INTEGRATING INTELLIGENT TRANSPORTATION SYSTEMS WITHIN THE TRANSPORTATION PLANNING PROCESS:

An Interim Handbook

Prepared for

Federal Highway Administration
Office of Traffic Management and ITS Applications
and
Office of Environment and Planning

Prepared by

TRANSCORE
An SAIC Company

January 1998

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Publication No. FHWA-SA-98-048/
HTV-2/1-98(3M) EW

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1. INTRODUCTION AND OVERVIEW

WHAT ARE INTELLIGENT TRANSPORTATION SYSTEMS?

Title VI, Part B of the Intermodal Surface Transportation Efficiency Act of 1991 established the national Intelligent Vehicle-Highway Systems (IVHS) program. Now known as Intelligent Transportation Systems (ITS), the program was designed to promote the use of advanced technologies in multimodal transportation. While the use of advanced technologies in transportation has been ongoing for many years, the creation of the ITS program has accelerated the pace of innovation and integration of technologies into the transportation system. The program has brought new players into the transportation arena with interests in the application of technologies previously developed for defense, space, and other fields.

Intelligent Transportation Systems have been defined as:

> **"The application of advanced sensor, computer, electronics, and communication technologies and management strategies - in an integrated manner - to increase the safety and efficiency of the surface transportation system."**

This definition encompasses a broad array of techniques and approaches. This may be done through stand-alone technological applications or as enhancements to other transportation strategies.

One of the difficulties with incorporating ITS into the planning process is that, often, ITS has been represented as merely a collection of support technologies rather than a set of transportation strategies with specific objectives. As a partial remedy for this, ITS was structured around a set of "**user services**." There are currently 30 user services defined for the ITS program, listed in Exhibit 1-1. The purpose of defining user services was to relate ITS **strategies** (ITS projects and programs such as automatic vehicle location systems for transit) and **technologies** (hardware and software used to implement strategies) to specific user needs. User services represents a <u>customer orientation</u> rather than a facility or technology orientation.

> *"User Services represent a <u>customer orientation</u> rather than a facility or technology orientation."*

WHY A HANDBOOK FOR INTEGRATING ITS WITHIN THE TRANSPORTATION PLANNING PROCESS?

Much of the early interest in the ITS program has been stimulated by Federal funding, rather than through a systematic planning process. The benefit of this approach has been the generation of many innovative applications of technology in the arenas of safety, traffic operations, transit operations, emergency management and other areas of the transportation practice. However, the development of these innovations has not always been clearly connected to a transportation problem or need. Their development has not been well integrated with the range of other transportation strategies and programs. This has resulted in a lack of clarity at the local level as to the potential long term benefits of ITS applications and how ITS applications fit into other transportation projects and programs. In addition, ITS has a strong private sector component. Many of the

ITS innovations will find their way into commercial products with little or no investment from the government. Yet effective application of some of these products will require coordination with public agencies.

At the same time, changes also have been occurring in statewide and metropolitan planning processes. The Final Rule on Statewide Planning and Metropolitan Planning issued by the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) in October, 1993 established revised and more comprehensive processes for metropolitan and statewide transportation planning. ISTEA also established six management systems and a traffic monitoring system to support the planning and programming process. Though the management systems are now optional, except for congestion management systems in transportation management areas, many states and metropolitan areas are using the structure of the management systems as an integral element of the planning process. The rapid pace of change in technology and the new dimensions of the planning process present many challenges to successful ITS applications.

Exhibit 1-1. Listing of ITS User Services

- Travel and Transportation Management
  - En-route driver information
  - Travel services information
  - Traffic control
  - Route guidance
  - Incident management
  - Emissions testing and mitigation
- Travel demand management
  - Pre-trip travel information
  - Ride matching and reservation
  - Demand management and operations
- Public Transportation Management
  - En-route transit information
  - Public transportation management
  - Personalized public transportation
  - Public travel security
- Emergency Management
  - Emergency notification and personal security
  - Emergency vehicle management
- Advanced vehicle control and safety systems
  - Longitudinal collision avoidance
  - Lateral collision avoidance
  - Intersection collision avoidance
  - Vision enhancement for crash avoidance
  - Safety readiness
  - Pre-crash restraint deployment
  - Automated highway systems
- Electronic payment services
- Commercial vehicle operations
  - Commercial vehicle electronic clearance
  - Automated roadside safety inspection
  - Commercial vehicle administrative processes
  - On-board safety monitoring
  - Freight mobility
  - Hazardous material incident response
- Railroad/Highway Intersections

PURPOSE OF THE HANDBOOK

The purpose of the ITS Planning Handbook is to provide a tool to assist in meeting these challenges. Specifically, the purposes of the Handbook are to:

! Identify and describe ways that ITS should be integrated with the mainstream transportation planning process.

! Increase the likelihood of successful transportation projects and programs by providing lessons learned, good practices, and practical information on ITS.

! Provide specific guidance and resources in conducting ITS planning associated with metropolitan and statewide transportation plans, major investment studies (MISs), other corridor and subarea studies, region-wide strategic assessments of ITS (such as through ITS Early Deployment Planning Studies), and related ITS planning activities. This guidance is designed to cover both institutional and technical issues related to ITS planning.

! Identify and describe air quality requirements that can affect ITS projects.

! Ultimately improve the efficiency and effectiveness of the transportation system through successful ITS applications.

This Handbook focuses on applying ITS within the broader context of the planning process; it is not intended as a complete treatment of the planning process itself. The Handbook treats ITS not as a separate and distinct element, but as an integral element of all types of solutions to transportation problems.

> "*This Handbook treats ITS not as a separate and distinct element, but as an integral element of all types of solutions to transportation problems.*"

CHALLENGES PRESENTED BY ITS

ITS presents a set of challenges not found in most other types of transportation strategies. There is much that is unknown about ITS: the market for in-vehicle devices, the level of benefits ultimately achievable, and the impact that institutional barriers may have on the rate of deployment of ITS. This Handbook talks about the challenges that are somewhat unique to ITS and how they might be overcome. Some of these challenges include:

! ITS has a heavy emphasis on operations that many transportation departments are not used to dealing with. For example, information systems take more attention to maintain credibility with the public and other users.

! ITS crosses modal, institutional, and geographic barriers. This presents significant coordination challenges. These are usually substantially more difficult than the technological ones.

- ITS works best as a cohesive system of individual elements that work together. The integration of these elements makes the total concept of ITS more complex.

- ITS is not well understood by the public or elected officials.

- Up to this point, ITS has received substantial special attention and priority as the U.S. undergoes defense industry downsizing and transfer of some of those technologies into the realm of transportation. This has made it more difficult to integrate ITS strategies with other planning and implementation programs by state and local governments.

The Handbook draws on multiple sources of information:

- Current literature - Substantial data gathering and analysis on ITS planning and deployment has been conducted already by various academic institutions and government agencies. Some of the sources include FHWA-sponsored research, while others are papers and findings from ITS planning and deployment experiences throughout the U.S. These will be referenced later in the Handbook.

- Interviews with staff involved in ITS. Interviews were conducted by JHK & Associates (now TransCore) with personnel at selected FHWA and FTA regional and FHWA division offices, states, metropolitan planning organizations (MPOs), and local governments. These were coordinated with interviews conducted by the Volpe Center and with workshops held by Public Technology, Inc.

- Other discussions with professionals experienced in ITS and transportation planning.

EMPHASIS OF THE HANDBOOK

The Handbook considers all ITS user services. However, the emphasis of the Handbook is on that segment of ITS that tends to be the public sector's responsibility. This generally includes Travel and Transportation Management, Travel Demand Management, Public Transportation Management, Emergency Management, Electronic Payment Services, and Railroad/Highway Intersections. Several Commercial Vehicle Operations user services also would be included. The ITS public infrastructure is the key building block to achieving a fully-developed ITS. It lays the foundation for future services, including some of those to be provided by the private sector. Much of the case study information is from experience with implementing the ITS public infrastructure.

The *Interim Handbook for Integrating ITS within the Transportation Planning Process* was developed to describe how to improve transportation service to the customer through effective ITS applications. **It is not an advocacy statement for ITS; rather it is an advocacy statement for more integrated planning of ITS with the other dimensions of transportation planning.** For convenience of reference, this document will be referred to as the *ITS Planning Handbook*.

Although some portions of the material in the Handbook may overlap with other documents, the emphasis is distinct from much of the other information available. It is not the purpose of the Handbook to provide detailed information on ITS technologies. This information is contained in other material being provided through FHWA, FTA, ITS America and other organizations. Rather, the focus of the Handbook is on making decisions concerning ITS projects and programs: what to implement, where to implement it, and how to coordinate it with other transportation strategies. The *ITS Planning Handbook* addresses the following types of specific questions:

- Under what conditions should an ITS application be developed?
- What should be the process for how ITS applications are considered (groups to be involved, issues addressed, evaluation conducted, etc.)?
- What are the key decision items used to ensure proper selection and provision of effective ITS programs?
- How can decisions be made on the most appropriate ITS applications, given the defined problems and needs and within physical, financial, institutional, and environmental constraints?
- What actions can be taken to provide the greatest likelihood of success, when ITS applications are pursued?

> *"...the focus of the Handbook is on making decisions concerning ITS projects and programs: what to implement, where to implement it, and how to coordinate it with other transportation strategies."*

As with most transportation initiatives, success is not achieved through technology alone or through sheer engineering know-how. ITS cuts across geographic areas and modes as much or more than other areas of transportation. The institutional elements that are brought in by the modal and geographic diversity of ITS are a critical factor to ITS success. The added need for both technical and policy-level officials to understand ITS amplifies the institutional concerns. Thus, the ITS Planning Handbook dwells as much on the institutional issues as it does on the technical ones. In doing so, it exposes both the institutional and technical issues to both technical and non-technical staff. The cross-fertilization of information among these groups and a partnership at both the technical and institutional levels is vital to the long-term success of ITS.

