standards development..

Phone: (202) 484-4847

World Wide Web at **<http://www.itsa.org/notice.html>**

## Other Standards

**The American Association of State Highway and Transportation Officials (AASHTO)**
Suite 249, 444 North Capitol Street, NW, Washington, DC 20001
Focus: State-level Agency Participation and Roadside Infrastructure.

World Wide Web at **<http://www.aashto.org/main/>**

**The American Society for Testing & Materials (ASTM)**
Focus: Dedicated Short Range Communications (DSRC) systems.

World Wide Web at **<www.astm.org>**

**The Institute of Electrical and Electronics Engineers (IEEE)**
Focus: Electronics and Communications Message Sets.

World Wide Web at **<http://stdsbbs.ieee.org/groups/sec32/index.html>**

**The Institute of Transportation Engineers (ITE)**
525 School St., SW Suite 410, Washington, DC 20024-2797

Focus: Traffic Management and Transportation Planning systems.

Phone: (202) 554-8050

World Wide Web at **<http://www.ite.org/standards.htm>**

**The Society of Automotive Engineers (SAE)**
Focus: In-vehicle and Traveler Information

World Wide Web at **<http://www.sae.org/prodserv/standard/standard.htm>**

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# References

See Section 5 for web page URLs, phone numbers and addresses for the primary sources for most of these documents. Also, please be aware that most Federal reports may be obtained through:

National Technical Information Service (NTIS), Technology Administration, U.S. Department of Commerce, Springfield, VA 22161

Phone: (703) 605-6000; Fax: (703) 321-8547.

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# Appendix A. ITS Standards

## A.1 Overview

The intent of this appendix is to identify and describe existing and planned ITS standards that are applicable to traveler information systems. The need for these standards has been identified by transportation industry.

The development, promulgation, and adoption of standards is an issue of utmost importance in the use of a new technology. Adoption of standards can have a number of different effects. On one hand, the adoption of a technology in the marketplace can be stimulated. On the other hand, the further development of a technology could be frozen. Commercial broadcast television in the United States serves as an example of both of these effects.

Early adoption of standards for commercial TV in the United States allowed for explosive growth of industry here in the immediate post-World War II years. However, U.S. technology was frozen at a level that subsequently proved to be inferior to that achieved soon after in Europe. The technology of communicating data over telephone lines provides a counter example. New standards for increasingly fast data transmission over the phone lines periodically emerge, but the new modems that capitalize on these standards also generally operate according to the old ones if such operation is needed. This capability for backward compatibility increases the flexibility for all users of a technology, thus spurring both greater adoption on the marketplace and further technological advancement.

Standards development is critical to the success of implementing ITS. Well defined standards help agencies better prepare procurement specifications, Requests For Information (RFIs), and Requests For Proposals (RFPs). These standards need to be open instead of proprietary in order to allow for new technologies and new products from different manufacturers to be added. Open standards are generally owned by a public organization, or the underlying technology is licensed on a low-cost, non-discriminatory basis by its owner, and made available to anyone wanting the documentation for an interface. Open standards encourage interoperability of products from different manufacturers. Proprietary standards have restricted access, usually to the company that developed the standard or their chosen licensees.

Utilizing standards to ensure ITS interoperability and the interchangeability of like equipment will benefit the transportation industry by decreasing procurement costs (larger numbers of competing manufacturers will spur competition), increasing system flexibility, and providing easy upgrade paths.

Even though equipment standards are important, this section does not provide equipment-specific standards because of the vast number of different equipment technologies. In addition, the establishment of strict standards for device-specifications is not only location-dependent but it would also restrict progress and innovation, and is therefore not desirable.

### A.1.1 Previous work

Several organizations have been tasked, voluntarily and through contracts, to develop ITS-related standards. Existing standards are generally based on the need of a particular industry or agency. The U.S. DOT subsequently awarded a contract to the Jet Propulsion Laboratories (JPL) to serve as the lead organization to:

- Collect ITS-related standards
- Create a database
- Organize the standards in the database
- Maintain and update the database content
- Provide interested parties with the entire content or excerpts of it

The content of this database is updated continuously and it can be visited on the ITS America Internet home page at:

<http://www.itsa.org/notice.html>

under the heading "Standards Catalog." This Appendix will address communications standards, automatic vehicle identification, advanced traveler information systems (ATIS) and other ATIS-related standards.

## A.2 Communication Standards

This overview of communication standards is designed to provide the reader with information on ITS-related communications protocols. The communication standards presented allow agencies to transmit data from one device or system to another. Some of these standards currently exist or are very close to being completed, while others are either in an early development or planning stage.

### A.2.1 Overview

Since many interfaces have not been standardized, the U.S. DOT funded the development effort of creating standards for ITS technologies.

Some of these new standards for ITS are described below. The listing is neither complete nor does it indicate levels of importance.

#### A.2.1.1 NTCIP

The National Transportation Communications for ITS Protocol (NTCIP) was originally conceived to be an extension of the NEMA TS-2 Controller Standard covering traffic controller communications. The NEMA traffic control equipment manufacturers recognized that for true hardware interchangeability, the standard had to cover the more complex issues of systems interoperability and communications standards. As the NEMA development work grew, a general industry forum evolved and ultimately the Federal Highway Administration (FHWA) identified the concerns of ITS designers.

Today, the Joint NTCIP Committee, a steering committee consisting of members from three Standard Development Organizations (SDOs), NEMA, ITE, and AASHTO, is overseeing and directing all efforts with respect to NTCIP that are being executed within each of the above SDOs.

For ITS to be a reality, all the components that make up the traffic and transportation monitoring and control community must be able to communicate with a common, or at least understandable, language. The words that are spoken must have a clear and unambiguous meaning to everyone. The NTCIP development participants started out by defining a language needed for a traffic controller, and extended it to include Traffic Management Centers (TMCs). It has been further refined into an open set of protocols that meet the diverse needs of ITS.

This openness is achieved by embracing features of several existing worldwide communications standards established by the International Standards Organization (ISO), the International Telecommunications Union, Telecommunications Sector (ITU-T; formerly CCITT), and the Internet Engineering Task Force (IETF). These standards map onto the ISO Open Systems Interconnect Reference Model (OSI Model) that deals with how information can be passed through the various processing layers in an open system. The OSI Model breaks down the aspects of communications into seven layers or discrete functions to reduce complexity. Each layer is built upon its predecessor. These seven layers are shown in Figure A1.

| | |
|---|---|
| Layer 7 | Application Layer |
| Layer 6 | Presentation Layer |
| Layer 5 | Session Layer |
| Layer 4 | Transport Layer |
| Layer 3 | Network Layer |
| Layer 2 | Data Link Layer |
| Layer 1 | Physical Layer |

**Figure A-1: OSI Layers**

These seven layers can be viewed as forming two groups of functionality to support open communications. The first group (Layers 1-4) is responsible for data transport while the second group (Layers 5-7) is responsible for data processing.

Protocols utilized on the different layers of the OSI models are mostly existing computer standards that have been used for years within the industry. However, due to the nature of transportation infrastructures, a few new protocols and modifications to existing protocols had to be defined such as the development of the Simple Transportation Management Protocol (STMP), a new application layer protocol, and Point-to-MultiPoint Protocol (PMPP), which follows the existing Point-to-Point Protocol (PPP). PMPP has not yet been approved.

#### A.2.1.1.1 Class Profiles

Within the NTCIP there are various profile classes defined:

- A - Connectionless
- B - Central direct to field
- C - Connection oriented
- D - Dial-up
- E - Center to Center
- F - Alternate Center-to-Center

These classes are described below. The Class B Profile is the only Class Profile that has been standardized to date. While development of this standard has been completed and it has been balloted with the results indicating that the standard is acceptable , as of February 1998, it has not reached a maturity level needed for final approval and publication by the Joint NTCIP Committee and for U.S. DOT rules requiring use in Federally funded ITS projects beyond a trial basis. However, it is not expected to undergo any significant changes from testing and field trials. Manufacturers are developing compatible products and agencies are encouraged apply the standard.

#### A.2.1.1.2 Class A Profile

Class A is a suite of protocols allowing the connectionless transmission of data packets over a medium that does not require a permanent connection between two devices. For example, when sending two letters via regular mail, it cannot be ensured that both letters will take the same route (one letter might get from location A to location B via location C, while the other letter is sent via location D). The Class A Profile is based on existing protocols already in use by the Internet community and other network systems, therefore utilizing proven protocols. The only exception is the utilization of STMP as the application layer protocol and a modified form of the HDLC protocol that includes an initial protocol identifier (IPI) as the data link layer protocol.

The Class A Profile suite of protocols will use the Transmission Control Protocol (TCP) as its Transport Layer protocol to guarantee delivery or signal when a message cannot be delivered correctly. TCP uses sequence and acknowledge information and timers to make sure the individual frames are received and that they are put in their proper order. If a frame is garbled or lost, re-transmissions are attempted. If a frame cannot be delivered, the upper layer is notified. This class of service ensures data integrity and correctness; its primary use is for large data transfers.

This standard has not yet been approved but is in the process of being developed by device manufacturers in conjunction with users of these devices. This development process ensures that the devices utilizing this protocol will meet the requirements of the user community.

The main difference between the Class A Profile and the Class B Profile is that Class A messages can be routed through an intermediate device, e.g., from a central location to a field device.

#### A.2.1.1.3 Class B Profile

The NTCIP Class B Profile defines a set of communication protocols to be used in field devices and their management systems that are part of an Intelligent Transportation System. The profile provides for exchange of information between a primary station and each secondary station on a particular communications channel or subnet. The profile sets forth standards to allow devices to share a common interconnect, establish a common language for them to communicate and define the structure under which the data in these devices is structured and managed. It does not address the need for the exchange of information between devices on different subnets.

Class B provides for bandwidth efficient exchange of information between the primary station and each secondary station on the same physical link. Class B does not ensure delivery. Frames received with errors are discarded. If re-transmissions are needed, it is the responsibility of the Application Layer to provide them. This class of service is primarily intended for short command and reply messages where delivery time is a strong consideration.

The Class B Profile can be used to poll or transmit data to and from roadside devices such as traffic signal controllers, surveillance detectors, variable message signs, or preemption devices. It can also be used for communicating with traveler information kiosks or similar devices. A prerequisite is the direct connection of management center and roadside device, because the Class B Profile does not allow for routing of messages

#### A.2.1.1.4 Class C Profile

Class C is a profile providing connection-oriented services similar to the data transmission within the Internet. In fact, the Class C Profile includes the same protocols on the Network (using Internet Protocol or IP) and Transport (using TCP) Layers of the OSI model. This profile is not yet finalized but will probably not include the untested Simple Transportation Management Protocol (STMP), as required for the Class B and Class A Profiles. Instead, it will utilize the Simple Network Management Protocol (SNMP), TELNET, and the File Transfer Protocol (FTP), which are well-tested and implemented within the Internet and intranet networks.

Class C may seem to provide the ideal service; however, it imposes additional overhead. Before any information can be passed, a connection between the devices must be established. The connection procedure takes a certain amount of time. When the information transfer is completed, the connection must be formally closed.

The main difference between the Class C Profile and the Class B Profile is that Class C messages can be routed through an intermediate device, e.g., from a central location to a field device. Another aspect is the capability to "chop" large data files into smaller data packets (file transfer) and to sequence these packets so that they can be assembled correctly at the receiving end.

A variety of traffic signal applications can benefit from the Class A and/or Class C Profiles. Different types of field devices, such as traffic signal controller, video surveillance cameras, and variable message signs, from various different manufacturers could be connected to one common communications line and still be controlled and monitored from the traffic management center. Currently, it is not possible to connect existing field devices that utilize different communications protocols to the same communications channel as NTCIP.

#### A.2.1.1.5 Class D Profile

The Class D Profile is intended for dial-up connections. The protocol will include security features such as dial-back. Development work on the Class D profile has not occurred yet.

#### A.2.1.1.6 Class E Profile

The Class E Profile specifies the suite of protocols that allows for center-to-center communications. The specification of this Profile is at a very preliminary stage and its anticipated development completion date is 1999. One of the first steps in developing this standard is the definition of the Transportation Management Data Dictionary (TMDD) specifying the content of data that needs to be transmitted between management centers.

Several different existing and emerging protocols, mostly specifying the application layer protocol and ultimately influencing the underlying layers of the OSI model, are under consideration for this profile but a consensus has not been reached.

The transportation industry can utilize this standard to ensure compatibility between multiple transportation management centers or service providers. The Class E Profile should not be used separately unless the data format of messages to be exchanged are known to both the transmitting and receiving management centers.

#### A.2.1.1.7 Class F Profile

Another NTCIP compatible and NTCIP-compliant method for center-to-center communications has been introduced. The introduction of a Class F Profile took place in December 1996 but the information regarding this proposed standard development effort has not yet been specified in writing.

#### A.2.1.1.8 Message Sets

NTCIP utilizes message sets that define how a particular function or parameter is defined and described, and what the allowed ranges are for each parameter (or objects as they are called). All objects have a unique name which is based on a location under a global tree. NEMA has a node (or branch) within the global tree and assigns unique names to each known and defined object. Because of the history, NEMA first tried to define signal controller objects, but detected very quickly that many objects (parameters and/or functions) are not unique to signal controller applications (e.g., time) and created another message set that contains common objects (referred to as Global Object Definitions). As of February 1998, five of these message sets have been completed and voted as acceptable and are available from NEMA (see Section 5). Manufacturers are developing compatible products and agencies are encouraged apply these standards.

### A.2.1.1.9 Future Developments

NTCIP is envisioned to cover many different types of communications. The flexibility of NTCIP achieved through following the OSI Reference Model allows the expansion to various, not yet considered communications protocols on the different layers of the OSI model. Interoperability is provided by defined interface setups (APIs) that the layer protocols are required to follow.

### A.2.1.2 TCIP

The Transit Communications Interface Profiles (TCIP) is a standards development effort that may consist of several suites of protocols and data message sets. The TCIP standar's primary goal is the definition of data interfaces to both transit-related applications and the National ITS Architecture data flows. Transit-related application interfaces are anticipated to include the FTA National Transit GIS standard (under development, see below) and consider the Advanced Public Transit Systems (APTS) Map and Spatial Database User Requirement specifications (also under development) as well as the NTCIP, DSRC, and other standardization efforts. TCIP will be developed by addressing data flows as identified within the National ITS Architecture to the greatest extent possible. Interfaces needed for other transit-related applications that have not been addressed will also be identified.

The TCIP development effort is expected to augment the information management area of NTCIP with transit-related information and message formats that facilitate the exchange of transit information among operations centers, transit vehicles and the infrastructure. The TCIP will provide additional NTCIP Class Profiles or subsets of existing and planned Class Profiles, and the necessary bridges for information transfer from legacy transit systems to advanced information systems developed conforming to the National ITS Architecture. The characteristics of transit information exchange may be best served, for example, by one of the five NTCIP Class Profiles, by one of the Profiles of SAE J1708, or by TCIP. However, the main focus of TCIP will be the development of message formats to exchange transit information in a standardized manner.

The TCIP effort is lead by the Institute of Transportation Engineers (ITE) and supported by a large group of technical advisors consisting of members of the transit community such as FTA, APTS, and APTA. ITE is a recognized Standard Development Organization (SDO) that was awarded a contract by the US DOT to develop the TCIP standard. As of February 1998, the time frame currently scheduled for the TCIP development ends in 1998.