> *"...a partnership at both the technical and institutional levels is vital to the long term success of ITS."*

It also should be acknowledged that ITS is merely a means to an end; it is not the end itself. ITS represents a group of transportation technologies and strategies that can be used independently or in combination to foster mobility, safety, and environmental protection. This Handbook presents a framework for decision-making concerning ITS and aids practitioners in successfully deploying ITS in the context of the overall transportation program.

ORGANIZATION OF THE HANDBOOK

The ITS Planning Handbook is generally organized around tasks that practitioners will need to perform in examining ITS applications. These tasks are viewed to be anchored to the overall transportation planning process and are not independent from the planning process. Chapter 2 provides the framework for ITS planning, as it is integrated with the overall planning process. There are three principal contexts described for ITS planning within that overall process:

- The transportation plan and transportation improvement program (discussed in Chapter 3). The transportation plan prepared for a state or metropolitan area is a comprehensive, coordinated look at transportation requirements extending over at least a 20-year period.
- Corridor and subarea transportation studies, including major investment studies and environmental studies (discussed in Chapter 4). Many decisions on appropriate transportation strategies are made at the corridor/subarea level.
- Strategic assessments of ITS (discussed in Chapter 5). These have been called by various names in certain states or metropolitan areas, such as ITS strategic planning efforts, ITS strategic studies, or ITS early deployment planning studies.

There are also other support functions, such as traffic monitoring support and evaluation (discussed in Chapter 6). ITS program administration is discussed in Chapter 7. Air quality issues, which are of significant concern with ITS, are addressed in their appropriate context.

The Handbook also underscores the need to take a wide range of circumstances into account in approaching ITS. Each metropolitan area has its own unique environment--institutionally, physically, and in terms of the transportation system and travelers on that system. Failure to account for these differences will be a major impediment to success. There is no "one size fits all" solution.

AUDIENCES FOR THE HANDBOOK

It is recognized that there may be diverse audiences that will read or refer to the Handbook. Some readers may have a technological background and wish to find out more about the planning process. Others may have a planning background and wish to find out more about ITS. Material is contained in the Handbook that will appeal to both these audiences and others. Exhibit 1-2 provides a cross-referencing of Handbook topics with possible audiences. The identification of an audience does not mean that the section will be of no interest to other readers. Rather, it indicates sections that will be of particular relevance to the identified groups. It is advisable that all audiences should be familiar with the entire breadth of material to foster interdisciplinary communications.

The audiences are classified into two broad categories: ITS implementers and transportation planners. ITS implementers are further classified into ITS managers (managers of implementation) and ITS engineers (those involved in hardware and software development and integration or in ITS operations). Planners are further classified as planning managers and planning analysts. It is assumed that ITS managers and engineers are generally familiar with ITS-related material (the national architecture, etc.) and that planning managers and analysts are generally familiar with transportation planning processes.

Exhibit 1-2. Audiences for Selected Handbook Topics

Chapter and Topic	**Audience**
Chapter 1 - Introduction and Overview	All
Chapter 2 - Integrating ITS into the Transportation Planning Process	
ISTEA and the Clean Air Act Amendments	ITS Managers
Where does ITS fit?	All
Overview of ITS Strategies or "Market Packages"	Planning managers Planning analysts
Overview of the National ITS Architecture	Planning managers Planning analysts
Chapter 3 - ITS Connections to Transportation Plans and TIPs	ITS Managers Planning Managers
Chapter 4 - ITS Connections to Corridor/Subarea Studies	
Overview of a corridor/subareas study	ITS managers
Defining problems: project purpose and need	ITS managers
Evaluation criteria	ITS & planning mgrs. Planning analysts
Defining relevant ITS strategies or market packages	All
Agency and public involvement	ITS & planning mgrs.
Devel. of recommendations and implementation plan	ITS & planning mgrs.
Chapter 5 - Statewide or Regional ITS Strategic Assessments	All
Chapter 6 - ITS Evaluation and Monitoring	ITS & planning mgrs. Planning analysts
Chapter 7 - ITS Program Administration	ITS & planning mgrs.
Appendix A - Description of ITS Market Packages.	Planning mgrs & analysts
Appendix B - ITS Tool Box (Annotated Reference List)	All
Appendix C - Funding Sources for ITS	ITS & planning managers
Appendix D - Description of Simulation Models	Planning mgrs & analysts
Appendix E - Analytical Approaches to ITS Evaluation	ITS & planning analysts

DEFINITIONS

A wide variety of terms are used in the ITS Planning Handbook. It is important to have an understanding of these terms to effectively communicate concepts. The listing below is not intended as a comprehensive list of all transportation terminology related to planning and ITS, but the key terms that will be used in this document. Further explanation of some of these terms will be provided later in the Handbook. Exhibit 1-3 provides a listing of basic ITS and transportation planning definitions.

Exhibit 1-3. Basic ITS and Transportation Planning Definitions

Architecture	A framework that describes what a system does and how it does it. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components.
Data dictionary	A detailed set of definitions of information that must be communicated between ITS subsystems.
Equipment packages	Units that can be deployed in the field, control centers, vehicles, etc. that make ITS happen.
Intelligent Transportation Infrastructure	The integrated set of nine basic infrastructure components needed to get ITS deployment started, primarily in urban areas.
Interfaces (also abbreviated I/F)	Connections between subsystems that transfer information between subsystems.
ISTEA	The Intermodal Surface Transportation Efficiency Act of 1991. This was legislation passed by the U.S. Congress that established initiatives for transportation planning, ITS, and other transportation elements.
ISTEA Management Systems	Six infrastructure management systems that are intended to help states and metropolitan areas develop systematic approaches to making decisions on projects and programs related to congestion, intermodal transportation, transit, safety, pavement, and bridges.
Legacy systems	Systems that have already been in operation. New ITS systems that are implemented will need to develop ways to interface with these systems, or the legacy systems will need to be upgraded.
Logical architecture	A description of the functions required to carry out an ITS system in a defined area. The logical architecture is typically shown in data flow diagrams (DFDs) and process specifications (P-specs).
Major Investment Study (MIS)	A type of corridor or subarea planning study required by the U.S. DOT to examine potential solutions to defined transportation problems, where a major metropolitan investment of Federal funds is potentially involved.
Market packages	Groupings of equipment that need to work together to deliver a particular ITS service. A market package is the basic level of ITS definition for which benefits and costs can be evaluated. Different levels of sophistication could be provided in individual market packages. Market packages could be described as the "how" of ITS.

National ITS architecture	Provides a master plan established by the U.S. DOT for deployment of ITS technologies and systems into the next century.
National Environmental Policy Act (NEPA) Documentation	A required documentation of the environmental impacts, consequences, and mitigation actions associated with certain projects.
Organizational architecture	A description of the agency responsibilities associated with carrying out the functions in the logical architecture. The agreement for agencies to carry out the identified functions is a key to successful ITS implementation.
Physical architecture	A description of how the functions of a logical architecture should be carried out. It typically groups functions together.
Regional ITS architecture	A structure for how individual ITS elements are linked together and intended to work together on a regional basis, both physically and logically.
Regional ITS framework	A comprehensive structure describing how ITS will be deployed within a region. It is all-encompassing, and includes the regional architecture as well as all the institutional, operations, and management activities necessary to implement the architecture.
Standards	Provide the means by which compatibility of ITS systems will be achieved. Standards may occur primarily in the communications area, but may also involve user interfaces where safety is a particular concern. Standards may be regulated or may be "de facto," in which the industry gravitates toward certain protocols without regulation because it has become common practice.
State Implementation Plan for Air Quality (SIP)	The portion or portions of an applicable implementation plan approved or promulgated under sections 110, 301(d) and 175A of the Clean Air Act (Public Law 101-549)
Strategic Assessment for ITS	An evaluation or study conducted for a state, metropolitan area, or other geographic region regarding how ITS will be implemented and operationally coordinated over a period of time. The word “assessment” is used as a broad, general term to describe the process. Other terms that have been used include ITS Strategic Plan, ITS Strategic Study, or Early Deployment Plan. Strategic assessments are typically multi-modal and multi-agency collaborative efforts.

Statewide Transportation Improvement Program (STIP)	A staged, multiyear, statewide, intermodal program of transportation projects which is consistent with the Statewide transportation plan and planning processes and with metropolitan plans, TIPs and processes.
Subsystems	Logically independent entities (personal vehicles, traffic and transit management centers, various roadside devices, etc.) among which information must be shared.
System integration	The process of physically making the hardware and software components of ITS technologies work together.
Technologies	Types of electronics, communications, software, and hardware components that can be used in equipment packages.
Transportation conformity	A requirement in the Clean Air Act that transportation plans, transportation improvement programs, and Federally funded highway and transit projects conform to the State Implementation Plan for air quality.
Transportation Improvement Program (TIP)	A staged, multiyear, intermodal program of transportation projects which is consistent with the metropolitan transportation plan.
Transportation plan	A document required to be prepared periodically by each state and metropolitan area that identifies transportation needs over a 20-year (or longer) period.
User interfaces	Methods of communicating and interacting with operating ITS elements or with the customer (e.g. ways of displaying information at a computer terminal).
User services	Descriptions of the type of ITS initiatives or enhancements that could benefit the customer (traveler, shipper, transporter, etc.). User services could be described as the "what" of ITS. Generally, market packages represent ways to implement an ITS user service, but there is no one-to-one correspondence.

It must be stressed that this is an <u>interim</u> handbook. It is a working document. The final Handbook will be based on additional input received by the user community and from case studies. Comments, suggestions, or corrections should be forwarded to Mr. Doug Laird, FHWA Office of Environment and Planning, Room 3232, 400 7th Street S.W., Washington, D.C., 20590, Phone 202-366-5972, Fax 202-366-3713, e-mail doug.laird@ fhwa.dot.gov.

2. INTEGRATING ITS INTO THE TRANSPORTATION PLANNING PROCESS

ISTEA AND TRANSPORTATION PLANNING

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) introduced a significantly different approach to the delivery of transportation services than had been in effect previously. Among other significant changes, the ISTEA recognized that system preservation, rather than new construction, needs to become a higher priority. The ISTEA also acknowledged the changing development patterns, the economic and cultural diversity of metropolitan areas, and the need to provide metropolitan areas with more control over transportation in their own regions by strengthening planning practices and coordination between states and metropolitan areas and between private and public sectors. It also sought to improve linkages and connections between different forms of transportation. Further, for the first time, statewide transportation planning was required.