The following have been identified as preliminary targets for the TCIP work:

1.) data flows internally and externally:

| | |
|---|---|
| a) internal data flows: | interdepartmental within a transit property or within the different branches (remote offices), Transit Management Center (TrMC) to transit vehicles, transit kiosks, and other items such as roadside transmitters |
| b) external data flows: | TrMC to TMC or other centers such as service providers and financial agents (e.g., credit card companies and banks) |

2.) static reference and dynamic data transfers:

a) static reference data flows: for example, route and bus stop inventory, schedule, fare, and spatial data transfers

b) dynamic data flows: for example, pre-trip itinerary planning, safety and security information, and detour and service delay data transfers TCIP will ensure interoperability and compatibility to NTCIP and SAE J1708/J1587 by creating gateway protocols, also termed application programming interfaces (APIs).

Further information can be obtained from the following source:

<http://www.tcip.org>

### A.2.1.4 Dedicated Short Range Communications (DSRC)

Dedicated Short Range Communications (DSRC) consists of short-range communications devices that are capable of transferring high rates of data over an air interface between mobile or stationary vehicles and normally stationary devices that are either mounted to structures along the roadway or are hand-held. One way of accomplishing these communications is through use of radio frequency (RF) beacons. RF beacon technology generally consists of a transponder (tag), transceiver (reader), and transceiver antenna (beacon). DSRC is also known as vehicle-roadside communications (VRC).

The National ITS Architecture program recognized the need for DSRC systems for those specific applications that require a close physical interaction between the vehicle and the roadside infrastructure, such as in toll collection, commercial vehicle electronic clearance and roadside safety inspection, etc. However, DSRC is considered inappropriate for applications such as route guidance that can be more efficiently served by wide-area ITS communications. Because of the dedicated nature and limited range of DSRC systems, the National ITS Architecture realizes that the costs of deploying DSRC will have to be absorbed by the ITS applications they support, including both public and private investment. The technical and applications aspects of DSRC are covered in the Communications, Physical Architecture and Theory of Operations documents produced by the National ITS Architecture program.

The following applications have been identified as candidates to utilize DSRC as a primary communications technique or mechanism:

- Electronic Toll and Parking Payments
- Commercial Vehicle Operations
  - International Border Clearance
  - Electronic Clearance
  - Safety Inspection
  - Automated Equipment Identification and Freight Management
  - Off-Line Verification
- Transit and Emergency Vehicle Operations
- Fleet Management

- Use of Vehicles as Probes to Obtain Link Travel Times
- In-Vehicle Signing
- Intersection Collision Avoidance and Automated Highway Systems
- Commercial Applications (e.g., drive-through purchases)
- Intersection Safety Warning

To encourage development of nationally, and perhaps internationally, compatible Intelligent Transportation Systems using DSRC, the ITS Joint Program Office (JPO) in the U.S. Department of Transportation has promoted the voluntary consensus development approach with wide private and public participation. Leading this effort are the American Society for Testing and Materials (ASTM) and Institute of Electrical and Electronic Engineers (IEEE).

## A.3 Automated Vehicle Location (AVL) Systems

The application of AVL is a very beneficial application in terms of implementing ITS technologies. It will enable fleet, transit and emergency services managers to manage vehicles in real-time with reference to the roadway network.

There are many AVL systems in existence. However, all of these AVL systems are proprietary, locking implementing agencies into a vendor-specific system. Most of these AVL systems have not been designed to allow for integration with an overall management system. Therefore, expansion to include upgrades, include other subsystems, or the integration of an AVL system into an overall management system will be very expensive.

The transportation industry has expressed the need for an AVL standard to allow for interoperability and integration of subsystems. The U.S. DOT placed AVL high on the priority list of standards that need to be developed for ITS technologies.

The Institute of Electrical and Electronic Engineers (IEEE) has been designated as the lead organization to develop the message set (applications standard) for AVL. However, other standards specifying the communications protocols are also needed.

Currently existing and planned standards usable for AVL are listed in the ITS Standards Catalog available on-line at the following World Wide Web site:

<http://www.itsa.org>

## A.4 Traveler Information Systems Standards

Standards-setting organizations have identified traveler information message lists as fundamental for achieving broad interoperability of ITS throughout the world. Such message lists and data dictionaries are necessary for the development of protocols that will permit modular system implementation, allow regional or national systems to interconnect, and will promote competition in the ITS marketplace. To this end, efforts have begun by the Joint SAE/ITS America ATIS Standards Committee to develop a message list and data dictionary standard for ATIS messages, taking into account different end user services, media, and devices. A primary basis of this effort will be the National ITS Architecture, along with existing message sets from field experience.

### A.4.1 ATIS Data Dictionary

The ATIS data dictionary is a minimum set of medium-independent messages and data elements needed by potential information service providers (ISP's) to deploy ATIS services, and provide the basis for future interoperability of ATIS devices. The general objective is to create initial standards for data elements and messages that are essential to the provision of information to travelers in the next few years as this new market develops. The focus is intended to be pragmatic by dealing at first only with those data and messages where there is a clear, current market and industry demand. At the same time, this is intended to be comprehensive and systematic in looking at all stages of travel (pre-trip and en route), all types of travelers (drivers, passengers), all categories of information (advisory, route guidance, traveler services, etc.) all means of surface travel (auto, truck, transit, etc.), and all platforms for delivery of traveler information (in-vehicle, portable devices, kiosks in mobile, public, work, and home environments).

### A.4.2 ATIS Message Data Flow

This effort is being addressed in SAE draft document J2369. ATIS messages originating from a TMC or ISP are sent via wireline or microwave link to the broadcaster who may combine the data stream with other broadcast digital data such as paging messages. The data is J2369 encoded and sent to the transmitter. Data received by a mobile user is J2369 decoded and translated to a usable format based on the given application. In the case of an in-vehicle application, data is translated and sent to the IDB for distribution to other vehicle systems.

## A.5 Other ATIS-Related Standards

### A.5.1 ITS Data Bus (IDB)

Chartered in late 1995, the SAE Data Bus Committee is targeting its work toward the concept of a dedicated ITS data bus that may be installed on a vehicle to work in parallel with existing automotive electronics. The data bus will facilitate the addition of ITS electronics devices to vehicles without endangering any of its systems.

#### A.5.1.1 IDB Protocol Standard

The objective of this standard is to provide an open architecture to permit interoperability that will allow manufacturers, dealers, and vehicle buyers to install a wide range of electronics equipment in vehicles at any time during the vehicle's life cycle, with little or no expert assistance required.

This effort is aimed at developing SAE recommended practices and standards that define an ITS data bus, message formats, message header codes, node ID's, application services and service codes, data definitions, diagnostic connectors, diagnostic services and test mode codes, ITS Data Bus-Vehicle Bus gateway services and service codes, network management services/functionality, and other areas as may be needed. The standard will be developed in cooperation with EIA/CEMA, CTIA, the SAE Multiplex and Diagnostics Committees, and other interested standards developing organizations.

The ITS Data Bus Protocol Standard J2366 will include specifications such as power ratings and moding, environmental, physical, mechanical, and electrical performance requirements and will also cover the specifications of the appropriate protocol layers for the ITS Data Bus application. Internet access from the car is still being considered as a requirement.

#### A.5.1.2 ITS Data Bus Vehicle Gateway Reference Design Recommended Practice

The scope of standard J2367 will cover the performance specifications of the vehicle gateway-specific aspects of J2366, including the minimum set of messages propagated across the gateway and performance issues such as gateway latency, etc., but will leave the packaging issues to the OEM.

#### A.5.1.3 ITS Data Bus Conformance Testing Standard

The scope of this standard will be to specify the set of testing procedures required to certify a device as being IDB compliant.

### A.5.2 In-Vehicle Systems Interface Standards

#### A.5.2.1 High Speed FM SubCarrier

This effort of the SAE In-Vehicle Systems Interface Committee (IVSIC) is in cooperation of the NAB-EIA-NRSC, who is testing several systems to become U.S. transmission standards. J2369 will specify a general framework and set of message formats that allow cooperative transmission of Advanced Traveler Information System (ATIS) Data over FM SubCarrier. The expertise to perform the message coding resides in the SAE division and among other ITS practitioners, while the oversight of suitable system bandwidth and other parameters resides with the National Association of Broadcasters (NAB). The resulting SAE standard would be incorporated in the master specification developed by NRSC. At present, the SAE IVSI Committee has established "real-time traffic," "historical," and "pre-planned incidents" as priorities for ATIS message development. The initial focus of the project is to create a preliminary coding and message structure for link travel times and network support functions for deployment of the standard modulation selected by the NRSC High Speed Committee. The project will draw on various message sets being developed elsewhere, formatting them specifically for transmission in FM SubCarrier modulation. The SAE IVSIC will then expand the scope of the project to include additional messages beyond link travel times, such as transit schedules. The Committee continues to address incident numbering, indexing methods, naming methodology, and interoperability issues. Draft of J2369 is scheduled for completion by the end of 1997.

### A.5.2.2 On-Board Land Vehicle Mayday

SAE Standard J2313 addresses the On-Board Land Vehicle Mayday Reporting Interface. At this time, over 30 different private firms are fielding early Mayday systems that do not have any inter-compatibility and do not directly talk to, or receive cooperation with, the existing National, State, and Local level "911" response agencies. Today, most of these systems are simple cellular phones equipped with a GPS and a modem. However, future systems are expected to be heavily integrated into the vehicle electronics suite and will be capable of fully automated deployment without human intervention. The interests of public service versus private profit, combined with a public perception that such systems should have a basic level of functionality anywhere in the country, can only be met by developing in a way that components can work together with common interface standards. This specification J(2313) is being developed by SAE to further industry standards in two key areas. First, the message content that vehicles can be expected to exchange with the response agency. Second, internal methods of interconnection between this sub-system and other safety electronics in the vehicle. Finally, it prescribes various protocol methods so that vendors with different communication methods can speak to the response agency in a standard format, thus saving public investment capital and fostering a basic level expected performance.

## A.5.3 Navigation Standards

Position and location determination, route planning, route following, route guidance, traffic data functions, probe functions, communications strategies, and upper layer protocol are among the focus issues for the SAE Navigation Committee. They will evaluate these aspects and determine which standards may be beneficial in contributing to the overall safety of those types of systems. The group will provide direct benefit to users by assuring interoperability among subsystems that may be provided by more than one manufacturer, and helping to define the minimum functionality that would be considered "ITS- compatible."

The information contained in this Appendix, Parts A.4 and A.5 was drawn with permission from the SAE web site. Further information on all the SAE ITS standards can be obtained at:

<http://www.sae.org/TECHCMTE/gits.htm>.

# Appendix B. Glossary

**Advanced Traffic Management Systems (ATMS)** - The Advanced Traffic Management System category of ITS functions. Includes adaptive traffic signal control, electronic road pricing, and toll collection.

**Advanced Traveler Information Systems (ATIS)** - The Advanced Traveler Information System category of ITS functions. Includes vehicle navigation, route guidance, in-vehicle signage, intermodal travel information, trip planning, and mayday communication.

**Algorithm** - A procedure, process, or rule for the solution of a problem in a finite number of steps. An algorithm may be a set of computational rules for the solution of a mathematical problem or for evaluating a function.

**Advanced Public Transportation Systems (APTS)** - The Advanced Public Transportation System category of the ITS functions. Includes vehicle location and schedule monitoring, real-time transit, ride-share and HOV information.

**Architecture Flow** - A grouping of data flows (from the logical architecture) that originate at one subsystem and end at another (in the physical architecture).

**Automated Vehicle Identification (AVI)** - System that has three functional elements: a vehicle-mounted transponder (also known as a vehicle tag); roadside reader unit (also known as a tag reader); and a processing control unit.

**Automated Vehicle Location (AVL)** - A computerized system that tracks the current location of vehicles, buses, etc., enabling fleets to function more efficiently.

**Bus Priority** - Cycle-by-cycle timing of a traffic signal so the beginning and end times of green may be shifted to minimize delay to approaching buses. The normal sequence of signal displays is usually maintained.

**CCTV** - Closed Circuit Television

**CCTV Monitoring Systems** - Advanced traffic management systems with continuous CCTV coverage of the transportation facilities (e.g. freeways, intersections, bridges).

**Communication System** - The composite of communication links and associated communications equipment which interconnect all the control and surveillance components of a traffic control system.

**Communications Addressing** - The process of selecting a specific receiving unit on a multidrop line or network so that the message can be sent to the unit alone.

**Congestion** - A freeway condition where traffic demand exceeds roadway capacity. Normally occurs during peak travel periods or when a traffic incident reduces capacity by creating a bottleneck.

**Council of ITS Standards** - The council established by ITS America (Standards and Protocol Committee) to coordinate the standards-setting efforts in USA and international. Includes representatives from ANSI, IEEE, SAE, ASTM, EIA, NAB, NEMA, TIA, ITE, and AASHTO.

**Delay** - The retardation of traffic flow through a segment of roadway or intersection for a definite period of time.

**Demand** - The need for service, e.g., the number of vehicles desiring use of a given segment of roadway or intersection during a specified unit of time.

**Detector** - A device for indicating the presence or passage of vehicle or pedestrians. The general term is usually supplemented with a modifier; loop detector, magnetic detectors, etc. indicating type.

**Diversion** - An aspect of corridor control which refers to the directing of traffic from a corridor with excess demand to those with excess capacity.

**Diversion Strategy** - a strategy for diverting traffic that optimizes corridor operations in response to corridor incidents.

**Emergency Management** - The bundle of ITS user services that includes; emergency notification and personal security; and emergency vehicle management.

**Emergency Vehicle Preemption** - The transfer of the normal control of signals to a special signal control mode for emergency vehicles.

**Equipment Packages** - A grouping by function or p-specs of a given subsystem into implementable packages of hardware and software.

**Equipment Status Monitoring** - The ability to determine the operational characteristics of a remote device in terms of: *operating normally, malfunctions, communications errors*, etc.

**Global Positioning System (GPS)** - A spaced-based radionavigation system comprised of a constellation of satellites that transmit navigation signals, allowing a vehicle to determine the real-time position of its navigation receiver.

**Hardware** - The physical equipment in a computer system. (see *Software*).

**Highway Advisory Radio (HAR)** - Also know as Traveler's Information Stations (TIS), or Traveler's Advisory Radio (TAR). These systems provide travel or roadway information to motorists via their AM radio sets. The FCC regulates the use of HAR.

**Information Service Provider** - A subsystem of the National ITS Architecture which provides the capabilities to collect, process, store, and disseminate traveler information to subscribers and the public at large. Information provided includes basic advisories, real time traffic condition and transit schedule information, yellow pages information, ridematching information, and parking information. The subsystem also provides the capability to provide specific directions to travelers by receiving origin and destination requests from travelers, generating route plans, and returning the calculated plans to the users

**Incident** - An occurrence in the traffic stream which causes a reduction in capacity or abnormal increase in demand. Common incidents include accidents, stalled vehicles, spilled loads, and special events.

**Intelligent Transportation Systems (ITS)** - The collection of transportation services and infrastructure that will implement the goals of ISTEA. ITS uses advanced technologies to provide the range of traffic-based user services.

**Intermodal** - Those issues or activities which involve of affect more than one mode of transportation, including transportation connections, choices, cooperation and coordination of various modes. Also known as "multimodal."

**Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA-91)** - A Congressional act whose purpose is to develop a National Intermodal Transportation System that is economical efficient and environmentally sound, provide the foundation to compete in the global economy and move people and goods in an energy efficient manner. Provides governmental basis for research and deployment of ITS technologies.

**International Organization for Standardization (ISO)** - An international standards organization. ANSI is the U.S. representative to ISO.

**Internet** - A vast collection of interconnected networks that all use TCP/IP which evolved from ARPANET in the late 1960s and early 1970s. The Internet is a global network and is not proprietary. It has become a major medium to make information available (including traveler information).

**Kiosk** - In the transportation context, an interactive computer center for traffic or travel related information. Usually located in shopping malls, hotels, airports, businesses, and transit terminals, kiosks provide pre-recorded and real-time information using text, sound, graphics, and video clips.

**Layer** - A breakdown or stratification of the physical architecture; comprised of the transportation layer and the communications layer.

**Logical Architecture** - The identification of system functional processes and information flows grouped to form particular transportation management functions. These processes are broken down into subprocesses and further into process specifications or p-specs.

**Market Packages** - Within the National ITS Architecture, a set of equipment packages required to work together to deliver a given service and the major architecture flows between them and other important external systems.

**Measures of Effectiveness (MOE)** - The quantitative variables derived from traffic measurements that measure the improvement in traffic operations ranging from one signalized intersection to a complete system. Common MOEs are total travel time, total travel, number and recent of stops, delay, average speed, accident rate, and throughput.

**National Transportation Communications for ITS Protocol (NTCIP)** - A family of protocols being developed for the transportation community.

**NEMA** - National Electrical Manufacturers Association, a standards development body.

**Open Systems Interconnect Reference Model (OSI Model)** - A communications model established by the International Standards Organization (ISO) that breaks down the aspects of communications into seven layers or discrete functions to reduce complexity and provide support for open communications. The layers range from the physical layer to the application layer.

**Personal Digital Assistant (PDA)** - A compact processor, typically smaller than a personal laptop computer. Its size makes it convenient to carry when traveling. Many PDAs can be connected to a portable wireless modem or can be accessorized with pager modules. This allows the PDA to receive transportation information broadcast over wireless communications channels.

**Physical Architecture** - The physical (versus functional) view or representation of a system.

**Process Specifications** - The lowest level of functional hierarchy, process specifications (also know as p-specs) are elemental functions that must be performed to satisfy user service requirements.

**Preemption/Priority Systems** - Preemption control of normal signal timing plans applies in the following situations: priority for selected transit vehicles; preemption for emergency vehicles; and preemption for approaching trains at signals adjacent to railroad grade crossings.

**Project Management** - A management process that transforms a design into an installed system. Uses management tools such as: contract administration; project scheduling; construction management; work breakdown structure; defined and budgeted work packages; project design reviews and audits; and costs/progress status reports. This process carries forward the implementation of the system design. Tasks include: procurement of subsystems, software, and equipment, contractor performance monitoring, documentation; design reviews, development, integration, development testing, acceptance testing; training, hands-on training, and turnover to user, followed by a warranty period covering design, construction, installation and operational

**Queue Detector** - (1) A vehicle presence detector installed on a freeway entrance ramp just downstream of the frontage road to detect queue spillback onto the frontage road. (2) Component of a traffic signal control system which senses the presence (or number) of vehicles waiting in a queue.

**Queue Length** - (1) Number of vehicles stopped in a lane behind the stopline at a traffic signal. (2) Number of vehicles that are stopped or moving in a line where the movement of each vehicle is constrained by that of the lead vehicle.

**Ramp Metering** - The most widely used form of freeway traffic control. It regulates the number of vehicles entering the freeway over a given time interval so that demand does not exceed capacity.

**Recurrent Congestion** - A type of congestion which is routinely expected at predictable locations during specific time periods

**Roadside Radio** - Type of driver information system by which messages are conveyed to motorists from local transmitters beside the roadway to radio receivers in their vehicles.

**Route Preemption** - Emergency vehicles have pre-planned routes that are incorporated into the signal system. Signal control on an emergency basis can be modified at EMS, fire, or police headquarters.

**Signal Priority Systems** - Priority control at signalized intersections are typically used for reduction of transit delay. Conditional signal priority for transit vehicles can be implemented through: phase/green extension; phase early start or red truncation; red interrupt or special phase; phase suppression or skipping; and window stretching.

**Smart Card** - Card with a computer chip embedded in plastic. The user transfers a cash value to the card's microchip. The card can then be used to pay subway, bus, tolls, or parking fees.

**Software** - Various computer programs to facilitate the efficient operation of the system. Software items include: assemblers; compilers, generators; subroutines; libraries; operating systems; and application programs.

**Software Maintenance** - Those tasks required to locate and correct errors remaining in computer programs after they are placed in operation, as well as making other program modifications to meet the demands of changing system needs. This is an ongoing activity that is required on any large automated system.

**Subsystem** - A physical entity within the transportation layer of the National ITS Architecture.

**Threshold** - A present level or value of a parameter which indicates that a change of activity will occur if the current value is above or below this level.

**Transit Communications Interface Profiles (TCIP)** - A subset of NTCIP protocols which are specific to the transit community.

**User Service** - Those ITS functional capabilities provided to address identified problems or needs of a distinct user community.

**User Service Bundle** - A collection of ITS user services that have common characteristics and can be deployed in a coordinated manner.

**User Service Requirements** - The decomposition of each user service into fundamental needs.

**Variable Message Sign** - Also referred to as Changeable Message Signs (CMS) or Dynamic Message Signs (DMS). Signs that electronically or mechanically vary the visual word, number or symbolic display as traffic conditions warrant. Also referred to as changeable message signs or as dynamic message signs.

**Wide Area Network** - Any one of a number of technologies that provides geographically distant transfer.

# Appendix C. Physical Architecture Data Flows Associated With Traveler Information

The physical architecture allocates the functionality defined in the logical architecture into subsystems based on the functional similarity of the process specifications and the typical locations of functions in transportation systems. By defining four subsystem classes (Traveler, Roadway, Center and Vehicle) and 19 subsystems, the National ITS Architecture provides a framework for development of a regional physical architecture. Once the subsystems of the physical architecture have been defined, and the interfaces required between them identified, a detailed system design can be developed.

Figure C-1 provides an illustration of the physical data flows into and out of the Information Service Provider Subsystem.

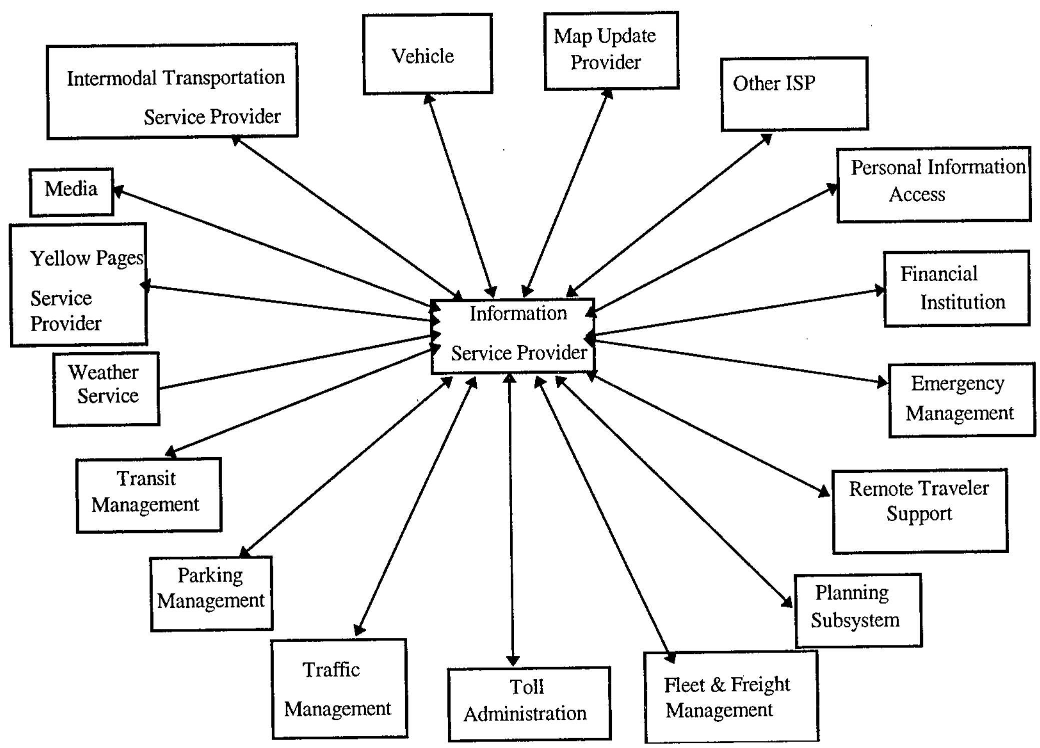



**Figure C-1. Physical Data Flows for Information Service Provider**

*Note to reader: This appendix was derived from the January 1997 version of the National ITS Architecture. Since this information is subject to change as updates are implemented, the reader should always consult and defer to the latest version of the National ITS Architecture (see Section 5 of this document).*

The balance of Appendix C lists important physical data flows that may be associated with traveler information. The format of each is as follows:

- ✦ Heading (bold) - Source subsystem to destination subsystem
- ✦ Physical Architecture flow name - italics
- ✦ Brief description of the data flow - line following Physical Architecture flow name
- ✦ Logical Architecture Reference Flow (bullets) - Logical data flows which comprise the Physical Architecture data flow

This list does not constitute the entire list of data flows that may be relevant to traveler information systems. For example, data flows exchanged with several external system interfaces (or terminators) are not included. Guidance for locating complete data flow lists for each market package is provided in Section 2.

**Emergency Management -> Information Service Provider**

*Physical Architecture Flow Name:* emergency vehicle route request

Special routing instructions and signal priority for emergency vehicles.

- ✦ Logical Architecture Reference Flow: emergency_vehicle_route_request

*Physical Architecture Flow Name:* incident information

Notification of existence of incident and expected severity, location, and nature of incident. Similar information for ERMS, Media, TMS, E911.

- ✦ Logical Architecture Reference Flow: incident_information

**Financial Institution -> Information Service Provider**

*Physical Architecture Flow Name:* transaction status

Response to transaction request. Normally dealing with request for payment.

- ✦ Logical Architecture Reference Flow: ffi_driver_map_payment_confirm
- ✦ Logical Architecture Reference Flow: ffi_registration_payment_confirm
- ✦ Logical Architecture Reference Flow: ffi_traveler_display_payment_confirm
- ✦ Logical Architecture Reference Flow: ffi_traveler_map_payment_confirm
- ✦ Logical Architecture Reference Flow: ffi_traveler_other_services_payments_confirm
- ✦ Logical Architecture Reference Flow: ffi_traveler_rideshare_payment_confirm

**Fleet and Freight Management** -> **Information Service Provider**

*Physical Architecture Flow Name:* route request -

Request for route and status of vehicle.

- ✦ Logical Architecture Reference Flow: cf_route_request
- ✦ Logical Architecture Reference Flow: cv_route_request

**Information Service Provider** -> **Emergency Management**

*Physical Architecture Flow Name:* emergency vehicle route -

Routing for emergency vehicle including greenwave paths.

- ✦ Logical Architecture Reference Flow: emergency_vehicle_route

*Physical Architecture Flow Name:* incident information request

Request for incident information, clearing time, severity.

- ✦ Logical Architecture Reference Flow: incident_information_request

**Information Service Provider** -> **Financial Institution**

*Physical Architecture Flow Name:* payment request

Request for payment from financial institution.

- ✦ Logical Architecture Reference Flow: tfi_driver_map_payment_request
- ✦ Logical Architecture Reference Flow: tfi_registration_payment_request
- ✦ Logical Architecture Reference Flow: tfi_traveler_display_payment_request
- ✦ Logical Architecture Reference Flow: tfi_traveler_map_payment_request
- ✦ Logical Architecture Reference Flow: tfi_traveler_other_services_payments_request
- ✦ Logical Architecture Reference Flow: tfi_traveler_rideshare_payment_request

**Information Service Provider** **->** **Fleet and Freight Management**

*Physical Architecture Flow Name:* route plan

Route provided by ISP in response to specific request.

- ✦ Logical Architecture Reference Flow: cf_route
- ✦ Logical Architecture Reference Flow: cv_route

**Information Service Provider** **->** **Intermodal Transportation Service Provider**

*Physical Architecture Flow Name:* intermodal information -

Schedule information for alternate mode transportation providers such as train, ferry, air.

- ✦ Logical Architecture Reference Flow: titsp_air_services_request
- ✦ Logical Architecture Reference Flow: titsp_confirm_intermodal_service
- ✦ Logical Architecture Reference Flow: titsp_ferry_services_request
- ✦ Logical Architecture Reference Flow: titsp_rail_services_request

**Information Service Provider** **->** **ISP Operator**

*Physical Architecture Flow Name:* ISP route planning parameters -

Parameters provided to the ISP Operator by the ISP to control route selection and travel optimization algorithms.

- ✦ Logical Architecture Reference Flow: tispo_broadcast_data_parameters_output
- ✦ Logical Architecture Reference Flow: tispo_route_selection_parameters
- ✦ Logical Architecture Reference Flow: tispo_trip_planning_parameters

**Information Service Provider** **->** **Map Update Provider**

*Physical Architecture Flow Name:* map update request

Request for a map update.

- ✦ Logical Architecture Reference Flow: tmup_request_other_routes_map_update
- ✦ Logical Architecture Reference Flow: tmup_request_route_selection_map_update

**Information Service Provider** -> **Media**

*Physical Architecture Flow Name:* incident information -

Notification of existence of incident and expected severity, location, and nature of incident. Similar information for ERMS, Media, TMS, E911.

- Logical Architecture Reference Flow: tm_incident_information
- Logical Architecture Reference Flow: tm_transit_emergency_information
- Logical Architecture Reference Flow: tm_transit_incident_information

*Physical Architecture Flow Name:* traffic information

Congestion, pricing, and incident information.

- Logical Architecture Reference Flow: tm_traffic_information
- Logical Architecture Reference Flow: tm_transit_schedule_variations
- Logical Architecture Reference Flow: tm_traveler_information_request

**Information Service Provider** -> **Media Operator**

*Physical Architecture Flow Name:* incident information

Notification of existence of incident and expected severity, location, and nature of incident. Similar information for ERMS, Media, TMS, E911.

- Logical Architecture Reference Flow: tmo_incident_information

*Physical Architecture Flow Name:* traffic information

Congestion, pricing, and incident information.

- Logical Architecture Reference Flow: tmo_traffic_information

**Information Service Provider** -> **Other ISP**

*Physical Architecture Flow Name:* ISP coord

Coordination and exchange of all types of information on behalf of a client.

- ✦ Logical Architecture Reference Flow: toisp_data_supply
- ✦ Logical Architecture Reference Flow: toisp_request_data

**Information Service Provider -> Parking Management**

*Physical Architecture Flow Name:* parking lot data request

Request for lot occupancy, fares, availability.

- ✦ Logical Architecture Reference Flow: advanced_other_charges_request
- ✦ Logical Architecture Reference Flow: advanced_traveler_charges_request
- ✦ Logical Architecture Reference Flow: parking_lot_data_request
- ✦ Logical Architecture Reference Flow: parking_lot_price_data_request

*Physical Architecture Flow Name:* parking reservations request

Reservations for parking.

- ✦ Logical Architecture Reference Flow: parking_lot_reservation_request

**Information Service Provider -> Personal Information Access**

*Physical Architecture Flow Name:* broadcast information

Common link travel times, advisories, transit schedule exceptions, other traveler information.

- ✦ Logical Architecture Reference Flow: traffic_data_for_portables
- ✦ Logical Architecture Reference Flow: transit_deviations_for_portables

*Physical Architecture Flow Name:* traveler information

Traveler routing, yellow pages etc.