The ISTEA recognizes the need for a new outlook on transportation and how it serves the Nation's economic, mobility, and accessibility needs. Although a continuing, cooperative, and comprehensive planning process has been required in urbanized areas since 1962, ISTEA calls for a more integrated planning process to better meet the needs of all constituencies. The ISTEA places significant emphasis on broadening participation in transportation planning to include key stakeholders who have not traditionally been involved, including the business community, members of the public, community groups, and other governmental agencies. The ISTEA also reflects an understanding of the constraints imposed upon further expansion of the highway network, particularly in metropolitan areas, and that system efficiency and system preservation need to become priorities.

Finally, ISTEA includes unprecedented linkages to achievement of the air quality objectives embodied in the Clean Air Act Amendments of 1990 (CAAA) and in state air quality plans. The CAAA recast the planning function to ensure that, in areas failing to meet Federal air quality standards, transportation planning is geared to improving air quality as well as mobility. The CAAA challenges officials to reduce emissions, to reduce the number of single occupant vehicles, and to make alternatives such as transit and bicycles a more viable part of the transportation network. These goals can be furthered by addressing management and operation of existing and future transportation facilities and consideration of ITS to meet transportation needs within the metropolitan and statewide planning processes.

Within metropolitan areas, the MPO provides a forum for cooperative transportation decision-making in which communities can identify shared goals and negotiate differences so that transportation plans and programs can be developed in an effective manner.

MPOs serve as a mixing bowl where local elected officials and the communities they serve can interact to resolve problems and build consensus in developing transportation priorities that will provide the most benefits to the community.

> *"... the MPO provides a forum for cooperative transportation decision-making in which communities can identify shared goals and negotiate differences..."*

Flexible Funding

One of the most important changes in Federal policy found in ISTEA involves funding flexibility. The Act provides extensive flexibility to State and local officials by eliminating the barriers traditionally standing between highway and transit funds. Under previous legislation, a relatively small amount of Federal highway funds could be used for transit projects. With the ISTEA, not only is fifty-eight percent of the Federal highway program ultimately available for transit projects, nearly thirty percent of the transit funds may be used for highway projects. Over the six-year span of ISTEA, more than $80 billion dollars may be flexibly programmed.

This flexibility will allow States, MPOs, and transit operators to respond better to their particular needs. Flexibility means choice. Making effective choices is strengthened by active participation from the community. Public participation is essential in considering the various funding trade-offs in selecting projects for implementation.

Financially Constrained Planning

ISTEA requires that the transportation planning processes conducted by State DOTs and MPOs produce two documents that indicate what transportation programs/projects will be implemented in the short-term and what the priorities are over the long-term. The short-term list of projects is called the transportation improvement program or TIP. According to ISTEA, the TIP must include a priority list of projects to be constructed over a three year period after its approval. The long-term priorities, covering a twenty year time period are incorporated into the transportation plan. The transportation plan, as defined by the Act, identifies transportation facilities including, but not necessarily limited to, major roadways, transit, multimodal, intermodal, bicycle and pedestrian facilities.

The production of the TIP and the long range plan do not represent new requirements. What is new, however, is that ISTEA requires that the metropolitan transportation plan and both the metropolitan and statewide TIPs be financially constrained to reflect revenues reasonably expected to be available over the time period that they cover. In other words, only projects for which funds are expected to be available may be included in these documents. Each must contain a corresponding financial plan that indicates how funding will be provided. This is a significant change from the past, where both of these documents were often "wish lists" that included everything desirable but did not represent projects that could be actually implemented.

The financial constraint requirement now adds credibility, accountability, and realism to the planning process. Correspondingly, participation in planning efforts becomes more important and more controversial since more is at stake. Communities actively participating in these efforts will expect to see the results of their work.

> *"... both of these documents (transportation plan and TIP) were often "wish lists" that included everything desirable but did not represent projects that could be actually implemented."*

Intermodalism

Intermodalism involves the use of many different modes of transportation and their connections in making a trip. As its name implies, ISTEA goes beyond the traditional highway/transit focus in transportation and suggests that all modes be considered in the planning process. The Act recognizes that the movement of both goods and people is critically important in improving the nation's transportation system. It suggests that the efficient movement of freight and people among different modes, and the improvement of connections between modes (truck/rail; bus/commuter rail; rail/ship; bus/airline, etc.) be addressed in developing plans and programs. Access to ports, airports, intermodal facilities (freight distribution centers, transit stations), and major freight distribution routes, including rail, must be considered. The private sector should participate in the process so that resulting plans meet the needs of shippers and merchants. The consumers should participate so that the plans meet their mobility needs. Improving intermodal transportation is one of the keys to increasing productivity and improving the competitiveness of U.S. industry worldwide.

Public Participation

If ISTEA is to be successful, broad public involvement in making transportation decisions must occur. The Federal Transit Administration and Federal Highway Administration jointly published the final planning regulations guiding the development of statewide and metropolitan plans and programs in the October 28, 1993 Federal Register. Both the statewide and metropolitan planning regulations include public involvement requirements. The joint planning regulations indicate that "public involvement processes shall be proactive and provide complete information, timely public notice, full public access to key decisions, and opportunities for early continuing involvement."

Why is public participation important? Quality of life and transportation have close ties. Early public involvement can steer the development of future highway and transit improvement alternatives into areas of support and away from deadlock at the end of the process. Broad participation is necessary in linking transportation strategies to environmental goals. The implementation of transportation strategies to reduce pollutant levels will require substantial public involvement to be successful. Ridesharing, HOV use, transit ridership, congestion pricing, and other pieces of the solution depend on an informed public for implementation. Early public involvement in developing these strategies will help to ensure their success.

WHERE DOES ITS FIT?

Although the planning process is only one of many elements that contributes to successful ITS implementation, its importance will increase as the dependence on set-aside Federal funding for ITS potentially diminishes in the future. Even with set-aside Federal funding, the coordination of ITS projects with other transportation programs is vital to optimizing the benefit of those programs and to the success of ITS. The integration of ITS with the planning process presents a win-win scenario. Failure to coordinate and integrate could result in missed opportunities for implementation, less effective implementations, and unnecessary increases in costs.

> *"The integration of ITS with the planning process presents a win-win scenario."*

Flow of the Planning Process

Put simply, the focus of the planning process is on making decisions. The various elements of the planning process provide information so that good decisions and wise investments can be made in the transportation system. Exhibit 2-1 is one depiction of the transportation planning process, indicating that it is iterative and has two primary planning and programming vehicles: the transportation plan and the TIP. Implementation is not a part of the planning process itself, but is shown to illustrate its relationship to the planning process.

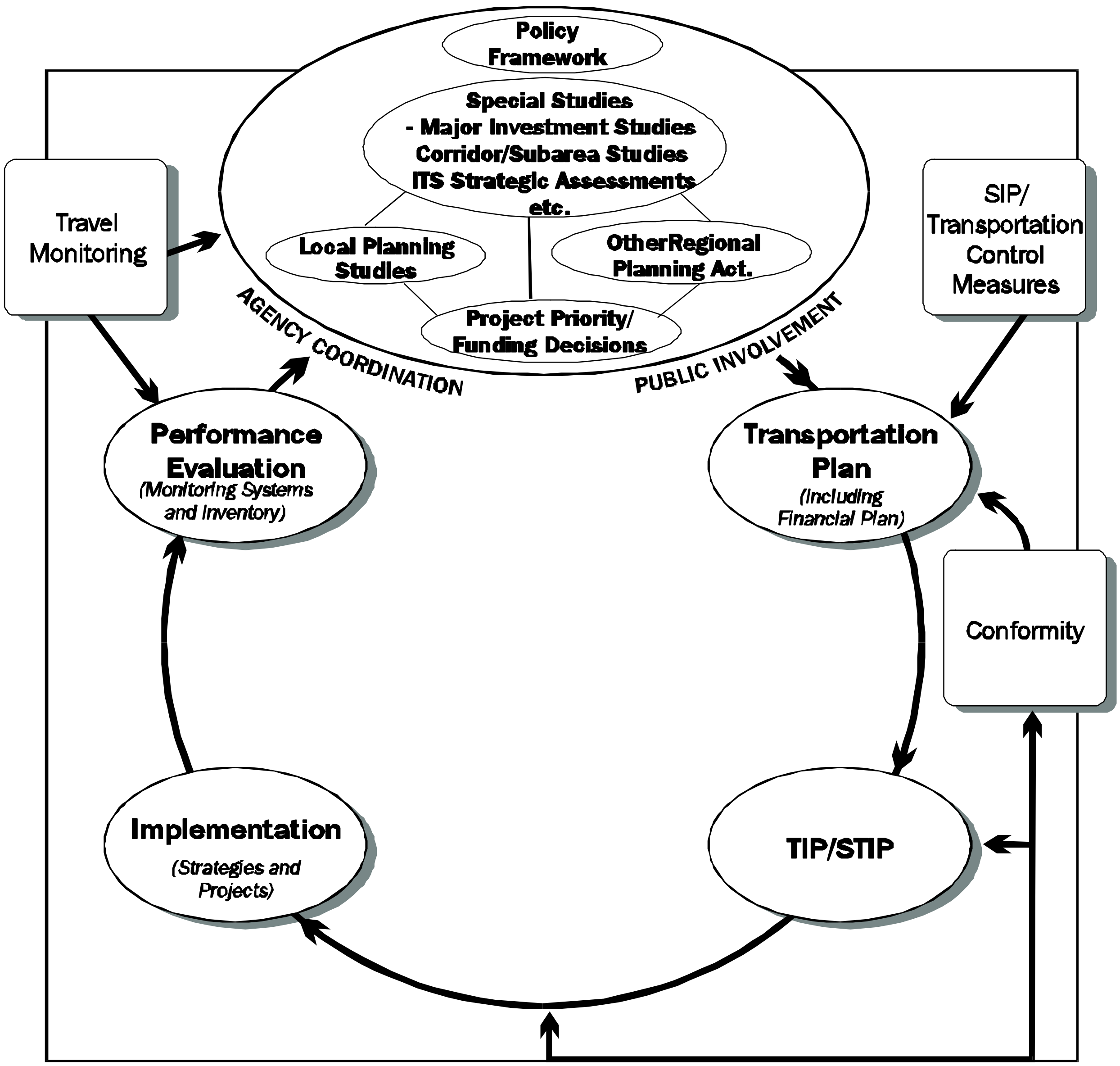
ITS has a place in virtually every step of the planning process. The transportation planning activities shown at the top of the chart represent multiple activities that feed information to the development of the transportation plan and TIP. As indicated, there are a number of inter-related planning activities that could take place. The relationship between ITS and the various elements of the planning process shown in Exhibit 2-1 are described below:

! **Transportation Planning Activities:** There are a broad array of activities that ultimately result in a set of recommended, fundable transportation projects and programs. These activities feed information to the principal products of the transportation planning process: the transportation plan and TIP. The process varies from one area to another and includes input from many agencies and individuals. Some of these transportation planning activities include policy definition, corridor/subarea studies, strategic assessments (an example of which is for ITS), etc.