- ✦ Logical Architecture Reference Flow: traffic_data_for_portables
- ✦ Logical Architecture Reference Flow: transit_deviations_for_portables
- ✦ Logical Architecture Reference Flow: traveler_map_update_payment_response
- ✦ Logical Architecture Reference Flow: traveler_personal_display_update_payment_response

- Logical Architecture Reference Flow: traveler_personal_payment_confirmation
- Logical Architecture Reference Flow: traveler_personal_transaction_confirmation
- Logical Architecture Reference Flow: traveler_personal_yellow_pages_data

*Physical Architecture Flow Name:* trip plan

A sequence of links and special instructions indicating efficient ways of navigating the links. Normally coordinated with traffic conditions, other incidents, preemption and prioritization plans.

- Logical Architecture Reference Flow: traveler_guidance_route
- Logical Architecture Reference Flow: traveler_personal_trip_information

**Information Service Provider -> Planning Subsystem**

*Physical Architecture Flow Name:* road network use

Aggregated OD data from clients for planning purposes.

- Logical Architecture Reference Flow: current_other_routes_use
- Logical Architecture Reference Flow: current_road_network_use
- Logical Architecture Reference Flow: payment_transaction_reports

**Information Service Provider -> Remote Traveler Support**

*Physical Architecture Flow Name:* broadcast information

Common link travel times, advisories, transit schedule exceptions, other traveler information.

- Logical Architecture Reference Flow: traffic_data_for_kiosks
- Logical Architecture Reference Flow: transit_deviations_for_kiosks

*Physical Architecture Flow Name:* traveler information

Traveler routing, yellow pages, etc.

- Logical Architecture Reference Flow: advanced_tolls_and_charges_roadside_confirm
- Logical Architecture Reference Flow: traffic_data_for_kiosks
- Logical Architecture Reference Flow: transit_deviations_for_kiosks

- Logical Architecture Reference Flow: traveler_payment_confirmation
- Logical Architecture Reference Flow: traveler_transaction_confirmation
- Logical Architecture Reference Flow: traveler_yellow_pages_data

*Physical Architecture Flow Name:* trip plan

A sequence of links and special instructions indicating efficient ways of navigating the links. Normally coordinated with traffic conditions, other incidents, preemption and prioritization plans.

- Logical Architecture Reference Flow: traveler_trip_information

**Information Service Provider -> Toll Administration**

*Physical Architecture Flow Name:* toll data request

Request made to obtain toll schedule information.

- Logical Architecture Reference Flow: advanced_other_tolls_request
- Logical Architecture Reference Flow: advanced_traveler_tolls_request
- Logical Architecture Reference Flow: toll_price_data_request

**Information Service Provider -> Traffic Management**

*Physical Architecture Flow Name:* incident notification

Notification of an incident on the roadway through emergency network.

- Logical Architecture Reference Flow: confirm_incident_data_output
- Logical Architecture Reference Flow: media_incident_data_updates

*Physical Architecture Flow Name:* logged route plan

Route plan which may be used for demand management or optimal routing.

- Logical Architecture Reference Flow: logged_hazmat_route
- Logical Architecture Reference Flow: low_traffic_route

*Physical Architecture Flow Name:* request for traffic information

Request issued to agency which collects traffic data for traffic conditions.

- ✦ Logical Architecture Reference Flow: request_incident_media_data
- ✦ Logical Architecture Reference Flow: traffic_data_media_request

*Physical Architecture Flow Name:* road network use

Aggregated OD data from clients for planning purposes.

- ✦ Logical Architecture Reference Flow: current_other_routes_use
- ✦ Logical Architecture Reference Flow: current_road_network_use
- ✦ Logical Architecture Reference Flow: current_transit_routes_use
- ✦ Logical Architecture Reference Flow: parking_lot_charge_details
- ✦ Logical Architecture Reference Flow: toll_price_details
- ✦ Logical Architecture Reference Flow: transit_fare_details

**Information Service Provider -> Transit Management**

*Physical Architecture Flow Name:* demand responsive transit request

Request for paratransit support.

- ✦ Logical Architecture Reference Flow: paratransit_trip_request

*Physical Architecture Flow Name:* selected routes

Routes selected by optimization algorithms.

- ✦ Logical Architecture Reference Flow: advanced_tolls_and_charges_vehicle_confirm
- ✦ Logical Architecture Reference Flow: paratransit_service_confirmation

*Physical Architecture Flow Name:* transit information request

Request for transit schedule information.

- ✦ Logical Architecture Reference Flow: advanced_other_fares_request
- ✦ Logical Architecture Reference Flow: advanced_traveler_fares_request
- ✦ Logical Architecture Reference Flow: transit_fare_data_request

- Logical Architecture Reference Flow: transit_services_advisories_request
- Logical Architecture Reference Flow: transit_services_guidance_request
- Logical Architecture Reference Flow: transit_vehicle_deviations_details_request

**Information Service Provider -> Vehicle**

*Physical Architecture Flow Name:* broadcast information

Common link travel times, advisories, transit schedule exceptions, other traveler information.

- Logical Architecture Reference Flow: broadcast_data
- Logical Architecture Reference Flow: link_and_queue_data

*Physical Architecture Flow Name:* traveler information

Traveler routing, yellow pages etc.

- Logical Architecture Reference Flow: advanced_fares_and_charges_response
- Logical Architecture Reference Flow: advanced_tolls_and_fares_response
- Logical Architecture Reference Flow: advisory_data
- Logical Architecture Reference Flow: driver_map_update_payment_response
- Logical Architecture Reference Flow: link_and_queue_data
- Logical Architecture Reference Flow: yellow_pages_advisory_data

*Physical Architecture Flow Name:* trip plan

A sequence of links and special instructions indicating efficient ways of navigating the links. Normally coordinated with traffic conditions, other incidents, preemption and prioritization plans.

- Logical Architecture Reference Flow: vehicle_guidance_route

**Information Service Provider -> Yellow Pages Service Providers**

*Physical Architecture Flow Name:* provider registration confirm

Confirmation of registration for travel service (e.g. hotel or dinner reservation).

- ✦ Logical Architecture Reference Flow: typsp_provider_registration_confirm

*Physical Architecture Flow Name:* travel service request

Request for reservation or other service.

- ✦ Logical Architecture Reference Flow: typsp_transaction_request
- ✦ Logical Architecture Reference Flow: typsp_yellow_pages_info_request

**Intermodal Transportation Service Provider -> Information Service Provider**

*Physical Architecture Flow Name:* intermodal information

Schedule information for alternate mode transportation providers such as train, ferry, air.

- ✦ Logical Architecture Reference Flow: fitsp_air_services
- ✦ Logical Architecture Reference Flow: fitsp_ferry_services
- ✦ Logical Architecture Reference Flow: fitsp_intermodal_service_confirmation
- ✦ Logical Architecture Reference Flow: fitsp_rail_services

**ISP Operator -> Information Service Provider**

*Physical Architecture Flow Name:* route planning parameters

Tuning and performance enhancement parameters to ISP algorithms.

- ✦ Logical Architecture Reference Flow: fispo_broadcast_data_parameters_request
- ✦ Logical Architecture Reference Flow: fispo_broadcast_data_parameters_update
- ✦ Logical Architecture Reference Flow: fispo_request_other_routes_selection_map_data_update
- ✦ Logical Architecture Reference Flow: fispo_request_route_selection_map_data_update
- ✦ Logical Architecture Reference Flow: fispo_route_selection_parameters_request
- ✦ Logical Architecture Reference Flow: fispo_route_selection_parameters_update
- ✦ Logical Architecture Reference Flow: fispo_trip_planning_parameters_request
- ✦ Logical Architecture Reference Flow: fispo_trip_planning_parameters_update

**Map Update Provider** -> **Information Service Provider**

*Physical Architecture Flow Name:* map updates

Either static or real-time map updates.

- Logical Architecture Reference Flow: fmup_other_routes_map_data
- Logical Architecture Reference Flow: fmup_route_selection_map_data

**Media** -> **Information Service Provider**

*Physical Architecture Flow Name:* external reports

Verbal reports from media.

- Logical Architecture Reference Flow: fm_traveler_information

**Media Operator** -> **Information Service Provider**

*Physical Architecture Flow Name:* incident notification

Notification of an incident on the roadway through emergency network.

- Logical Architecture Reference Flow: fmo_incident_details
- Logical Architecture Reference Flow: fmo_incident_information_output_request
- Logical Architecture Reference Flow: fmo_incident_information_request
- Logical Architecture Reference Flow: fmo_media_operator_identity
- Logical Architecture Reference Flow: fmo_traffic_information_output_request
- Logical Architecture Reference Flow: fmo_traffic_information_request

**Other ISP** -> **Information Service Provider**

*Physical Architecture Flow Name:* ISP coord

Coordination and exchange of all types of information on behalf of a client.

- Logical Architecture Reference Flow: foisp_data_supply
- Logical Architecture Reference Flow: foisp_request_data

**Parking Management** -> **Information Service Provider**

*Physical Architecture Flow Name:* parking availability

Parking lot occupancy and availability.

- ✦ Logical Architecture Reference Flow: parking_lot_availability

*Physical Architecture Flow Name:* parking lot reservation confirmation

Confirmation for parking lot reservation.

- ✦ Logical Architecture Reference Flow: advanced_other_charges_confirm
- ✦ Logical Architecture Reference Flow: advanced_traveler_charges_confirm
- ✦ Logical Architecture Reference Flow: parking_lot_price_data
- ✦ Logical Architecture Reference Flow: parking_lot_reservation_confirm

**Personal Information Access** -> **Information Service Provider**

*Physical Architecture Flow Name:* traveler information request

Request for any type of traveler information.

- ✦ Logical Architecture Reference Flow: traffic_data_portables_request
- ✦ Logical Architecture Reference Flow: transit_deviations_portables_request
- ✦ Logical Architecture Reference Flow: traveler_map_update_payment_request
- ✦ Logical Architecture Reference Flow: traveler_personal_current_condition_request
- ✦ Logical Architecture Reference Flow: traveler_personal_display_update_payment_request

*Physical Architecture Flow Name:* trip confirmation

Acknowledgment of acceptance of route.

- ✦ Logical Architecture Reference Flow: traveler_personal_payment_information
- ✦ Logical Architecture Reference Flow: traveler_personal_trip_confirmation
- ✦ Logical Architecture Reference Flow: traveler_route_accepted

*Physical Architecture Flow Name:* trip request

Request for special routing.

- ✦ Logical Architecture Reference Flow: traveler_personal_trip_request
- ✦ Logical Architecture Reference Flow: traveler_route_request

*Physical Architecture Flow Name:* yellow pages request

Request for reservation through yellow pages type service.

- ✦ Logical Architecture Reference Flow: traveler_personal_transaction_request
- ✦ Logical Architecture Reference Flow: traveler_personal_yellow_pages_information_request

**Remote Traveler Support -> Information Service Provider**

*Physical Architecture Flow Name:* traveler information request

Request for any type of traveler information.

- ✦ Logical Architecture Reference Flow: advanced_tolls_and_charges_roadside_request
- ✦ Logical Architecture Reference Flow: traffic_data_kiosk_request
- ✦ Logical Architecture Reference Flow: transit_deviation_kiosk_request
- ✦ Logical Architecture Reference Flow: traveler_current_condition_request
- ✦ Logical Architecture Reference Flow: traveler_payment_information
- ✦ Logical Architecture Reference Flow: traveler_transaction_request
- ✦ Logical Architecture Reference Flow: traveler_yellow_pages_information_request

*Physical Architecture Flow Name:* traveler selection

Items or route options selected by traveler.

- ✦ Logical Architecture Reference Flow: traveler_trip_confirmation

*Physical Architecture Flow Name:* trip request

Request for special routing.

- ✦ Logical Architecture Reference Flow: traveler_trip_request

*Physical Architecture Flow Name:* yellow pages request

Request for reservation through yellow pages type service.

- ✦ Logical Architecture Reference Flow: traveler_yellow_pages_information_request

**Toll Administration -> Information Service Provider**

*Physical Architecture Flow Name:* probe data

Aggregate data from probe vehicles including location, speed for a given link or collection of links.

- ✦ Logical Architecture Reference Flow: vehicle_toll_probe_data

*Physical Architecture Flow Name:* toll data

Current toll schedules for different types of vehicles.

- ✦ Logical Architecture Reference Flow: advanced_other_tolls_confirm
- ✦ Logical Architecture Reference Flow: advanced_traveler_tolls_confirm
- ✦ Logical Architecture Reference Flow: toll_price_data

**Traffic Management -> Information Service Provider**

*Physical Architecture Flow Name:* traffic information

Congestion, pricing, and incident information.

- ✦ Logical Architecture Reference Flow: current_highway_network_state
- ✦ Logical Architecture Reference Flow: current_road_network_state
- ✦ Logical Architecture Reference Flow: incident_data_output
- ✦ Logical Architecture Reference Flow: link_data_for_guidance
- ✦ Logical Architecture Reference Flow: parking_lot_charge_request
- ✦ Logical Architecture Reference Flow: predicted_incidents
- ✦ Logical Architecture Reference Flow: prediction_data
- ✦ Logical Architecture Reference Flow: retrieved_incident_media_data
- ✦ Logical Architecture Reference Flow: toll_price_request

- Logical Architecture Reference Flow: traffic_data_for_media
- Logical Architecture Reference Flow: traffic_data_media_parameters
- Logical Architecture Reference Flow: transit_fare_request

**Transit Management -> Information Service Provider**

*Physical Architecture Flow Name:* demand responsive transit plan

Plan regarding overall schedules and deployment of demand responsive system.

- Logical Architecture Reference Flow: paratransit_personal_schedule

*Physical Architecture Flow Name:* transit and fare schedules

Specific schedules from transit management.

- Logical Architecture Reference Flow: transit_deviation_data_received
- Logical Architecture Reference Flow: transit_fare_data
- Logical Architecture Reference Flow: transit_media_emergency_information
- Logical Architecture Reference Flow: transit_media_incident_information
- Logical Architecture Reference Flow: transit_services_for_advisory_data
- Logical Architecture Reference Flow: transit_services_for_guidance
- Logical Architecture Reference Flow: transit_vehicle_deviations_details

*Physical Architecture Flow Name:* transit request confirmation

Confirmation of a request for transit information or service.

- Logical Architecture Reference Flow: advanced_other_fares_confirm
- Logical Architecture Reference Flow: advanced_tolls_and_charges_vehicle_request
- Logical Architecture Reference Flow: advanced_traveler_fares_confirm
- Logical Architecture Reference Flow: transit_user_payments_transactions

**Vehicle** **->** **Information Service Provider**

*Physical Architecture Flow Name:* traveler information request

Request for any type of traveler information.

- ✦ Logical Architecture Reference Flow: advanced_fares_and_charges_request
- ✦ Logical Architecture Reference Flow: advanced_tolls_and_fares_request
- ✦ Logical Architecture Reference Flow: advisory_data_request
- ✦ Logical Architecture Reference Flow: driver_map_update_payment_request

*Physical Architecture Flow Name:* trip confirmation

Acknowledgment of acceptance of route.

- ✦ Logical Architecture Reference Flow: vehicle_guidance_route_accepted

*Physical Architecture Flow Name:* trip request

Request for special routing.

- ✦ Logical Architecture Reference Flow: vehicle_route_request

*Physical Architecture Flow Name:* vehicle probe data

Single vehicle probe data indicating link time and location.

- ✦ Logical Architecture Reference Flow: vehicle_guidance_probe_data

*Physical Architecture Flow Name:* yellow pages request

Request for reservation through yellow pages type service.