! **The Transportation Plan**: The plan is a primary product of the planning process and is required to be prepared periodically by each state and metropolitan area. It documents the policy direction for the region and describes how transportation projects and programs will be implemented over a 20-year (or longer) period. It has sometimes been called the long range plan, but it includes the entire time period out to the horizon year, including projects and programs that are short range as well as those that are long range. Projects for ITS need to be included in this document. Chapter 3 provides an extensive discussion of ITS in the transportation plan.

! **Transportation Improvement Program (TIP)**- A document required to be prepared periodically by each state and metropolitan area that describes specific projects that will be constructed and/or operated over

Exhibit 2-1. Overview of the Transportation Planning Process



the next several years (minimum three years, some areas include additional years). ITS projects need to be included in this document to receive Federal funds. Chapter 3 discusses ITS in relation to the TIP and project selection processes.

! **Transportation conformity:** A requirement in the 1990 Clean Air Act Amendments for transportation plans, transportation improvement programs, and Federally funded or approved transportation projects in non-attainment or maintenance areas to conform to the State Implementation Plan for air quality. Some ITS projects may be subject to conformity requirements. ITS may also be a way to help a metropolitan area achieve its air quality requirements. Chapters 3 and 4 both discuss ITS and air quality issues. The analysis approaches to air quality for ITS are discussed in Chapter 6.

! **Implementation:** For ITS projects, implementation takes on the broader definition of construction and operations. In most cases, ITS infrastructure requires active management to achieve the effectiveness levels anticipated. Implications for ITS implementation are treated mainly in Chapters 5 and 6.

! **Performance Evaluation:** Achieving maximum effectiveness of a system requires assessing its effectiveness and making adjustments, as necessary. This is perhaps more important for ITS than many other strategies, because of the strong operational emphasis of ITS. ITS infrastructure can also be used to assist in evaluating the effectiveness of other transportation strategies. Effectiveness evaluation is discussed in Chapter 6.

! **Travel Monitoring:** Ongoing monitoring of the transportation system helps in diagnosing continuing congestion and safety problems, as well as problems in the infrastructure itself. ITS can play a strong role in the overall transportation planning process for providing monitoring input. A specific section is devoted to monitoring and ITS in Chapter 6.

The sections below describe in greater detail the various planning activities that feed the transportation plan and TIP and how ITS relates to those activities.

Policy Definition

Decision-makers provide broad direction for the transportation planning process through the establishment of goals, objectives and policies. ITS should take its direction from these policies, not attempt to create a separate policy direction. However, policy makers should be made aware of how ITS could influence policy through the technological opportunities it affords.

Special Studies

A variety of special studies are often conducted to develop information to support the decision-making process. These studies are normally targeted toward addressing problems and needs for specific geographic areas or specific functional issues. The results of these studies are provided to the decision-making process for further consideration, funding, and implementation. Two types of special studies that can relate to ITS are discussed in the Handbook: corridor/subarea studies, and strategic studies or assessments.

Corridor/Subarea Studies

Corridor/subarea studies, including major investment studies (MISs), are used to flesh out transportation strategy and project recommendations on a geographic basis. A corridor or subarea is a context for evaluating how specific transportation conditions, problems, and needs should be addressed within the defined geographic area. A wide range of multimodal strategies, including ITS, are considered as candidate solutions for those problems.

A corridor/subarea study addresses problems and needs in greater detail than is possible in a transportation plan. The results (project costs, benefits, and an investment strategy) are then provided for consideration in the development of the transportation plan and TIP. Thus, corridor/subarea studies both provide information to and use information from the transportation plan. **Priority-setting and selection of alternatives <u>within</u> the corridor/subarea can be addressed in the corridor/subarea study. Priority-setting <u>among</u> corridor/subareas (which may also affect priorities within corridor/subareas) is addressed in the transportation plan development process.**

Strategic Assessments of ITS or ITS Strategic Planning

Some issues are regional in nature and cannot be addressed only at the corridor/subarea level. Yet they are beyond the level of detail that can be accommodated in the transportation plan. In some cases, details need to be worked out among a certain class of strategies to ensure that the eventual system is fully coordinated, that designs can take advantage of economies of scale, and that the operation of the system can be supported. ITS is one of those areas that can derive particular benefit from a strategic, regional approach. **A strategic assessment is used to develop a regional framework for implementation of ITS. The regional ITS framework incorporates a regional architecture, consistent with the National Architecture, along with the institutional, operations and management activities needed to implement the regional architecture.** The term "strategic assessment" is a broad term used to describe the process. The regional ITS framework, including a regional architecture, is a product of that process. Other terms that have been used for similar activities include ITS strategic plan, ITS strategic study, or ITS Early Deployment Plan. It should be noted that the idea of a strategic assessment or strategic plan goes well beyond the concept of early deployment, incorporating a long term view of ITS implementation in a state or region.

> *"ITS is one of those areas that can derive particular benefit from a strategic, regional approach."*

There are several reasons why an ITS strategic assessment can be beneficial:

- It helps to relate ITS solutions to specific transportation problems.

- It provides a mechanism for communicating potential ITS initiatives to other parts of the planning process. Other (non-ITS) projects may be able to integrate ITS elements more cost-effectively (e.g. along with a highway construction project) than if the ITS elements were implemented alone.

- It can ensure more cost-effective ITS deployment over time because of a comprehensive approach (rather than a piecemeal approach) that maps out growth paths that will result in good decisions on equipment purchases and operational management.

- It allows for easier integration of systems over time.

- It brings agencies together to discuss implementation, operation, and management issues of mutual concern. The bringing of multiple agencies to the table has been one of the most often cited benefits of a strategic assessment.

- It documents (and usually prioritizes) desired ITS projects so that funds can be sought and projects implemented in a reasonably logical, systematic fashion.

Most agencies have found that conducting an ITS strategic planning effort is a useful way to address regional issues associated with ITS: communications systems, regional information needs, enhancement to regional transit systems, etc. The concerns are broader than only a corridor or subarea. As long as the results are viewed as an integral part of the broader planning process (and not as an independent activity), a strategic assessment can be an efficient mechanism for bringing a broad cross section of stakeholders together to structure an approach to ITS that supports the entire regional transportation program. However, an ITS strategic assessment is <u>not</u> a requirement. Many states or regions have already conducted an activity similar to the ITS strategic assessment. Strategic assessments should usually be updated periodically, as with any planning activity.

An ITS strategic assessment is an important forum for bringing together a broad, multimodal cross-section of stakeholders, including those who would be unlikely to become directly involved in the transportation plan development. These public and private stakeholders (such as emergency service agencies, communications system providers, etc.) will deal with issues that tend to be specific to ITS strategies, providing solutions back to the transportation plan and TIP for further consideration.

> *"An ITS strategic assessment is an important forum for bringing together a broad, multimodal cross-section of stakeholders . . ."*

Interaction of the Transportation Plan, Corridor/Subarea Studies, and Strategic Assessments

The transportation plan guides and draws information from strategic assessments, just as it does from corridor/subarea studies. Strategic assessments may be visionary in nature and are often not financially constrained. They would usually result in a report that documents potential projects that may be a part of an ultimate plan or vision but for which funding is not yet available. In metropolitan areas, the transportation plan addresses how much of the plan or vision can be afforded with reasonably available resources.

It is important to note that the planning process does not need to cause delays to the implementation of ITS projects or to make implementation more difficult. If funds become available for certain projects, implementation can often proceed even if the planning is not completed, as long as other necessary requirements are satisfied (e.g. inclusion in the appropriate improvement programs). It is important that ITS projects (as well as non-ITS projects) take advantage of implementation opportunities as they arise. In doing so, however, agencies should be cautious of the following circumstances:

- Making commitments (e.g. to a certain technology) that will result in a greater long term cost.

- Investing in a project because the money is available but where the project is not well suited to the conditions and needs. The project could prove to be a distraction.

- Making commitments that will obligatean agency to ongoing costs for which resources may not be available. It is better not to implement a project than to implement one that must be terminated shortly thereafter.

- Making commitments to projects that will not integrate well with other ITS applications that may come later.

Strategic assessments are typically not just a long term view, but also incorporate the near term. An ITS strategic assessment, for example, may provide projects that can be included in both the plan and TIP and implemented in the near term. However, similar to the case with corridor/subarea studies, project selection/prioritization decisions among ITS and non-ITS projects are not finalized within a strategic assessment but within the development of the financially constrained TIP. This is illustrated in Exhibit 2-1 by the "project prioritization/funding decisions" ellipse. None of the individual planning activities can establish final priorities and ensure the allocation of funds. In metropolitan areas, these decisions are made at the regional level under the financially constrained conditions of the transportation plan and Transportation Improvement Program.