- ✦ Logical Architecture Reference Flow: yellow_pages_advisory_requests

**Weather Service** **->** **Information Service Provider**

*Physical Architecture Flow Name:* weather information

Predicted and accumulated weather data.

- ✦ Logical Architecture Reference Flow: From_Weather_Service
- ✦ Logical Architecture Reference Flow: fws_current_weather
- ✦ Logical Architecture Reference Flow: fws_predicted_weather

**Yellow Pages Service Providers** -> **Information Service Provider**

*Physical Architecture Flow Name:* provider registration

Registration by service provider (e.g. hotel or dinner).

- Logical Architecture Reference Flow: fypsp_request_provider_registration

*Physical Architecture Flow Name:* travel service info

Reservation information or yellow pages data.

- Logical Architecture Reference Flow: fypsp_transaction_confirmation
- Logical Architecture Reference Flow: fypsp_yellow_pages_data

Useful National ITS Architecture Document: Physical Architecture

# Appendix D. National ITS Architecture Products

Provided below is a brief overview of all documents that are part of the National ITS Architecture.

**Vision Statement** Written in "magazine style," the Vision Statement sketches a number of possible scenarios of ITS development over the next 20 years. It describes how travelers and system operators may be able to use and benefit from ITS technologies in their day-to-day activities. While the Vision Statement is not a technical document, it does describe the potential impact of ITS technologies on the management of the nation's transportation system.

**Mission Definition** The first of the technical documents, the Mission Definition covers a broad range of ITS-related issues. It contains the overall mission of ITS deployment, as well as the operational concept, which deals with specific ITS goals and objectives; ITS user groups and other stakeholders; ITS user services; and potential sources for funding, operations and maintenance. The document also defines operational requirements at the system level, user requirements, performance requirements, and program requirements.

These concepts are important aspects of the National Architecture throughout the deployment process, since they provide the overall direction for the ITS program. Constant evaluation of a region's ITS deployment against the national goals and objectives will ensure that regional ITS deployment is compatible with the philosophy of the National Architecture. The Mission Definition document is important for those that are involved with the initial concepts definition of an ITS system for a particular region.

**Logical Architecture** The Logical Architecture document contains three volumes: *Description* (Volume 1), *Process Specifications* (Volume 2), and *Data Dictionary* (Volume 3). These documents present a functional view of the ITS user services, contain diagrams that show processes and data flows among them, and define data elements, respectively.

**Physical Architecture** The Physical Architecture document describes the transportation and communications layers resulting from the partitioning of the processes within the logical architecture, presents architecture flow diagrams that show data passing among physical subsystems, and provides characteristics and constraints on the data flows.

**Theory Of Operations** This document provides a detailed narrative of the manner in which the architecture supports the ITS user services, described in the Mission Definition. It is a technical document, intended for engineers, operators, and others involved detailed systems design.

**Traceability Document** The Traceability Document is a technical document that is used in conjunction with and throughout the development of the Logical and Physical Architectures. It lists all the User Service Requirements (USR), which constitute the highest-level functional specifications for ITS, as provided by the U.S. Department of Transportation. In several tables, these USRs are mapped to the various logical and physical components of an ITS system. The document should be used primarily by those involved in detailed design.

**Implementation Strategy** The Implementation Strategy document ties the elements the National Architecture together, and is intended to assist ITS implementors at all levels with cost-effective, efficient ITS deployment.

**Standards Development Plan** This document discusses the issues that are involved in the development of system interface standards. It is primarily intended for Standards Development Organizations and system designers, and will be important at the integration step in the Systems Engineering Process.

**Standards Requirements** This is a set of 12 Standards Requirements Packages that presents detailed data flow and interface information pertaining to the priority standards packages that need to be developed to implement the architecture. It, too, is primarily intended for Standards Development Organizations and system designers, and will be important at the integration step in the Systems Engineering Process.

**Evaluatory Design** The Evaluatory Design document is intended to evaluate the National Architecture's performance, benefits, and costs for three conceptual scenarios at various points in time. The scenarios consist of "typical" deployment environments: urban, inter-urban, and rural. The entire document will assist you in developing an evaluation methodology for the architecture that you have developed for your particular region.

**Communications Document** This document provides a thorough analysis of the communications requirements of the National Architecture, and ITS in general, and includes a discussion of options for implementing various communications links. With the latest version of the National Architecture, an addendum to this document was published, detailing requirements for the Highway-Rail Intersections User Service. It is an important document for those involved in detailed design and integration during the Systems Engineering Process.

**Risk Analysis** This document presents an analysis of potential critical risks that may delay or prevent the deployment of ITS technologies, and recommends mitigation plans which will eliminate of reduce these risks to the deployment process. It is intended for implementors that are involved with the details of ITS deployment in their region, throughout the development of the Regional Architecture.

**Cost Analysis** The Cost Analysis document has two purposes. First, it develops a high-level cost estimate of the expenditures that are associated with implementing ITS components. Second, it is a costing tool for implementers, by providing unit prices and systems costs of ITS subsystems. There is significant correlation between the Cost Analysis and the Evaluatory Design documents; the Cost Analysis is based largely on the assumptions made for the three deployment scenarios (urban, inter-urban, and rural). The latest version of the National Architecture documents contains an addendum to the Cost Analysis, accounting for the Highway-Rail Intersection User Service. This is an important document for those involved in planning and design, and could be useful to those responsible for project management in the Systems Engineering Process, including funding and procurement.

**Performance and Benefits Study** This document assesses the technical performance of the National Architecture on a number of system-level and operational-level criteria. It could be helpful in supporting the case for ITS deployment, as it provides a measure of the degree to which ITS can help achieve some regional transportation goals.

**Evaluation Results** This document contains a concise summary of the various evaluations that were performed in five other National Architecture documents: Evaluatory Design, Communications Analysis, Cost Analysis, Performance and Benefits, and Risk Analysis.

**Executive Summary** Provides an overview of the most important aspects of the National Architecture, most notably the Logical and Physical Architectures.

# Appendix E. Traveler Information System Technologies

## E.1 Overview

A brief list of technologies discussed in this appendix are listed below:

**Pre-Trip Information Technologies (Section E.2)**
Home and Office Computer-Based Systems (Internet, Electronic Bulletin Board Service, Videotex)
Telephone-Based Systems (Traveler Advisory Telephone, Loop Tape System, Voice Response System)
Television-Based Systems (Broadcast Television, Teletext, Cable Television, Interactive Television)

**En route Information Technologies (Section E.3)**
Roadway-Based Systems (Variable Message Signs, Highway Advisory Radio, Portable Systems)
Station-Based Systems (Public Announcement Systems, Display Monitors, Message Boards, Kiosks)
Personal-Based Systems (Personal Digital Assistants, Pagers)

**In-Vehicle Technologies (Section E.4)**
In-Vehicle (Automobile) Systems (AM Radio, Static Route Guidance, Dynamic Route Guidance, Mayday)
In-Transit Vehicle Systems (In-Vehicle Message Boards, Automatic Annunciation Systems)

## E.2 Pre-Trip Information Technologies

Computer-based, telephone based, and television-based traveler information systems are discussed below.

### E.2.1 Home and Office Computer-Based Systems

Computer-based pre-trip traveler information, including the Internet, Electronic Bulletin Board Services, and Videotex are discussed in this section. These technologies provide access to pre-trip information from the home and office.

#### E.2.1.1 Internet

On-line services to access the Internet represent a growing method for disseminating pre-trip traveler information. The Internet originally began as a small, specialized network connecting scientists to distant computers and to each other, around the country and around the world. The Internet can be accessed from home or office computers and PDAs.

On the Internet, dozens of different types of computers using the same telecommunication technology. The Internet is accessed using commercially available computer programs called web browsers.

A wide variety of organizations have developed, or are currently developing Internet-compatible systems to provide roadway and transit related transportation services and information for major metropolitan areas around the country. Types of information available include:

- Comprehensive bus and rail system schedule information, and details on fare payment systems
- Traffic speeds
- Color maps showing locations of light, moderate and heavy traffic congestion, as well as locations of stopped traffic along major roadways.

- Construction information
- Real-time photos of traffic conditions
- Incident information

#### E.2.1.2 Electronic Bulletin Board Services

Electronic Bulletin Board Services are two-way information system that use computer terminals in the home or office to request and display traveler information. Information can be disseminated to the public through a commercial provider such as America On Line, CompuServe, etc., or the user can directly log in by using a telephone number. Another option includes posting traveler information directly to subscribers. For example, commercial trucking companies can be informed in advance about construction and affected routes on a weekly or biweekly (fixed time intervals) basis. These services can be provided for free or at a nominal charge.

#### E.2.1.3 Videotex

Videotex is a consumer oriented, two-way information system that uses computer terminals in the home or office to request and display information about products and services. It is an on-line computer-based travel information system that provides routing information, though primarily using audiotex technology (i.e., the push button phone is the primary means of accessing the database). To request routing information, the user enters the origin and destination telephone numbers via a touch tone phone and receives the directions via synthesized voice, fax, or video display.

### E.2.2 Telephone-Based Systems

Telephone-based pre-trip traveler information systems, including Traveler Advisory Telephone and Automated Trip Planning Services, are discussed in this section. While these technologies can be used to provide access to pre-trip information, use of a touch-tone cellular telephone allows travelers to inquire about current travel conditions, or to plan the next leg of a trip, while traveling en route to a specific destination.

#### E.2.2.1 Traveler Advisory Telephone

Traveler Advisory Telephone (TAT)—also known as audiotex—can provide up-to-the-minute traffic information in the form of voice messages delivered to motorists before or during a trip. Traveler advisory telephone functions include the ability to provide traffic conditions, real time traffic information for trip planning, public transit information (i.e., transit fares and schedules), and operational information (i.e., roadway construction and ramp closures) capabilities. Users of traveler advisory telephone can access information simply by dialing a telephone number either from their home, office, or automobile. Upon calling a TAT system, the user is guided through voice menus enabling them to access the desired information.

#### E.2.2.2 Loop Tape System

Loop tape systems play pre-recorded messages continuously and cannot accept any interactive commands from the callers. This is a basic telephone information system intended for very simple applications, or as an alternative service for users who do not have the touch-tone telephone access. Pre-recorded messages can also be regularly updated and stored for use by the loop tape system.

#### E.2.2.3 Voice Response System

A voice response system (VRS) provides callers with interactive voice response and voice messaging service. A voice response system interfaces between the telephone network and host application. Functions provided can include speaking voice menus to callers, prompting for caller inputs (touch-tone signals), and translating the received touch-tone signals into digital data. The digital data is transmitted to the host application, which can then use the voice response system to provide synthesized or pre-recorded voice messages to the caller.

### E.2.3 Television-Based Systems

Television-based pre-trip traveler information systems, including the Television Media, Teletext, Cable Television, and Interactive Television are discussed in further detail in this section. These technologies provide access for travelers at the home, workplace, hotels, and other public environments which may be equipped with television.

#### E.2.3.1 Broadcast Television Media

An ITS-based system is a repository for significant amounts of real-time information on traffic flow conditions and incidents, transit operations, and construction/maintenance activities. It should therefore include some form of interface for filtering this information and providing up-to-the-minute data to television and radio stations, and private entities (Information service Providers), either automatically or upon inquiry. Possible interfaces include:

- Teletype Network - Text information on current traffic flow conditions (e.g., average speeds, estimated travel times, congested areas, incident locations) is periodically transmitted to dedicated printers or FAX machines at the various stations. One procedure is called "rip and read," where relatively final copy is provided. Another method is to just provide traffic flow information in a standardized format that can then be used by broadcasters in preparing their traffic reports.

- Workstations - This is similar to the teletype network, but now the television and radio stations have workstations and two-way communications, permitting them to directly query the ITS system. With this form of media interface, the ITS must be capable of limiting the data to which the stations have access.

- Color Graphics - This option is identical to the workstation alternative, except that a high-resolution color monitor is included for showing real-time graphic displays of conditions throughout the roadway and transit network (e.g., different colors representing various speed or travel time thresholds, and adherence of transit routes). These real-time displays may also be televised over existing stations and/or a dedicated traffic channel (e.g., cable), thereby permitting residents to alter their travel plans (if necessary) before they become motorists and commit themselves to a particular route or mode.

- Video Information - CCTV images can be transmitted for locations where incidents are present or for selected freeway locations. The number of images available to the media would depend on the resources available to multiplex the data for transmission to the media and the level of manipulation (switching, number of monitors) the media outlet(s) would have available. A basic issue is whether video images are appropriate for rebroadcast over the public airways. CT DOT provides a video interface to the media, but with a 30 second delay that permits system operators to cut off the video feed should the current images be inappropriate (e.g., incident with serious injuries).

There are several additional issues associated with the dissemination of information to the media and the public which need to be considered. These include the following:

- Control of presentation format - If a data stream is sent to the media and other Information Service Providers (ISPs), one can expect that they will use this information to provide some value added service for their clients. The same data can be used very differently by different ISPs, and the public agency generating the data may not have control over these presentations, abbreviations, frequency of broadcast, etc. unless constrained by agreement.

- Consistency of information presentations - The same information can be interpreted by different agencies and ISPs in different ways. This has been an important consideration for other advanced transportation management centers. If freeway speeds are broadcast, then what constitutes "congestion" can become subject to interpretation. On the other hand, if Level of Service is sent, does this have any real meaning to the public?

- Protection of confidential information - Video images and incident reports may contain specific information (license plate number, names, severity of injuries, etc.) which may need to be filtered depending upon the agency receiving the information. It must be assumed that all data sent can and will be used by the media to meet their needs to promote their service.

- Impact on local roadways - If diversion recommendations are being made independently by the information service provider, its impact may not have been planned, and may be counter productive to the agencies' traffic management plan.

- Impact on toll and transit operations (revenue) - If inaccurate traffic information is transmitted to the public, it may adversely impact the revenue collection on the primary facility. Information about blockages/closures at toll facilities or transit networks will impact revenue as travelers choose alternate routes or modes. This is a proper function for the transportation management facility, but can lead to conflicting goals (i.e., generate revenue vs. accurate customer information).

- Accuracy and availability of the data - Transportation management systems have often been notorious for poor maintenance of surveillance and detection components. As real-time information is presented to the public, inaccurate data will be immediately apparent, and public agencies will have to allocate significantly more resources to maintenance of the surveillance subsystem. As more traveler information is provided to the public, it is reasonable that the public will begin to demand more timely and accurate information, with less and less tolerance or outages of system components, data collection elements, or dissemination elements.

### E.2.3.2 Teletext

Teletext technology uses the Vertical Blanking Interval (VBI) portion of the TV channel's bandwidth to transmit traveler information. The VBI is the black horizontal line located on the lower part of the TV screen, and can be seen when the TV vertical hold knob is adjusted. The information can be transmitted in conjunction with commercial TV channels or cable TV.

Teletext is a promising media for providing visual and up-to-date information on demand to the traveler at home. By providing a relatively simple means of obtaining traffic and transit information for trip planning purposes, the chances for user acceptance are improved. To view the transmitted information, observers must have a standard television equipped with a World System Teletext (WST) chip—the same device used to see the closed-captioned features available for the hearing impaired. Though currently only a relatively small percentage of televisions in the U.S. are equipped to receive teletext transmissions, the trend in the television manufacturing industry is to provide teletext reception as a standard feature. As televisions are replaced over the next few years, the potential audience for teletext will increase significantly.

Once city is currently using this technology to distribute information to the local media. The information —which includes schematic maps, lane closures, color indications of congestion levels, incident locations, and variable message signs—is transmitted over low power television, (UHF Channel 54) within the vertical blanking interval; and is currently received by the three major television networks within the City, the City's mainstream newspaper, and five radio stations. These partners pay a one-time software fee.