> *" . . . the planning process does not need to cause delays to the implementation of ITS projects or to make implementation more difficult."*

A strategic assessment provides information so that better decisions can be made in the transportation plan and TIP. It provides an opportunity to focus on the details of a certain type of transportation strategy or set of strategies (i.e. obtaining greater efficiencies out of the transportation system through advanced technology) to support the overall decision-making process. It is not an independent activity; rather it provides information to other activities and resolves issues that cannot be resolved in other frameworks. This is part of the iterative, interactive nature of the planning process.

Much like corridor/subarea studies, strategic assessments must take direction from the transportation plan and provide enough detail to identify appropriate strategies that address the plan's objectives. Priority setting among strategies is then addressed in the transportation plan.

A strategic assessment can also provide information to corridor/subarea studies. For example, if a regional transportation information system is envisioned in an ITS strategic assessment, this concept can be incorporated into the alternatives or concepts being evaluated in the corridor/subarea study. Likewise, if a corridor/subarea study identifies a problem or need that should be addressed with ITS, this can be taken up in the ITS strategic assessment (or an update, if one has already been completed) to be incorporated into the overall ITS architecture for the region.

Local plans and studies are also an important part of the iterative planning process. Certain projects may originate in a locally-sponsored transportation study or proposal. These projects need to be considered as a factor in other corridor/subarea or strategic studies that are regional in nature.

Relationship to the Management Systems

ISTEA established six management systems (bridge, congestion, intermodal, pavement, public transportation, and safety), plus a traffic monitoring system. The management systems are optional, except that the planning process in transportation management areas must include a congestion management system.

There are several ways of thinking of ITS in relationship to management systems. The management systems typically have components of data collection/monitoring, deficiency/problem identification, strategy identification, strategy evaluation, and post-implementation effectiveness evaluation. ITS has significant potential to assist in data collection and monitoring. ITS is also a potential set of strategies that can be employed in addressing problems or deficiencies.

Some metropolitan areas may view an ITS strategic assessment and certain types of corridor/subarea studies to be a part of their congestion management system (CMS). Other areas may take a narrower definition of the CMS, classifying strategic and corridor/subarea studies as "other" planning activities, not as part of their CMS. All of the activities, whether they be the management systems, corridor/subarea studies, or strategic assessments, feed the transportation plan and TIP; they do not ultimately resolve project priorities and financing on their own. The resolution of priorities is done in the context of the financially constrained metropolitan transportation plan and TIP/STIPs.

Relationship to Transportation Conformity

Subpart T of 40 CFR Part 51 and subpart A of 40 CFR Part 93 address conformity of transportation plans, programs, and projects to state or Federal implementation plans prepared pursuant to section 110 and Part D the Federal Clean Air Act (CAA). Subpart T sets forth policy, criteria, and procedures for demonstrating and assuring conformity of these activities to the applicable implementation plan.

In areas that are nonattainment or maintenance for transportation-related pollutants, transportation plans and programs which are financed wholly or in part with Federal-aid or receive approvals from FHWA or FTA are required to be in conformance with the State Implementation Plan (SIP) for air quality. In most cases, ITS projects are Federally funded and it is mandatory for them to be in compliance with conformity regulations issued by EPA (August 1997) in nonattainment and maintenance areas. All regionally significant projects, including non-federally assisted projects, must be included in the plan and TIP conformity analysis. According to the CAAA, transportation plans and programs cannot create new National Ambient Air Quality Standard (NAAQS) violations, increase the frequency or severity of existing NAAQS violations, or delay attainment of the NAAQS.

In metropolitan areas, the MPO is responsible for making determinations that the plan and TIP conform to the SIP. The FHWA and FTA must also review the plan and TIP and make a conformity determination in order for projects contained in the plan and TIP to be eligible for Federal funding or approvals. If a transportation plan, TIP, or project does not meet conformity requirements, transportation officials have the following options:

- Modify the plan, TIP, or project to offset emissions

- Work with the appropriate state agency to modify the SIP to offset the plan, TIP or project emissions

If the above is not accomplished, the plan, TIP, or project cannot advance. This can affect ITS plans and projects.

Based on a literal reading of the regulations, many ITS projects would not appear to be exempt from regional emissions analysis. In a practical sense, many ITS projects could not be included in a regional emissions analysis because their effects are so difficult to analyze. Exhibit 2-2 shows a diagram of the flow of the conformity process as it relates to transportation projects. This process would apply to non-exempt ITS projects.

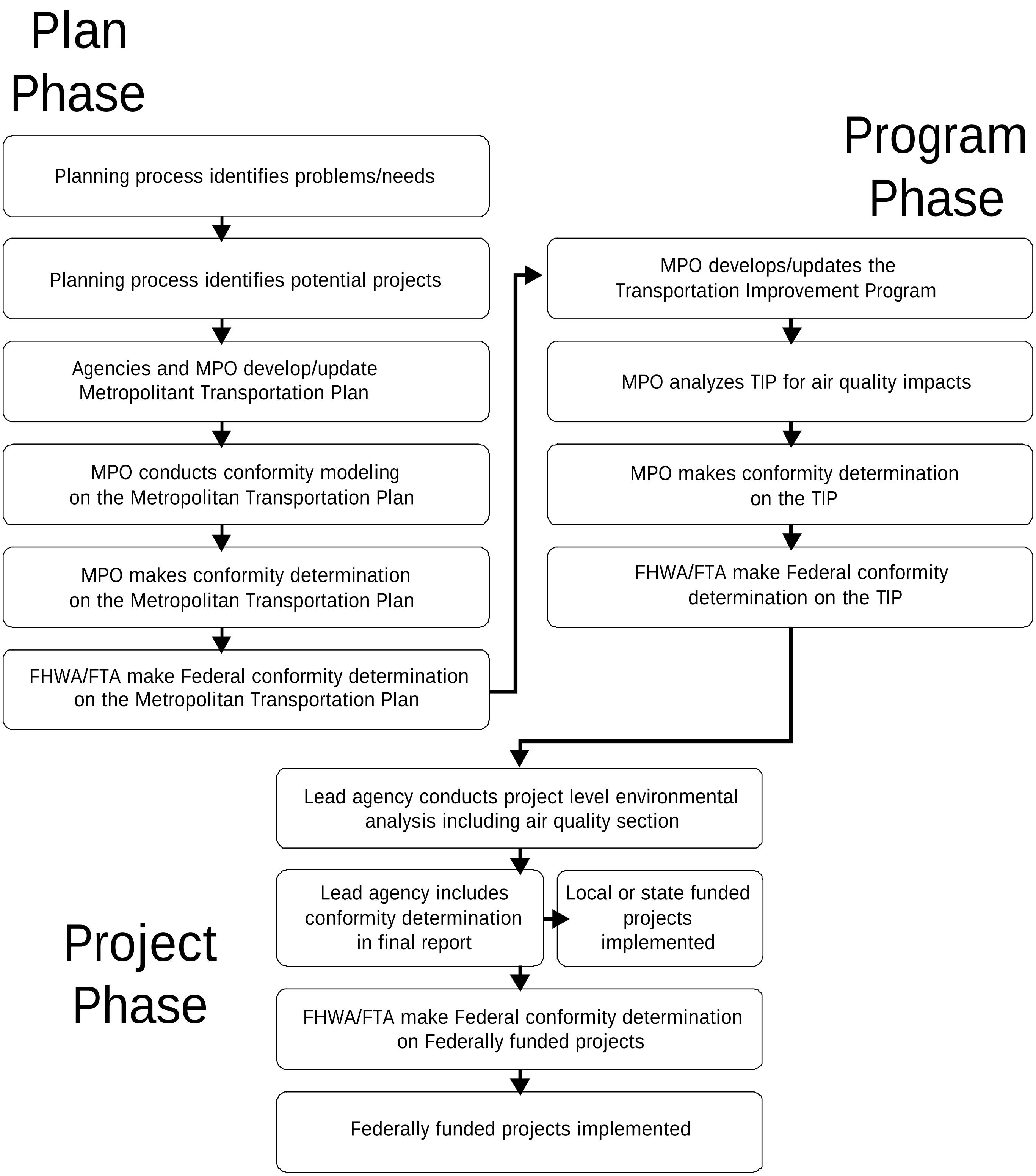


Exhibit 2-2. How a Project Passes Through Air Quality Conformity

Several types of ITS projects could be readily accepted as exempt from conformity determinations, such as safety-related ITS projects, equipment to improve transit operations, and fare payment systems. Signalization projects at individual intersections are exempt from regional emissions analysis, as are truck size and weight inspection stations. However, these projects are still subject to the requirements for CO and PM10 hotspot analysis. Traffic signal synchronization projects may be funded, approved, or implemented without being subject to a conformity determination; however, the effect of the emissions of such projects must be included in the supporting regional emissions analysis. Freeway control systems, and other ITS projects that affect traffic operations would not appear to be exempt, but may be difficult to analyze. A more comprehensive discussion of transportation conformity and its relationship to the planning process is included in the FHWA/FTA publication *Transportation Conformity, A Basic Guide for State and Local Officials* (Publication No. FHWA-PD-97-035).

Americans with Disabilities Act of 1990 (ADA)

The ADA gives civil rights protections to individuals with disabilities similar to the rights provided to individuals on the basis of race, color, sex, national origin, age, and religion. It guarantees equal opportunity for individuals with disabilities in public accommodations, employment, transportation, State and local government services, and telecommunications.

Under the ADA, the Department of Transportation has issued regulations mandating accessible public transit vehicles and facilities (49 CFR 27,37, and 38). They include requirements for accessible fare vending machines and fare collection areas. The regulations also require transportation terminals and stations with public address systems to make messages accessible to persons with hearing impairments. The requirements for accessible information provide opportunities for ITS technologies to help meet the transportation needs of the disabled.

OVERVIEW OF ITS STRATEGIES

ITS is not a new concept. It began with the early computers and vehicle detection systems over 25 years ago, with applications to traffic signal systems and freeways. What is new is the rapidly increasing array of advanced technologies applicable to multimodal transportation. These technologies can be packaged in various ways into strategies that improve the efficiency and effectiveness of transportation systems. In the planning of ITS, strategies will be specified in terms of specific locations for implementation and technologies to be included.

The ITS National Architecture uses the term "market package" to represent an ITS improvement strategy or set of strategies that can be deployed as a unit to address a transportation or air quality objective or problem. The market package terminology is used throughout the Handbook as synonymous with improvement strategies. The term "ITS user services" has also been used in the past to represent ITS strategies. User services represents a customer/user orientation to ITS strategies, while market packages are oriented toward the equipment to be implemented. The emphasis of the user services is on "what" is to be achieved, while the emphasis of market packages is on "how" to achieve it. There is substantial flexibility in how a region may wish to refer to ITS strategies. Some may prefer user services, some may prefer market packages, and others may refer to ITS strategies. However, it is important to use terms that are meaningful to the stakeholders involved in your local process. Agencies involved in ITS should be careful not to use ITS “lingo” that does not communicate well with the audience.

In examining terminology to be used to represent ITS strategies, it is important to define strategies in a way that benefits, costs, and impacts can be defined. Neither ITS market packages or user services can be considered detailed enough to allow this to occur. Additional definition is needed for some of the user services or market packages. For example, a ramp metering system is an ITS strategy that has certain effects on speeds, accidents, etc., yet neither market packages or user services explicitly identify ramp metering. Additional definition is needed to allow an evaluation of that strategy to take place. Market packages tend to be defined at a greater level of detail than user services. Exhibit 2-3 provides a list of ITS market packages associated with ITS user services.

> *“... it is important to define ITS strategies in a way that benefits, costs, and impacts can be defined.”*

It is at this level that the most meaningful evaluation can take place. It is important to note that the list of market packages in Exhibit 2-3 is not necessarily a complete list. Additional market packages may be identified to address specific problems or opportunities, or some market packages can be further subdivided.

Current ITS Applications

Substantial information exists on current operational ITS projects and programs. It is not the purpose of this Handbook to provide a comprehensive listing of these applications. However, a summary of references (The ITS Tool Box) is provided in Appendix B. These documents show how far the transportation community has come in implementing ITS. References are listed from both transit and highway modes.

Assessment of ITS Benefits

Information on documented benefits of ITS is more difficult to obtain. However, there is a growing body of evidence from a variety of projects and programs. Exhibit 2-4 provides a summary of information on quantifiable ITS benefits, extracted from the report <u>Assessment of ITS Benefits: Early Results</u>, Mitre Corporation for FHWA, August, 1995. There are also numerous benefits that cannot be quantified, such as management efficiency and responsiveness that are often associated with ITS. These will be discussed later in the report. Other useful references include *Traveling With Success* by Public Technology, Inc. And the *Intelligent Transportation Systems Action Guide: Realizing the Benefits,* by the Intelligent Transportation Society of America (ITS America).

Transportation planning revolves around making decisions on projects and programs. Good planning depends on a realistic assessment of the benefits and costs, and on the advantages and disadvantages of potential courses of action. In effect, that is the subject of this handbook: identifying the implications of choices so that agencies can make wise investments of their resources. Each

Exhibit 2-3. Market Package to User Service Relationships

		User Services																													
	Market Packages	1.1 - Pre - Trip Travel Information	1.2 - En - Route Driver Information	1.3 - Route Guidance	1.4 - Ride Matching And Reservation	1.5 - Traveler Services Information	1.6 - Traffic Control	1.7 - Incident Management	1.8 - Travel Demand Management	1.9 - Emissions Testing And Mitigation	1.10 Highway-Rail Intersection	2.1 - Public Transportation Management	2.2 - En - Route Transit Information	2.3 - Personalized Public Transit	2.4 - Public Travel Security	3.1 - Electronic Payment Services	4.1 - Commercial Vehicle Electronic Clearance	4.2 - Automated Roadside Safety Inspection	4.3 - On - Board Safety Monitoring	4.4 - Commercial Vehicle Administrative Process	4.5 - Hazardous Material Incident Response	4.6 - Commercial Fleet Management	5.1 - Emergency Notification And Personal Security	5.2 - Emergency Vehicle Management	6.1 - Longitudinal Collision Avoidance	6.2 - Lateral Collision Avoidance	6.3 - Intersection Collision Avoidance	6.4 - Vision Enhancement For Crash Avoidance	6.5 - Safety Readiness	6.6 - Pre - Crash Restraint Deployment	6.7 - Automated Vehicle Operation
ATMS	Network Surveillance						✓																								
	Probe Surveillance						✓																								
	Surface Street Control						✓	✓																							
	Freeway Control						✓	✓	✓																						
	HOV and Reversible Lane Management						✓		✓																						
	Traffic Information Dissemination						✓				✓																				
	Regional Traffic Control						✓																								
	Incident Management System							✓																							
	Traffic Network Performance Evaluation						✓		✓																						
	Dynamic Toll/Parking Fee Management								✓							✓															
	Emissions and Environmental Hazards Sensing									✓																					
	Virtual TMC and Smart Probe Data		✓				✓	✓																							
	Standard Railroad Grade Crossing										✓																				
	Advanced Railroad Grade Crossing										✓																				
	Railroad Operations Coordination										✓																				
APTS	Transit Vehicle Tracking											✓	✓	✓	✓																
	Transit Fixed-Route Operations											✓	✓																		
	Demand Response Transit Operations											✓	✓	✓																	
	Transit Passenger and Fare Management												✓			✓															
	Transit Security											✓			✓																
	Transit Maintenance											✓																			
	Multi-modal Coordination						✓		✓			✓																			
ATIS	Broadcast Traveler Information	✓	✓										✓																		
	Interactive Traveler Information	✓	✓										✓	✓		✓															
	Autonomous Route Guidance		✓	✓																											
	Dynamic Route Guidance		✓	✓																											
	ISP Based Route Guidance	✓	✓	✓												✓															
	Integrated Transportation Mgmt/Route Guidance		✓	✓												✓															
	Yellow Pages and Reservation	✓	✓			✓										✓															
	Dynamic Ridesharing	✓	✓		✓								✓	✓		✓															
	In Vehicle Signing		✓				✓				✓																				
AVSS	Vehicle Safety Monitoring																												✓	✓	
	Driver Safety Monitoring																												✓		
	Longitudinal Safety Warning																								✓				✓		
	Lateral Safety Warning																									✓			✓		
	Intersection Safety Warning										✓																✓		✓		
	Pre-Crash Restraint Deployment																												✓	✓	
	Driver Visibility Improvement																											✓			
	Advanced Vehicle Longitudinal Control																								✓						
	Advanced Vehicle Lateral Control																									✓					
	Intersection Collision Avoidance										✓																✓				
	Automated Highway System																														✓
CVO	Fleet Administration																					✓									
	Freight Administration																				✓										
	Electronic Clearance																✓			✓											
	CV Administrative Processes																✓			✓											
	International Border Electronic Clearance																✓			✓											
	Weigh-In-Motion																✓														
	Roadside CVO Safety																	✓													
	On-board CVO Safety																		✓												
	CVO Fleet Maintenance																		✓			✓									
	HAZMAT Managment							✓													✓	✓									
EM	Emergency Response																							✓							
	Emergency Routing																							✓							
	Mayday Support																						✓	✓							
	ITS Planning											✓																			

Exhibit 2-3. Market Package to User Service Relationships

Exhibit 2-4. Selected Quantifiable ITS Benefits
(Source: *Assessment of ITS Benefits: Early Results*)

ITS STRATEGY	LOCATION	DEMONSTRATED BENEFITS
Commercial Vehicle Operations: - Electronic clearance, improved inspection procedures, and vehicle performance monitoring	Oregon	- increase in weighing of 90%, and an increase in safety inspections of 428% between 1980 and 1989 with staff increase of only 23%
Motor Carrier Safety Assistance Program	Nationally	- the cost/benefit ratio estimated at 2.5 while yielding a reduction of 2,500-3,500 accidents annually. - improved brake inspection technology will reduce inspection time by 10-15 minutes - use of pen-based computers will reduce the duplicate input of inspection report data resulting in a savings of 125 staff years annually
Ramp Metering/Traveler Info	Minnesota DOT - TMC (January 1994)	- increase average speeds from 34 mph to 46 mph - accident rates dropped 27%, from 428 to 308 per year - annual accident experience dropped from 3.4/MVM to 2.11/MVM
	Seattle, Washington (WSDOT, 1989, measured)	- over a six year period, freeway speeds increased up to 20% - 38% reduction in accidents - ramp delays 3 minutes or less
	Long Island, NY (INFORM)	Freeway speeds increased 13% (with 5% increase in VMT for PM period) - 300,000 vehicle hours saved/year with motorist info - 7% increase in throughput in some sections, no change in others
Route Guidance	Los Angeles - Pathfinder	- Drivers using Pathfinder were 40% more likely to divert
	Orlando - TravTek	Decrease in travel times of 19% for equipped vehicles

ITS STRATEGY	LOCATION	DEMONSTRATED BENEFITS
Incident Management	Twin Cities area - Minnesota Highway Helper Program	- reduces duration of a stall to 8 minutes - annual benefit estimated at $1.4 million with a cost of $.6 million - reduction of secondary collisions (difficult to estimate)
	Maryland CHART program	Estimated 10:1 benefit/cost ratio
Transit services - vehicle location systems	Baltimore - Mass Transit Administration	- 23% improvement in on-time performance
	Kansas City - K.C. Area Transportation Authority	Improved schedule adherence by 12%
	Milwaukee - Milwaukee County Transit System	Improved on-time performance by 28%
Electronic toll collection/ Automatic vehicle identification	Detroit, Michigan to Windsor, Ontario	- Benefit/cost ratio estimated at 30:1
	Oklahoma Turnpike	- 91% savings in annual costs per lane
Advanced vehicle monitoring and communications	Telesat, Canada	- increased loaded mileage by 9% to 16% - reduced operating costs $.12 to $.20 per track mile
	Dundas, Ontario - Frederick Transport	- increased loaded miles by 20% - reduced phone costs by $30 to $150 per month - increased load factors by .07%
	Fort Wayne, IN - North American Van Lines	- increased shipping business by 16.9% - expedited service by 24.5% - reduced cancellations by 3.8%
	Fenton, MO - United Van Lines	- easier recovery of stolen equipment