### E.2.3.3 Cable Television (CATV) Channels

Television can aid in disseminating traveler information through community access or cable television channels (CATV). CATV can transmit graphical, textual, and audible information during specific time periods or 24 hours per day if allotted a dedicated "traffic channel." This form of traveler information requires a cooperative effort between the transportation agency distributing the information and the local cable television franchise. In areas where penetration of cable in the market is high, CATV can be an extremely cost-effective way to disseminate information. Currently, cable television is not found extensively in rural areas. However, cable services are expanding and there are many small urban areas with cable access where it may be appropriate to transmit information.

Information which may be made available may include:

- An overview map of the city or region with color-coded highway segments which indicates the current speed at which traffic is moving, and a second overview map which utilizes icons to place incident locations.
- A pre-recorded message can inform viewers what the color coding means and to stay tuned for more detailed information.
- The system can report individual incidents and provide a detailed incident location map as well as textual descriptions.
- Live video feeds matching the incident and narration describe the nature of the incidents available from the incident map.

- A commercial break provided by the local cable TV station follows incident reports.
- A scrolling text bulletin board which provides special traffic and transit advisories.

### E.2.3.4 Interactive Television

Interactive television is similar to cable television and broadcast television in that real-time information is made available to travelers via the TV medium. The major difference is that, while cable and broadcast television simply presents the information on a programmed and repetitive basis, interactive television allows a traveler to directly obtain specific information at any point in time.

Information which may be made available through an interactive channel may include:

- Incident Information - From an overview map, users could request more information on particular incidents by selecting one of the pre-defined zones in the overview map. The incident in the selected zone was described in a more detailed street map with an icon indicating the location and textual descriptions of the incident.
- Highway Speed Map - By selecting this function, the user could see a stylized overview map of the city or region in which the color coded road segments indicate the current traffic speed on the major highways, with smaller icons pointing out the location of incidents. A pre-recorded narration explained the legends and the meaning of color coding scheme.
- Public Transit - By selecting this function, the user gained access to several presentations including a description of the transit (bus and subway) system, the transit frequency tables for appropriate transit lines, park and ride lot status, and directions (i.e., a presentation of where the park and ride lots are and how to drive to them), and wide area traveler information on passenger rail, buses, and airline information.
- Directions to Major Arenas - Users could access the direction service for locations where sporting and special events occur. Users can select a destination and received a slide presentation with audio narration on how to travel to the destination.
- Restaurant and Area Attractions - Users could view restaurants by cuisine and other area attractions, select a destination, and receive a slide presentation with audio narration on how to travel to the destination.
- Hotel Services - To make the complete information service of value to the user, hotel conveniences such as the in-hotel stores and services can also be made available.
- Weather - National and local weather reports of current and forecast conditions.
- Yellow Page Information - This service would allow users to perform on-screen queries on a comprehensive geocoded electronic yellow page database. The database would be designed to contain listings of interest to the traveler; thus, it had restaurants, other hotels, car repair stores, and other categories. The requested information could be generated and printed out on the computer in the hotel.

# E.3 En Route Information Technologies

Roadway-based, in-vehicle-based, in-transit vehicle based, station-based, and personal based systems for disseminating traveler information en route are discussed in further detail in this section.

## E.3.1 Roadway-Based Systems

Variable Message Signs (VMS) and Highway Advisory Radio (HAR) systems technologies represent the two basic technologies currently available to provide drivers with real-time and static information from roadside equipment while en route.

### E.3.1.1 Variable Message Signs

Variable message signs (VMS) provide dynamic information to motorists regarding a variety of conditions, including:

- Congestion - Variable message signs can be used to warn motorists of congestion that lies ahead as a result of an incident, bottleneck, or special event. The VMS can also be used to provide warnings when unexpected queuing occurs in areas of restricted sight distance such as around a curve or over a road crest.
- Diversion - Variable message signs can be used to inform motorists of available or required alternative routes.
- General Guidance Information - Variable message signs can be used to provide directions and information on ways to obtain additional information through other means (e.g., radio).
- Maintenance and Construction Work Sites - Variable message signs can be used to warn motorists of lane closures in order to avoid abrupt weaving. End of queue warnings and alternative route information can also be provided to motorists approaching work sites.
- Roadway Status - Variable Message Signs are used extensively to provide information regarding the status of roadways such as environmental conditions (i.e., snow, fog) and special operational features (HOV lanes, reversible lanes, drawbridges).

Variable message signs (or message boards) can be used at transit stations to provide schedule information (e.g., arrivals, departures, status), on platforms to identify the arrival time and destination of the next vehicle, and on vehicles themselves to identify the next stop and estimated time before arrival. This functionality is discussed in a subsequent section.

**Variable Message Sign Types**

Several different types of variable message signs have been developed. One is the "blank-out" sign in which a single message can be turned on or off as conditions require. Signs of this type are applicable to Highway Advisory Radio sites where the signs are turned on in advance of a particular segment whenever radio messages are being broadcast. When only a few fixed messages are needed at a particular site, a rotating drum sign—consisting of a three or six-sided prism for each line of the message—can be used.

The most flexible type of VMS is the matrix sign. The desired legend is displayed by turning on or off individual pixels. Matrix options include:

- Character Matrix - An individual module is provided for each character (letter). The letter spacing and maximum letter width is fixed.
- Line Matrix - A single matrix is provided for each line. This allows proportional spacing between letters, but limited graphics capability.
- Full Matrix - There are no built-in divisions between letters or lines. This configuration allows the greatest flexibility in the size and stroke of letters plus graphic symbols.

#### E.3.1.2 Highway Advisory Radio

Highway advisory radio (HAR) systems, usually located at roadside stations, communicate locally relevant traveler information to all vehicles in the vicinity of the station. They are commonly "broadcast only" (infrastructure to vehicle) systems using the conventional AM broadcast band radio in the vehicle. HAR can provide travelers with information regarding construction activities, special events, road closures or hazards, traffic congestion, incidents, alternate route guidance, and traveler information concerning local attractions. The transmission range of traditional HAR systems is limited to a few miles.

HAR were initially authorized for use in the United States by the Federal Communications Commission (FCC) in 1977. These systems are also used by airports, train and bus stations, national, state and regional parks, counties and local municipalities, sports arenas, convention centers, and other entertainment venues, for disseminating traveler information. HAR uses the AM radio frequency spectrum, and almost all privately owned automobiles are equipped with a broadcast band AM radio. Until approximately two years ago, the AM broadcast band encompassed 530 kHz to 1610 kHz. Many automobile AM radios operate only within this range.

**Portable and Mobile Systems**

Portable systems permanently installed on trailers and mobile systems installed on service or maintenance vehicles can be of value in providing timely dissemination of information to motorists during short term deviations from normal highway conditions. This is particularly true in areas where there is limited or no normal coverage or the permanent transmitter site has failed. These systems can be solar powered, generator powered, or battery powered.

Portable and/or mobile systems could be set up at decision points where a route guidance system directs motorist to an alternate route. This will increase motorist comfort level by reinforcing their confidence that they are following the alternate route instructions correctly.

### E.3.2 Station-Based Systems

Station-based systems provide schedule updates and transfer information for passengers already en route. This information includes arrival and departure times, identification of next arriving vehicles, information on transfers and connections, information on other regional transportation services and information on related services, such as park-and-ride lot availability. This information can be provided via message boards, display monitors, public announcement systems, or kiosks. Information, available through the use of technologies such as automated vehicle location (AVL) systems, will help transit agencies now, and in the future, provide information in real time. The key benefit for the traveler will be a more accurate sense of departure and arrival times for a trip.

Traditionally, in-terminal and wayside information has been disseminated manually in the form of paper schedules or static signs. Further, real-time information, such as actual bus arrival or departure time, has not been traditionally available to give to the customer. With the advent of advanced surveillance and vehicle location technologies, real-time en route transit information can be made available to the customer in a variety of forms. However, automated in-terminal and wayside information systems are in their infancy in North America, primarily because the supporting technologies needed to support these systems are just beginning to be fully implemented. Currently, there are only a few of these systems in operation, although many are being planned. A few transit agencies are providing smart kiosks which convey schedule information, trip planning information, and static files such as location of popular restaurants. Visually and hearing disabled travelers are enjoying the benefits of kiosks that convey transit information in a form that they can acquire with a minimum of effort. Display Monitors, Message Boards, Public Announcement Systems, and Kiosks are discussed below in further detail.

#### E.3.2.1 Public Announcement System

Public announcement systems are used to keep travelers informed of significant changes to the schedule, destination, track assignment, and performance information. The systems routinely broadcast information to travelers within the main lobby of transit stations.

#### E.3.2.2 Display Monitors

Display monitors are used to provide the traveler with current schedule, destination, and performance information. Within major transit stations, they are typically used in platform areas to keep travelers abreast of current conditions.

#### E.3.2.3 Message Boards

Message boards are also used in transit stations, and bus stops as well as in the in-vehicle environment. Within the station, message boards are used to provide the traveler with current schedule, origin, destination, track assignment, and performance information. They are typically mounted within full view of any traveler who would be passing through the lobby area of a transit station.

#### E.3.2.4 Interactive Kiosks

The advent of the personal computer has supplied the technology that allows information systems to directly interact with all types of users, in multiple locations, and for a low cost. A device that is increasingly being used to allow interaction between information systems and users is the computer-based kiosk. The computer-based kiosk originally imitated the functions of a newsstand on the corner of a city block. The newsstand was a source of information and, likewise, the kiosk (named after the hut or structure that housed the newsstand) is a supplier of information. However, being computer-based, the kiosk allows the public access to a computer terminal and thereby access to databases and software within larger computer systems. The kiosk has evolved from an information-only device (such as those used in trade shows) to one that supplied and sold services (the most prevalent of which is the automated teller machine used to supply banking services to the public).

An automated kiosk is a stand-alone unit most commonly containing a computer terminal and some form of user interface (e.g., keyboard, touch screen). Kiosks may be installed in transit stations, rest areas, visitor information centers, and lobbies of major origins/destinations. Although a kiosk could be installed in a completely stand-alone facility, it is unlikely that a traveler would stop just to use the kiosk for both convenience and safety reasons.

Kiosks are becoming an important traveler information communication device and have been adopted by many transportation agencies. Kiosks can allow travelers to access current data on road and transit conditions, directions to destinations specified, weather, and current news regarding local events. Further benefits of kiosks lie in their availability to the traveler at rest stops, transit stations, and major origins and destinations; the ability of a computer system to keep the information current and updated; and the ability of the kiosk to record user requests and reactions to the system that allow future modifications and enhancements which are responsive to the public.

The kiosks can provided travelers with access to the following information:

- Real-time traffic and incident data.
- Point to point route planning by vehicle and public transit.
- Transit schedules and itinerary planning.
- Passenger rail and long-distance bus services.
- Area-wide hotel reservation services.
- Weather information.
- Special event and tourism information.
- Airport facility and airline schedule information.

## E.3.3 Personal-Based Systems

Pagers and Personal Digital Assistants (PDAs) are discussed in this section. Pagers and PDAs provide the capability to receive digitized data summarizing transportation network conditions ( and other information) both pre-trip and en route. Both technologies represent what many in the ITS industry believe to be a large untapped market—the dissemination of customized personal real-time traveler information.

### E.3.3.1 Pagers

Paging technology is used to broadcast messages to low-cost receivers. Alphanumeric paging allows those messages to carry text as well as numbers. This form of wireless technology has been in existence for more than thirty years and has been extremely effective in providing information under a variety of environments. This is a technology that has matured considerably and is a very practical, viable, and cost-effective method of transmitting real-time traffic and other traveler information in a timely manner.

Many transportation agencies currently disseminates information on incidents and other unusual events to affected agencies and other interested parties via a pager network. The format for these short messages at one agency is:

**New or Updates to Transit, Incidents, Construction, and Special Events**

- Reporting Agency (2-3 character alphanumeric code)
- Location (2-3 character alphanumeric code)
- Severity of impact on others (1-5)
- Details of Incident (72 characters)
- Estimated time to restore in hours (used only for construction projects)
- Date-Time of report

**Clear**

- Literal text "*CLEARED*"
- Agency reporting
- Repeat of Details of Incidents
- Date/Time of clear

#### E.3.3.2 Personal Digital Assistants

Personal Digital Assistants (PDAs)—also known as Personal Communication Devices (PCDs)—utilize two-way wireless communication to small devices which relay information to the user. PDAs operate on limited bandwidth and are not designed for high-speed transfer of large data blocks.

A number of manufacturing companies produce devices that are suited for the business professional which focus on organizing and providing communications to enhance the individual's production. The primary design considerations are size, portability, ease-of-use, cost, and ability to provide multiple sources of information from the outside world. Current products on the market come with vastly improved connectivity options, both for connecting to the desktop and for a wide variety of communication networks. Some models are extremely lightweight, while others are similar to portable personal computers. Manufacturers are also building in software to access the Internet.

#### E.3.3.3 PDAs versus Pagers

- PDAs can support map displays, graphics, and graphical interface.
- Provide more advanced textual presentation and larger amounts of text than pagers.
- Some PDAs include paging capabilities.
- PDAs can support multiple modems types and therefore have more options in terms of communications.
- PDAs are typically 2-way communications; pagers are 1-way and have rudimentary 2-way support.

- Custom applications can be developed to support specific needs on a PDA.
- Many PDAs are compatible with desktop systems.
- PDAs are bulkier than pagers—sizes range from pocket size to size of small laptop.
- PDAS have limited battery life measured in hours, compared with pagers which can run on batteries for weeks.

# E.4 In-Vehicle Systems

## E.4.1 In-Vehicle (Automobile)

In-Vehicle (Automobile) technologies include AM Radio, Static Route Guidance Systems, Dynamic Route Guidance and Mayday Alert Systems.

### E.4.1.1 AM Radio

Commercial radio broadcasting is currently the primary method for disseminating traffic information to motorists. Most radio stations provide some form of traffic information, generated by either their own reporters or contracted through a traffic reporting service. The traffic information is obtained from a variety of sources including traffic reporters in airplanes, helicopters, cars, or high buildings; motorists who call the station over cellular phone; phone calls to police; private CCTV networks; and inter-ties with ITS-based systems.

Research on the public's interest in traveler information within one region has indicated that traveler information was most often obtained from traffic and transit news on the radio and TV (81% of those surveyed). This source was used most often by peak-period motorists (87%), but it was also used by 74% of peak period transit customers. Overall satisfaction levels were generally high; although less than a majority (34%) were very satisfied with the traffic and transit news broadcast over the media.

Design of an ITS-based system should include an interface for providing up-to-the-minute information to radio stations and other private entities. The various issues addressed in the previous section on **Broadcast Television Media** also pertain to radio.

### E.4.1.2 In-Vehicle Route Guidance Systems

**Static Navigation Systems**

Static navigation systems, also known as autonomous route guidance systems, provide motorist information directly to their vehicle—currently available units can show current vehicle location on maps, and textual and audio information. Wireless communications to the vehicle is accomplished through global positioning systems (GPS), analog and digital cellular telephone, FM sub-carrier broadcasts, and Radio Data Broadcast Systems (RDS).

**Dynamic Navigation Systems**

Dynamic navigation systems, also known as dynamic route guidance systems, contain the same features/capabilities of the static systems, but also provide real-time traffic information and dynamic routing capabilities.