ITS STRATEGY	LOCATION	DEMONSTRATED BENEFITS
Automated Vehicle Inspection	Nationwide (projected)	- reduced impacts of HAZMAT incidents by $1.7 million annually - reductions in tax evasion from $0.5 to $1.8 million annually per state - reduction in overweight loads saving $5.6 million annually - weigh station operating costs reduced up to $160,000 annually per state - with automated credential checking, operating costs could be reduced from $4.3 to $8.6 million annually per state - with automated safety inspections, operating costs could be reduced from $156,000 to $781,000 annually per state
Bus priority traffic signal system	Portland, OR	5% to 8% reduction in bus travel time
Transit - Automated vehicle location/CAD system	Kansas City	- reduction in schedule time - two year cost savings of $1.5 million in capital expenses and $404,000 annually in operating expenses
Transit - Computer-aided dispatching and scheduling	Winston-Salem	Improved productivity - 9% lower expenses per mile - 2% lower expenses per passenger trip
Automated traffic surveillance and control (signal systems)	California	- 13% reduction in travel time - 35% reduction in vehicle stops - 14% increase in average speed - 12.5% lower fuel costs - 20% reduction in intersection delay - 10% reduction in HC emissions - 10% reduction in CO emissions
Closed loop signal system	Abilene, TX	- 13.8% lower travel time - 5.5% reduction in fuel consumption - 12.6% reduction in CO emissions - 9.8% reduction in HC emissions

chapter that follows makes a contribution to the procedures and methods that support the making of these choices.

WHAT IS THE NATIONAL ARCHITECTURE? (Excerpts from "The National Architecture for ITS: A Framework for Integrated Transportation into the 21ST Century.")

ITS is basically all about information—the collection, sharing, processing, and redistribution of information—to help move people and goods better. Information lets travelers make better decisions, and helps improve the efficiency and safety of the various elements of our surface transportation infrastructure.

An architecture is a framework that lays out the boundaries, players, and strategies for that process of information management and in the case of ITS, it has to have an intimate knowledge of the way transportation works, in order to get the new systems to work well with the existing ones. The framework can then guide agencies and the private sector in developing standards and making deployment decisions that will result in efficiency, economies of scale, and national inter-operability.

The architecture will help coordinate the development of Intelligent Transportation Systems. It will help ITS elements to use a common vocabulary, think about a common set of issues, and, eventually, use a common set of design and interconnection standards, as advanced transportation systems are gradually tied together and new ones are created.

In many ways, the National Architecture—reflecting as it does a fair consensus of the diverse parties that have had a role in its formation—provides a master plan for deployment of ITS technologies and systems into the next century...much as the architecture (or master plan) for the Interstate Highway System influenced a half-century of transportation development. As indicated, an architecture is basically a framework...a way of thinking about the world of transportation and information management. The National ITS Architecture relies on interactions among three "layers" of infrastructure:

! **Communications Layer**. This is the information infrastructure that connects elements of the transportation layer—it is what puts the "System" in ITS—and allows coordination and sharing of information among systems and people. The Architecture carefully lays out Ø what types of information and communication are needed to support various ITS services; Ù how data should be shared and used by which physical entities (subsystems); and Ú what types of standards are needed to facilitate this sharing.

  Communications is what puts the "S" (for "system') in ITS. Ever increasing availability of communications, together with fast, cheap, and small computing technology, have combined to create an unprecedented opportunity for ITS development. The types of linkages advocated by the Architecture include:

  - Wide Area Broadcast—such as a car's FM radio receiver
  - Wide Area Two-Way Wireless—allows more advanced, interactive services over, for example, a cellular phone link.
  - Dedicated Short Range Communication—such as the emerging wireless vehicle 'tags' for toll collection.
  - Vehicle-to-Vehicle Communication—which will someday help in avoiding collisions and improving vehicle control.

- Wireline Communication—regular 'phone lines': phone, fax, modem, video, and high speed data networks.

! **Transportation Layer**. This is the 'real world'—our physical ITS infrastructure that is beginning to evolve and will continue to evolve. This layer identifies the key players and establishes a common terminology for existing and future ITS subsystems. The Architecture is made up essentially of: travelers; vehicles; management centers; and roadside elements.

! **Institutional Layer**. Our socioeconomic infrastructure of organizations and social roles—reflecting jurisdictional boundaries and including agencies at all levels of government, private companies, and those that may be impacted by ITS services. Activities on this level include developing local policy, financing ITS, and creating partnerships to guide ITS deployments. The architecture does not propose modifications to this layer, acknowledging that there are reasons why things are the way they are...and that they are very difficult to change. It does recommend who should be connected to whom; and what types of things they need to be telling each other.

ITS Market Packages: Bringing the Architecture to Life

The architecture groups equipment into sample **market packages**, each of which describes a group of elements (equipment packages) that need to work together to deliver a particular ITS service. For example: for a single ITS user service such as Dynamic Route Guidance, a range of equipment is needed:

! **The Traveler** requires two equipment packages in the vehicle: a route guidance system; and some way of receiving dynamic information (for example, an enhanced FM radio that can receive data; or, better yet, a two-way interactive means of requesting and receiving routes from an Information Service Provider.

! **An Information Service Provider** (ISP) needs to have the equipment to calculate route/traffic information, and the means to communicate it to the customers.

! **A Traffic Management Center** (or other source) needs the means of collecting this information, and providing it to the ISP.

This suite of equipment together makes up the market package, the whole of which is necessary to deliver the service (dynamic route guidance) to the user. The architecture recognizes that a diverse marketplace will result in a whole *range* of market packages that can deliver this user service. One should be able to find equipment with different levels of capability at correspondingly different prices.

Several important perspectives on the National ITS Architecture include:

! **The architecture is a tool**, a framework, for the people who will be designing and building the systems that will deliver ITS services to the user. For instance, designers can find guidance on how much and what kind of information needs to be produced by a traffic management center; and what other systems it needs to be shared with. The Architecture does not prescribe any technologies, designs, or policies; it provides the *framework*. It gives each ITS center, or system, or information device an understanding of how it should relate to the rest of ITS.

! **The architecture prioritizes** the key ITS market packages that bring the greatest benefit early on, and recommends early deployments: things that make sense to do NOW due to technological or institutional opportunity, high potential benefits, market demand, or pre-existence of required standards.

! **The architecture leaves maximum room** for and strongly encourages private sector participation in ITS. Functions are broken out such that there is maximum opportunity for private sector involvement in providing ITS services—especially in the role of an Information Service Provider, or ISP.

! **The architecture proposes implementation scenarios** that first enable islands of ITS development NOW, which leverages existing assets and ITS investments; and then encourage increasing integration over time, resulting in progressively greater inter-operability and capability among systems.

! **The architecture developers** have recommended policy to USDOT, for example: Ø facilitate achievement of nationwide inter-operability by supporting standards development efforts; Ù maintain the architecture over time; Ú develop education and training programs for the local ITS implementor; Û provide 'handbook'-type guidance for ITS design and procurement; and Ü emphasize evaluation of systems to determine actual benefits derived from investments.

The Next Step: Standards

As with any system, the critical links in ITS are the interfaces that tie together the different parts of the system—for instance, between a vehicle and roadside equipment; between a traffic management center and a company that repackages raw travel data; between two vehicles cruising on an automated highway. The Architecture describes these interfaces to be *descriptive*, not *prescriptive*, in keeping with its role as a *framework*. There is not enough detail that a hardware or software designer could actually build a given interface. There are many different ways to design architecture-defined interfaces. Consequently, consensus standards are needed. No matter how solid an architectural master plan is, standardized parts will be needed to carry out the plan consistently throughout the country.

Over the coming years, agreement will be reached on how to standardize each of the critical links in the architecture which will ensure that users can interface with systems in a consistent way. The architecture will continue to evolve, to accommodate new user services and—by guiding the standards development process—to preserve the ability of systems to operate throughout the nation.

An Overview of Documents from the National Architecture for ITS

A substantial amount of information has been developed through U.S. DOT's National Architecture development process. Although many of the documents extend well beyond the planning process into project development and design, an introduction to the documents is warranted here. The documents are available on a CD-ROM entitled *The National Architecture for ITS*, available from the Federal Highway Administration.

The *Vision* contains a magazine style description of what users can expect to see in the transportation world of the future. The document contains easy to read descriptions addressing each of the major ITS stakeholders. Also presented are vignettes of life in the years 1997, 2002 and 2012.

The *Mission Definition* ties the architecture program to U.S. DOT's *National Program Plan* for ITS. Here, the stage is set for the architecture work. The document addresses goals, objectives, user service requirements, and expected benefits. The document also contains a communications threat analysis to remind us of the pitfalls that we should avoid.

The Architecture Definition is contained in a set of 4 volumes. The *Logical Architecture* presents a functional view of the ITS user services. This perspective is divorced from likely implementations and physical interface requirements. It presents only the functions (process specifications) that are necessary to perform ITS services and the information (data flows) that need to be exchanged between these functions. The *Logical Architecture* document contains diagrams showing such processes and data flows between them. The document also contains a complete data dictionary.

The *Physical Architecture* collects related functions together into subsystems. This document contains a collection of Architecture Flow Diagrams that show all of the data that passes between subsystems. The characteristics and constraints on the inter-subsystem data flows are also presented. The logical and physical architecture are tied together with a collection of cross-reference tables in the *Traceability Matrix*. The *Theory of Operations* provides a simple walk-through of how the architecture supports ITS implementations. This document contains easy-to-read text and diagrams that explain the operational concepts the architecture uses to implement the user services. Advantages and disadvantages of alternative operational concepts are also presented. Several documents report the results of the numerous evaluations conducted on the architecture. Because the architecture is not something that one can directly see or touch, the evaluations are based on possible implementations.

The *Communications Document* presents a thorough analysis of the communications aspects of the architecture. Analysis begins with the communications requirements resulting from analysis of the architecture data flows. Quantitative data loading requirements are proposed for a hypothetical system design whose parameters are documented in the *Evaluatory System Design*. A far reaching technology assessment is presented that covers several potential communications technology choices. These alternatives are compared with estimated ITS requirements. In particular, data loading requirements are used in a detailed simulation of one of the candidate wireless wide area communications technologies (CDPD). The document has an extensive set of appendices, each dealing with a specific communications study.