**Discussion**

In-vehicle information provided to the driver can include current vehicle position, real-time traffic flow conditions (e.g., areas of congestion, speed limits, travel times) on the driver's route and on alternate routes, routing guidance to the user's desired destination as well as yellow pages and other information. This in-vehicle information can be presented to the driver in several ways, including:

- ✦ Map display - the various items of traveler information may be overlaid on a map display of the region that includes the roadway network. An arrow indicating the vehicle's location may be included when vehicle location information (as provided by AVL technologies) is available. The background maps are stored on a high density medium such as CD ROM or on a PCMCIA plug-in computer card
- ✦ Text information and messages
- ✦ Directional arrows indicating the next action (e.g., turn left/right) that the driver should prepare for and then execute

Techniques to display this visual information to the motorist while he is driving include self-contained CRT, vacuum fluorescent or LCD units mounted in the vehicle, and projection of the information onto the windshield as a 2-dimensional holograph (i.e., "heads-up display"). In most of the current in-vehicle programs, the visual displays are being augmented with audio messages generated by synthesized voice. The audio messages eliminate the need for the driver to continually take his or her eyes off of the road.

Heads-up display (HUD) is a technique for projecting visual images, focused on infinity, into a driver's field of vision, allowing him to see information without taking his eyes off of the road. The technology was originally developed for use in military aircraft, and is being transitioned into the automotive environment. A HUD is made up of three major components:

Most in-vehicle navigation systems provide the same basic features, including:

- ✦ Digitized road map and a database of addresses, businesses, points of interest, etc.
- ✦ Global Positioning System (GPS) antenna for determining vehicle location.
- ✦ Navigation computer to determine the vehicles location based on the GPS, wheel sensors that track the distance traveled, and gyroscope to sense changes in direction. The computer also calculates the "best" route based on user-entered criteria (e.g., shortest time, route, use freeways, avoid freeways).
- ✦ A display screen with controls for entering information. The system displays the note on the map (with zoom capabilities), the vehicle location, and "next turn" arrow indicators and distance to the next tuner or destination. Some systems also provide an audio capability for turn-by-turn voice instructions.

Transmission of real-time information regarding traffic flow and roadway conditions to the in-vehicle device requires an air-path communications medium such as an FM subcarrier, infrared beacons, satellite, or various RF techniques. Communications between the vehicle and an ITS-based system is generally two-way—with the system transmitting data on traffic flow conditions to the on-board devices, and the equipped vehicles transmitting data to the system for processing. These data may include individual vehicle speeds, travel times, and frequency of stopping. With the addition of vehicle identification, the equipped vehicles can also serve as traffic probes.

#### E.4.1.3 Mayday Alert Systems

Mayday systems can contact emergency management services (EMS) in the event of a breakdown or accident and communicate the exact location of the vehicle. Some products will operate automatically when a vehicle airbag is deployed.

### E.4.2 In-Transit Vehicle Based Systems

In-transit vehicle based technologies include technical innovations which support the transit user en route. Customers are aided by in-vehicle message board and automated annunciation systems which provide information on routes, schedules, and connecting services. Transit agencies are including these devices in their vehicles for two key reasons:

- To facilitate the transit trip and make the desired information more customer friendly
- To comply with the requirements of the ADA

The ADA requires that all fixed-route transit vehicles provide both visual and audible information at transfer points with other fixed routes, at major intersections and destination points, and at intervals along a route sufficient to permit individuals with visual impairments or other disabilities to be oriented to their location. Further, any stop must be announced/displayed on request of an individual with disabilities. Automated annunciation devices also remove the responsibility for announcing stops from the drivers, leaving them free to concentrate on driving which should result in greater safety for passengers.

Rail systems typically have provided audio announcements for stops because they operate on exclusive rights-of-way. Bus systems are in the process of providing this type of information through automated annunciator technology. This technology, based on GPS location or on odometer readings, automatically announces/displays stops, major intersections, and major transfer points. As transit agencies implement AVL systems, more accurate and real-time information will become available. Both rail and bus are beginning to implement in-vehicle information systems that provide not only transit-related information, but also news, weather, and advertising information. Table E-1 below summarizes in-vehicle information needs, as determined via a series of passenger and systems operator focus groups held recently in Dallas and Seattle.

**Table E-1. In-Vehicle Information Needs**

| Type of Information | Passenger Information Needs | | Operator Information Needs: Have System | | Operator Information Needs: Do Not Have System | |
|---|---|---|---|---|---|---|
| | Visual | Audio | Visual | Audio | Visual | Audio |
| Route name/number | X | X | | | | |
| Next stop information | X | X | X | X | X | X |
| Key destinations at next stop | X | X | | X | X | X |
| Upcoming three stops | X | X | | | | |
| Connecting routes | X | X | X | X | X | X |
| Vehicle arrival times | X | X | | | X | |
| Other information affecting transit service (traffic, route/schedule changes) | X | X | X | X | | |
| Emergency messages | | | | X | X | X |
| Time of day | X | X | | | | |
| Trivia | X | | | | | |
| Paid advertising | | | | | X | |

### E.4.2.1 In-Vehicle Message Boards

Several readable matrix message display systems are in use at the present time on transit vehicles, including flip data displays, liquid crystal displays (LCDs), and light emitting diode (LED) displays. LED is the most commonly used technology for providing passenger on-vehicle visual information. These products have the capability of providing nearly any type of information, including next-stop identification, estimated arrival and service revisions, routine transit announcements, emergency messages, entertainment, and advertising.

### E.4.2.2 Automated Annunciation Systems

Automated Annunciation Systems announce stops, transfer points, and major interchanges as required by the ADA regulations to passengers located inside and outside the vehicle. Some of the characteristics found in Automated Annunciation systems are listed below:

- Interfacing with various advanced vehicle location (AVL) systems
- Providing transit operator control of on-board electronic signs via a single keyboard
- Supporting of future integration needs, as it is fully reprogrammable
- Providing simultaneous internal and external announcements
- Accommodating on-site message updates. New messages can be remotely recorded and programmed onto a memory card, and subsequently transferred to the field for use.

Beside this audio announcement, the locations are displayed inside the bus just above the operator, for passengers with hearing disabilities. After the operator has stopped the bus and opened the door, visually impaired passengers outside the bus hear another automated announcement that identifies the bus route number and its destination. Hearing impaired customers can identify the bus route by the destination sign on the front of the bus.

# Appendix F. Communications Technologies

## F.1 Overview

A brief listing of the communications technologies discussed in this appendix are given below (these technologies are given as examples but do not represent an exhaustive listing):

**Center-to-Center Wireline Technologies (Section D.2)**

- Leased Telephone
- Facsimile

**Wide Area Wireless Technologies (Section D.3)**

- Satellite
- Cellular Radio
- Cellular Digital Packet Data (CDPD)
- Mobile Data and Wireless Messaging
- Cellular Telephone
- Radio Data Systems
- Area Radio Network
- Dedicated Short Range Communications Technologies (D.4)

## F.2 Center-to-Center Wireline Technologies

### F.2.1 Leased Telephone

Leased telephone circuits are mostly wire to the end user and possess the flexibility, speed, and bandwidth required for an ITS communications network. A wide variety of circuits are available from the region's telephone companies including:

- Voice-grade data channels providing full-duplex multi-point analog service at 1200 bps. These circuits can be used to provide communications between the operations center and VMS, ramp meters, detector stations; and for camera control. Dial-up voice-grade circuits may also be used for the transmission of slow-scan images.
- Two-way digital data channels transmitting at rates between 2.4 kbps and 56/64 kbps (DS-O). These circuits can be used for low-speed multi-point data channels operating at rates between 2400 and 9600 bps. These circuits can also be used for data trunking in which several low-speed channels are collected at a "hub," multiplexed together in a higher speed trunk, and transmitted to the control center. They may also support digital video transmission with a proprietary 56 kbps CODEC.
- T-1 (DS-1) channels operating at 1.544 Mbps. These circuits might be used for transmitting digitized video or as high-speed data trunks.

- DS-3 links operating at 44,736 Mbps may be used for extending LANs or transmission of studio quality CCTV.

Additional services, such as fractional T-1 and dial-up ISDN, are offered in other areas of the country. Recently, several new services have been developed for high bandwidth requirements. These services, such as Frame Relay (FR) and Asynchronous Transfer Mode (ATM), are slowly being deployed throughout the country. While not quite "ready" for ITS use, they do hold promise for applications such as video transmission over networks.

Leased telephone is a very reliable communications solution in that some grid redundancy is incorporated into the carrier's network. One potential advantage over a dedicated fiber network is that maintenance responsibilities are shifted from the transportation agency to the telephone company, although determining who is responsible for a particular failure can be problematic. It also ensures upward compatibility over time as new communications hardware and updated standards are introduced. Leased telephone service can generally be abandoned at any time, thereby providing flexibility to change the communications media should the need or opportunity arise.

Typical costs and sample applications are shown below.

**Typical Leased Line Costs**

| Line Type | Available Capacity | Low Price | High Price | Example Application |
|---|---|---|---|---|
| DS0 | 56 Kbps | $50 | $100 | Data Only: Traffic Update, Incidents, Transit |
| DS1 | 1.5 Mbps | $400 | $700 | 3 Video Channels - 10 to 15 frames per second |
| DS3 | 45 Mbps | $2,000 | $6,000 | 1 Broadcast quality video channel |

### F.2.2 Facsimile

A fax machine has become a standard piece of equipment for modern TOCs. Facsimile transmission is defined as a process involving the transmission and reproduction of photographs, maps, drawings, other graphic matter, and text at a distance. Specific information can be easily transmitted on the nature of the problem, extent, expected duration, closed or affected routes, and suggested alternate routes. Fax machines are also capable of broadcasting faxes, i.e., one fax message can be sent to several agencies.

In addition to fax machines, many E-mail software packages now have the capability of accepting data entry from various computers, storing the entered messages, and transmitting these messages to fax machines. This allows for faxes to be sent automatically to agencies.

# F.3 Wireless Technologies

Satellite, cellular radio, cellular digital packet data, mobile data and wireless messaging technologies, radio data systems, and area radio network are discussed in further detail in this section.

## F.3.1 Satellite

Satellite is similar to terrestrial microwave in that it uses some of the same frequencies for transmission through space. With satellite, however, instead of using a line-of-sight transmission path, the signal is directed at a transponder located on the satellite. Satellite service has been available for many years for voice, data, and video transmissions. Very Small Aperture Terminal (VSAT) satellite systems are a part of a mature, robust satellite industry that has a good record for availability and reliability. VSAT systems operate within the KU-band, with the uplink (i.e., transmissions from the earth to the satellite) using 14 GHz, and the downlink (i.e., transmissions from the satellite to the earth) using 12 GHz. The satellites themselves are in a geosynchronous orbit above the Earth's equator, thereby appearing stationary in the sky and providing 24-hour a day coverage. These high-altitude satellites also avoid various earth-level interferences.

Full-duplex VSAT channels of 56-512 kbps (and larger) may be leased from several vendors, with most offering 112 and 224 kbps channels, to provide a CODEC-supported video channel, or several low-speed data channels in a point-to-multipoint configuration (i.e., one transmitter communicating with several receivers). The monthly lease costs for a VSAT channel are a function of the percent use of the satellite transponders and the length of the lease period. This translates to approximately $2,000 per month for a continuously active video link (at 112 kbps) and a three-year lease. For higher speed channels, the monthly cost increases proportionally.

In addition to the satellite links, a central hub element and earth stations are required to provide a VSAT-based communications network for a freeway management system.

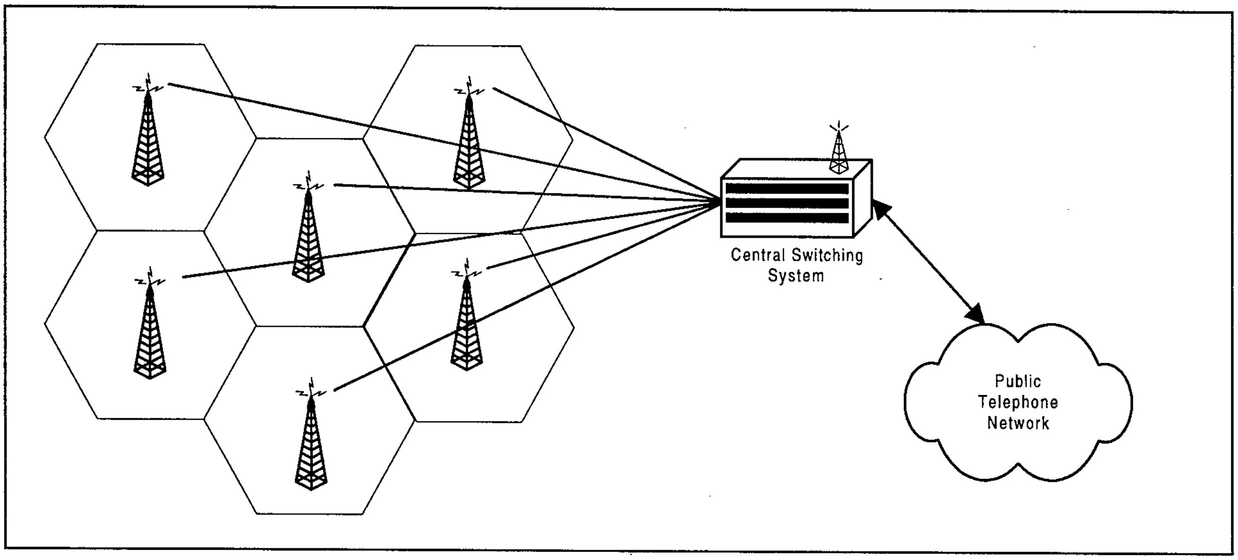
The "hub" is at the operations center, and serves as the focal point for communications between the remote sites and the operations center. The nominal antenna diameter for the hub is 6 to 9 meters. All data transmitted to a remote site (i.e., field location) must originate at the hub, and all data from the field must be received at the hub. The term "enroute" is used to identify the hub-remote link; with each enroute and outroute consisting of an uplink and downlink path via the satellite.

The "earth station" is the communications component of a remote site. The earth station consists of an antenna (with nominal diameter of 0.75-1.25 meters), an RF transceiver (mounted on the antenna), and a digital interface unit. For video applications, the digital interface unit is connected to the camera's central receiver (for pan, tilt, zoom) and a CODEC unit.

The VSAT medium is ideal for long-distance communication links since the costs of leasing VSAT channels are independent of distance. Moreover, since VSAT lease costs depend on the percent of time that the enroute/outroute link is actually used, this technology may also have cost-effective applications in a local-area communications network where transmissions are required only on an as-needed basis. Other potential uses of VSAT include communications where a dedicated cable network and/or leased telephone circuits are not readily available and where a surveillance camera needs to be mobile; for example, maintenance and protection of traffic during roadway construction, or during major incidents in areas where CCTV is not available, but real-time video surveillance would be an asset. (Note - An operational test of VSAT applications in Philadelphia is underway. This test will investigate the video quality, switching techniques, interference, and the feasibility of a portable CCTV platform using a generator for power and VSAT for communications.) VSAT is very expensive, unless resource or cost-sharing is done.

### F.3.2 Cellular Radio

Cellular radio is a technique for frequency reuse in a large radio communications system. It is primarily used for mobile telephone networks. It gets its name from an area being divided into cells that are 2 to 20 miles in diameter. In the center of each cell is a control radio that bundles the network management functions, including the assignment of frequency sub-channels. A radio requests a frequency over a control channel and one is assigned by the cellular control system. The cellular layout allows frequencies to be reused in non-adjacent cells.




**Cellular Radio System Concept**

Due to the demand for car telephones, a second generation of systems is emerging that will be characterized by digital speed transmission and enhanced network control. The new system will provide greater bandwidth and frequency reuse capability. In North America, standard IS-54 has been written to govern digital cellular. This standard specifies that a time-division multiple access (TDMA) scheme be used to split the bandwidth of each of the existing cellular channels into three channels. Each channel would then carry compressed digitized voice. Though the initial standard did not address data transmission, the latest revision does.

Recent advances in an alternate technology, code division multiple access (CDMA), have stalled the acceptance of IS-54 and the changeover to digital cellular. CDMA is a spread-spectrum technique distributing the signal over a range of frequencies. The governing standard for cellular systems using CDMA is IS-95. In the interim, an alternate technology, cellular digital packet data (CDPD), that permits the transmission of data over the existing cellular network, is being introduced by McCaw, IBM, and several other companies. In CDPD, data is formed into packets which are transmitted at a data rate of 19.2 kb/s over idle voice channels. CDPD is being tried in Las Vegas and is scheduled for nationwide testing.

With the new networks likely having the same or similar rate structure, cellular radio would be economically unsuitable for constant connections with fixed (as opposed to mobile) devices such as ramp meters and detectors. On the other hand, devices such as VMS and HAR, where communications are needed only on an as-needed basis, may be suited to cellular radio.

Cellular radio service was introduced to the United States in 1983 and currently has grown to over 16 million subscribers. The United States is divided into 734 service areas by the FCC with each service area being divided into cells serviced by a low-powered radio transceiver. The transceiver is connected to a Mobile Switching Center (MSC) which is in turn connected to the Public Switched Telephone Network. In moving from one cell's coverage area to another, the MSC tracks the call and automatically "hands off" the call to the other cell site. While the "hand off" is barely noticeable for voice communication, it can seriously degrade data communication; hence the reason that cellular calls were primarily intended to serve voice communication. However, new digital cellular-phones can serve as a data-communications system if a modem is connected between the cellular telephone and a computer. Cellular radio communications offers many advantages for traffic control. It is readily accessible since it is estimated that about 93 percent of the United States is covered by cellular service. Although cellular service can be expensive depending on the usage, from $0.19/minute (off-peak) to $0.55/minute (peak), it can prove to be cost effective where infrequent communication is required by eliminating the need to provide owned land lines. It can also prove effective for temporary installation and in controlling portable VMS and HAR devices. Cellular telephone service can be used to transmit data between agencies and can provide an effective alternative to fixed point-to-point communications for traffic control purposes, e.g., reporting on the status of alternate routes during incidents.

### F.3.3 Cellular Digital Packet Data (CDPD)

The newest of the cellular technologies is Cellular Digital Packet Data (CDPD). This technology is a digital data connection provided over existing cellular telephone networks. The most important feature of this technology is its relative low cost for basic connectivity. By using the voice infrastructure for digital pathways in such a way as to interfere very little with the voice functionality, this technology allows almost universal coverage with little investment in new infrastructure. The cost effectiveness is high for communication solutions which require random intermittent connectivity and short message length.

The growing demand by cellular telephone customers who want to be able to transmit data over the cellular telephone network has driven the creation of CDPD standards. This packet data technology has had an overwhelming response from cellular carriers in the United States. CDPD is an open industry standard making it available to any developer for virtually any wireless data packet transmission application. CDPD systems will provide high system throughput, accommodate multiple host connections, have the capability to store data messages, allow electronic data interchange, access public databases, support interactive sessions with electronic mail system servers, and perform file transfers.

Although CDPD uses the circuit switched cellular telephone network as its transport medium, CDPD is a packet switched architecture.

CDPD will allow the cellular telephone user to utilize a single wireless service for both voice and data requirements. This will make CDPD one of the fastest growing technology applications of the 1990's.

### F.3.4 Mobile Data and Wireless Messaging

Private wireless mobile data services have been in use by several large corporations in the United States since the early 1980's. Public wireless mobile data and messaging communication services have been in varying degrees of use in the United States and some European and Asian countries for several years. These systems/services have primarily been used to support field service organizations, fleet vehicle management, and some emergency services. The last two years have seen enormous growth in the use of these networks for Personal Communication Systems (PCS), primarily in the areas of electronic mail and remote log-in to host based applications.

As is the case with any wireless service their availability and reliability have direct correlation to the radio frequency (RF) "cloud" and the protocols utilized. These service capabilities are provided by wireless networks whose sole function is to support the transmission of packetized data. To the network there is no difference between the different types of data or end-user application(s) with which they communicate. They are simply data packets and as such are transmitted and routed in virtually the same manner as any other packet network. In the U.S., experience to date has shown that the most successful mobile data wireless messaging and mobile radio applications have used packet switching as the transmission technology and architecture of choice. Almost all of these networks have chosen the CCITT Standard X.25 as their protocol of choice. Data throughput in these networks has a direct correlation to the frequency bandwidth allowed for the specific frequency band as set by the ITU/IRAC and/or the governing frequency control and management entity of the host country.

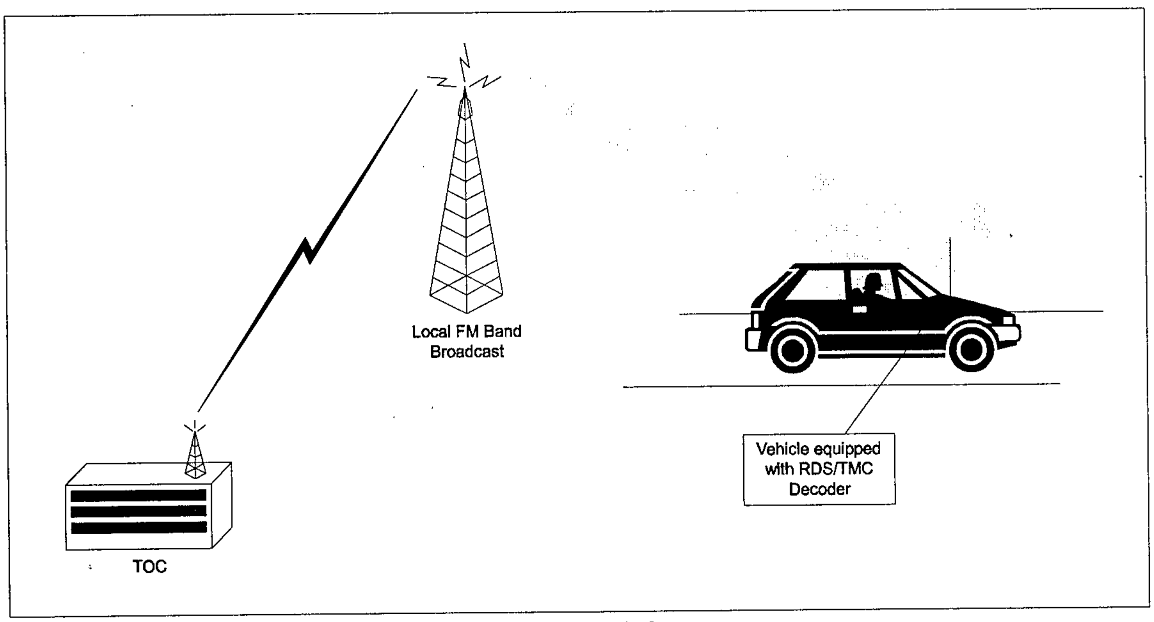
### F.3.5 Radio Data Systems

The Radio Data System (RDS), which is covered by the United States Radio Broadcast Data System (RBDS) Standard, was developed for Frequency Modulation (FM) by the European Broadcasting Union (EBU) and its member countries. It is a form of data coding channel designed to operate in conjunction with commercial FM radio broadcasts.

The Exhibit below illustrates the RDS principle. Commercial FM radio has "space" between the frequencies. This spare space, which serves as a buffer between stations, can be used to convey a subsidiary audio program or to transmit digital information. This subcarrier has been used in the past to play background music (i.e., MUZAK) in restaurants and shops. The effectiveness of the system lies in the fact that there is no crosstalk from the subcarrier into the main audio program.

The primary motivation behind RDS is to allow commercial radio broadcasters to be identified on the radio's front panel, and to allow special self-turning radios to automatically select the strongest signal carrying a particular type of program (e.g., news, sports, drama, different types of music, and traffic). From an ITS perspective, an important feature of RDS is the Traffic Message Channel (TMC) that can provide motorists with the latest traffic information by superimposing inaudible data on existing FM station carriers. The TMC is an additional feature of RBDS that is aimed at providing a better method for transmitting information. The traffic information transmitted to motorists via the RDS digitally encoded silent messages will trigger a display and/or speech synthesizer in the in-vehicle receiver. The messages are language-independent; they can be decoded into the language of the user's choice. Incoming messages are stored in receiver memory and can be selected by the user according to travel corridor, area, or highway route numbers.

RDS-TMC requires a special decoder. This is because RDS-TMC is a subcarrier that consists of ultrasonic signals above the range of human hearing. Moreover, conventional radios cannot decode these signals without the added special decoder. The basic implementation allows a radio to indicate whether or not the tuned station broadcasts traffic information as part of its programming, and whether the tuned station is currently broadcasting a traffic message. This information could be used to stop a cassette or CD and turn on the radio for the duration of the announcement. RDS radios typically allow the listener to use this information as a search criteria when scanning the band, stopping only on stations which broadcast traffic information. While the receiver/decoder generally provides the user interface to the traveler information service, its functionality may vary substantially according to technical developments and market requirements.




**RDS Principle**

The RDS-TMC has the capability of transmitting information using "virtual language." Under this specification, the codes broadcast over-air comprise addresses of information stored in databases in the decoders. These databases contain look-up tables for coded values of different variables, plus lists of locations, including road or transit links. The processes involved in applications using this specification are as follows:

- Before transmission, information is mapped into the virtual language by selection from look-up tables and location tables.
- The resulting coded messages are transmitted via RBDS, with frequent repetitions.
- In the receiver, codes received are translated back into user information using look-up tables, for use by the route guidance system or for presentation to the traveler.

### F.3.6 Area Radio Network

Area Radio Networks (ARN) refer to systems that broadcast signals to an area rather than to a specific location. These are also known as Specialized Mobile Radio (SMR) or Private Land Mobile Radio Services (PLMRS). ARNs are primarily utilized in the dispatch of bus and taxi fleets.

Area radio signals radiate uniformly in all directions, unlike point-to-point microwave links. As the signal multiplies it may 'bend' slightly over changes in the ground surface, reflect off buildings or other obstacles, and penetrate into buildings. Scattering and reflection allow the signal to extend into built-up areas although these effects reduce signal strength. Terrain barriers may limit the feasibility of this technology.

There are various frequency bands available for ARN applications. Typically, one frequency pair is allocated for an application, meaning that all the application transmitters must share the transmit and receive channels. Thus, for voice communications, all receivers tune to the same broadcast and users respond only to messages directed to them.

A more sophisticated version of this technology is known as Enhanced Specialized Mobile Radio (ESMR). This radio utilizes digital technology to enable more users per channel and provide more services to the user. ESMR is provided by companies such as Nextel, Dial Page and Cencall, who own licenses for use of SMR frequencies across the USA. Services based on this technology are likely to represent major competition for cellular telephone services in the near future.

## F.4 Dedicated Short Range Communications (DSRC)

Also known as vehicle-roadside communications (VRC), DSRC consists of short-range communications devices that are capable of transferring high rates of data over an air interface between mobile or stationary vehicles and normally stationary devices that are mounted to structures along the roadway or are hand-held. One way of accomplishing this communications is through use of Radio Frequency (RF) beacons. RF beacon technology generally consists of a transponder (tag), transceiver (reader) and transceiver antenna (beacon).

To support deployment of nationally, and perhaps internationally, compatible Intelligent Transportation Systems (ITS) using DSRC, the ITS Joint Program Office (JPO) in the U.S. Department of Transportation issued a work order to build consensus and generate the necessary documentation to support the process for developing a dedicated short range communications standard for ITS applications, both for the near term and for the long term.

A movement is underway that describes consensus among the user and vendor communities as to the operation of all ITS applications that require use of RF beacon DSRC. This is based on the state of the practice, and activities underway to support integration of different applications and technologies, so that a single tag could be used for multiple applications, or tags from multiple vendors could be used for the same application.

Establishment of consensus standards requires "buy-in" from both of these groups. Another important audience is all others involved in the process of trying to establish national ITS standards, including USDOT personnel, ITS AMERICA members, American Society of Testing Materials (ASTM), and Institute of Electrical and Electronic Engineers (IEEE) members, and representatives of other involved and affected standards developing organizations.

The National ITS Architecture recognizes the need for DSRC for those specific applications that require a close physical interaction between the vehicle and the roadside infrastructure, such as in toll collection, commercial vehicle electronic clearance and roadside safety inspection, etc.

In electronic toll collection, data is transferred from and to the vehicle's tag, while the vehicle is in a toll area, and the fee is automatically deducted from the driver's toll account or other monetary account. Beacon technology is used so that the toll collection agency can positively identify the location of the vehicle, both at the time of the toll transaction and when the vehicle enters the toll road, ensuring that the driver is billed correctly. This application allows the toll agency to reduce the cost of toll collection and allows the driver to proceed through the toll area without slowing, stopping, or experiencing traffic backups.

Using the parking payments application, a vehicle enters and exits a parking area, and the parking fee is automatically deducted from the driver's parking account or other monetary account. Beacon technology is used so that the parking agency can positively identify the location of the vehicle both at the time of the payment transaction and when the vehicle enters the parking area, ensuring that the driver is correctly billed. This application allows the parking agency to reduce the cost of parking payment collection and allows the driver to enter and leave the parking area faster.

Commercial Vehicle Operations (CVO) services require DSRC systems to provide two-way real-time communication between appropriately equipped commercial vehicles and the roadside infrastructure. There are a number of CVO services for which DSRC systems are incorporated to provide the service. International Border Clearance is the process of electronically transferring data between a commercial vehicle and the border checkpoint so that the vehicle can pass the checkpoint with minimal or no delay. Electronic Clearance is the process of electronically transferring data between commercial vehicle and the roadside checkpoint so that the vehicle can pass the checkpoint without stopping. This process obtains important vehicle information including weight, credentials, and safety information. Safety Inspection is a check of the safety characteristics of a commercial vehicle while it has been pulled off the highway at a fixed or mobile inspection site. Beacon technology is used to speed the inspection process since it does not require physical contact with the vehicle and it can transfer registration data, previous inspection data, and on-board sensor data at high transfer rates. Automatic Equipment Identification and Freight Management enables intermodal freight management to accommodate the need to track freight as it transitions from one mode of transportation to another. Off-Line Verification is a check of the data in a tag's memory when a vehicle has been stopped for any reason by an enforcement agency. Beacon technology is used to provide a fast, common interface for data. Power unit and electronic tags can transmit data to a hand-held reader carried by an enforcement agent.

DSRC technology can be used to allow for transit signal priority, transit vehicle data transfer and emergency vehicle signal preemption. Transit vehicle signal priority uses beacon technology in both an intersection and a transit vehicle to change the timing of a traffic signal and allow the vehicle to proceed through the traffic signal with a minimum of delay. Transit vehicle data transfer is the uplink of operational data from and the downlink of messages to an individual transit vehicle or a fleet of transit vehicles, using beacon technology. Beacons are positioned at transit vehicle stops along a route, and communications are initiated with tag-equipped vehicles at the stops as necessary. Emergency vehicle signal preemption uses beacon technology in both an intersection and emergency vehicle to change the timing of a traffic signal and allow the emergency vehicle to proceed through the intersection with a green light and a minimum of delay.



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