The *Risk Analysis* document assesses the risks threatening architecture deployment and suggests mitigation strategies. These strategies have been included in the overall implementation strategy for the architecture. The *Performance and Benefits Study* documents the results of a set of evaluation criteria as applied to the architecture. The results indicate that the architecture is flexible and adaptable. The document also presents an overall benefits discussion. This discussion is limited to benefits of the architecture (as opposed to benefits of ITS). ITS benefits can also be found in a number of other sources. A *Cost Analysis* document uses the same hypothetical system design used for the communication analysis, to provide a basis on which an implementor might begin to estimate the costs of deploying ITS in specific jurisdictions. The evaluations are summarized in an *Evaluation Summary* document that focuses on results of the various analyses.

Support for Implementors is provided in three documents. A *Standards Development Plan* presents the steps that need to be taken to produce a collection of interface standards. The document leads a standards development organization through the architecture documents. It defines those standards that require national interoperability for nationwide deployment of ITS. Those data flows that are related to near term deployments (e.g. Intelligent Transportation Infrastructure and Commercial Vehicle Information Systems and Networks) are listed. For each deployment feature (e.g. Traffic Signal Control), either a set of existing standards activities are identified, or new standards work is recommended. In either case, architecture information should be valuable. A top level view of how to use the detailed information is presented along with a mapping from deployment features to a set of 12 standards packages. The *Standards Requirements Document* contains detailed information for each standards package.

The culmination of the architecture effort is its ultimate implementation. This is described in the *Implementation Strategy* document. The document includes sample ways in which current deployment activities can use the architecture to identify interfaces that need to be standardized. It also presents a process for rolling out ITS services. The process is part of an overall strategy that includes recommendations for future research and development, operational tests, standards activities, and training.

THE CASE FOR A REGIONAL ARCHITECTURE AND OPERATIONS PLANNING

Each region of the U.S. is unique. There are differences in size, geographic layout, institutional structure, demographics, existing transportation infrastructure, etc. Because of these differences, transportation priorities also tend to be different. One region may emphasize transit more than others; another region may be an industrial distribution hub; another may be primarily a retirement area. Although the ITS National Architecture provides a framework, it is important for each region to tailor an ITS architecture to their specific needs. For example, each region will have a different set of legacy systems, and the agencies responsible for various elements of the transportation system differ as well. A regional architecture maps out how the various ITS components will ultimately be tied together, not only physically, but institutionally as well. It allows the system to built incrementally, in the most cost-effective way.

ITS presents an additional challenge not present in many other capital projects, particularly highway projects. Transportation planning has traditionally focused on capital projects. The challenge of ITS is not only to plan and build the ITS infrastructure, but to use it on a continuing basis to operate and manage the transportation system more safely and efficiently. Planning for operations and management is often either never done or is merely an afterthought to what are considered to be the major infrastructure decisions.

> *"The challenge of ITS is not only to plan and build the ITS infrastructure, but to use it on a continuing basis to operate and manage the transportation system more safely and efficiently."*

Operations planning takes the planning process a step beyond the traditional plans for building the infrastructure or the purchase of equipment. It addresses how the transportation system will function on a day-to-day basis. Operations and management should be factored into planning at several levels:

! In decisions on traditional infrastructure investment: The resources required for operations and management may influence the type of infrastructure that is built. For example, electronic toll collection not only is revolutionizing the way that toll operations are conducted, but is making infrastructure investments possible that may not have been possible without the advent of this technology.

! In decisions on ITS infrastructure: Operations and management costs are a significant consideration in identifying approaches to ITS. Personnel requirements, maintenance requirements, etc. need to be considered in making choices on how to invest in ITS and how to prioritize ITS projects. This is part of the life-cycle costing process that has become important as a tool in the thorough evaluation of transportation plans, corridor/subarea studies, and other planning activities.

! In decisions on investment levels in personnel and equipment to support implemented or soon-to-be-implemented ITS projects and the integration of those projects.

! In real-time management and coordination of inter-jurisdictional and agency operations. While this is more of an implementation element than a planning element, decisions made on real-time management and coordination of agency functions need to be understood not just within the responsible agency, but outside the responsible agency as well. A good example is incident management. Many agencies are involved in incident management, and incident management works best when agencies have determined their mutual responsibilities and protocols beforehand. The linkage between police, fire, transit, and traffic management agencies is critical for improved public safety. The process of making these determinations may impact the financial requirements of the transportation plan and could therefore be considered part of (or an important input to) the planning process. However, this level of operations planning tends to be very short term.

Operations planning is not unlike traditional infrastructure planning. It merely involves thinking farther through the process of delivering transportation services. It recognizes operations not just as an afterthought, but as integral to making good overall investment decisions. Just as the consumer has become educated to examine many dimensions of the purchase of an automobile (not just the physical characteristics of the vehicle, but fuel economy, maintenance costs, etc.) so transportation agencies need to consider the full implications of investing taxpayer dollars. In some cases, this means saving taxpayer dollars or being able to do more with the resources available. Operations planning means working smarter, not necessarily more expensively. It means providing the basis for system integration and system evolution, not building it and forgetting it.

> *"Operations planning is not unlike traditional infrastructure planning. It merely involves thinking farther through the process of delivering transportation services."*

In addition, operations planning does not need to be complicated, nor does it need to slow down the decision-making, funding, or implementation process. It involves assembling the appropriate players, identifying responsibilities, making reasonable resource estimates, and making decisions based on that information. It does not require a restructuring of traditional agency oversight over their facilities. It does involve <u>sharing</u> information so that all the agencies can deliver better service to their transportation customers. If agencies determine that a restructuring of some responsibilities is appropriate (e.g. a multi-jurisdiction traffic operations center), this option is available.

There are several possible forums for coordination of multi-agency operations planning and ongoing coordination of operations and management:

- Under the MPO umbrella.

- As a group of agencies with specific responsibility for a subarea that is geographically tied together (e.g. some cities organize themselves with an operations group or committee).

- Under the umbrella of an agency that has prime responsibility for an activity (e.g. when a state DOT seeks input from local agencies and transit agencies).

The ongoing coordination of operations and management is becoming a more important function as ITS becomes more prevalent. Agencies cannot live in isolation from one another. Not only do the actions of one agency affect another, but the operation and management of the transportation system crosses both geographic and institutional boundaries. An ongoing transportation management and operations group can:

- Provide a nurturing atmosphere for operations projects and operational enhancements. These can be projects in an ITS strategic assessment that are further developed, or additional projects that are introduced because of specific needs or opportunities.

- Troubleshoot existing interagency projects or projects being implemented.

- Develop and make adjustments to operational and management procedures.

- Serve as a communication mechanism for special events and emergency situations and a forum for debriefings on how planned operational strategies worked.

A number of examples of these arrangements exist. For example, in Los Angeles County, individual cities are members of the Metropolitan Transportation Authority's signal group, which was an outgrowth of an effort to coordinate signals across jurisdictional boundaries. This group now deals with ITS activities on a broader scale.

The most appropriate approach to ongoing operations and management likely depends on the level of operational detail being examined. Areas that have fewer operational issues will tend to have less formal arrangements. Operations planning can usually occur under existing organizational structures. It is not an activity that should be pulled out and conducted separately; rather, it is an activity that should be integrated with traditional infrastructure considerations. Operations planning is simply a dimension that should be an ongoing part of the overall planning framework. Its most concentrated form may be within an ITS strategic assessment, but it should integrated throughout the planning process.

3. ITS CONNECTIONS TO TRANSPORTATION PLANS AND TRANSPORTATION IMPROVEMENT PROGRAMS

REQUIREMENTS FOR THE TRANSPORTATION PLAN

The emphasis of ISTEA is on a systems approach to delivering transportation services. The "E" was deliberately included to promote the importance of <u>efficiently</u> using the existing transportation system. This is one of the principal assets of ITS. Thus, it is imperative that ITS be a significant consideration in transportation planning activities. One of the focal points of these activities is the transportation plan.

The transportation plan is one of the principal products of the planning process. It is the expression of a state or metropolitan area's long-term approach to constructing, operating, and maintaining the multimodal transportation system. It is the forum for balancing transportation investments among modes, geographic areas, and institutions. ITS should have a relationship to both the statewide transportation plan and the metropolitan transportation plan. The emphasis of this chapter will be on the metropolitan transportation plan.

The Federal regulation on Statewide and Metropolitan Transportation Planning (23 CFR, part 450) specifies requirements for transportation plans. Exhibits 3-1 and 3-2 indicate those requirements and highlight some of the associated considerations for ITS inclusion into those plans. There are several general observations from those exhibits:

- The exhibits can be used as a point of reference for ITS planners in the preparation of material to be included in the transportation plan.

- Although the transportation plan covers a long term horizon, it also is to include short-term projects and programs. Thus, even short-range ITS actions are appropriate for inclusion in the plan.

- There is substantial emphasis on the inclusion of actions that promote system efficiency. This is one of the strengths of ITS.

- There is significant emphasis on the multi-modal needs of the transportation system, a goal in common with ITS.

- Metropolitan transportation plans must be financially constrained. This requires that strategies involving ITS provide reasonable estimates of not only capital costs, but operations and maintenance costs as well.

Statewide transportation plans do not need to be financially constrained. However, many statewide plans tend to be policy plans more than plans identifying specific improvements.

Exhibit 3-1. Requirements for Statewide Transportation Plans and Considerations for ITS

Requirement	Considerations for ITS
Be intermodal and statewide in scope in order to facilitate the efficient movement of people and goods	ITS could be considered as an important component for maintaining system efficiency. ITS cuts across multiple modes.
Be reasonably consistent in time horizon among its elements, but cover a period of at least 20 years	Encourages examination of long-term approach to ITS. However, this is difficult given rapid changes in technology.
Contain, as an element, a plan for bicycle transportation, pedestrian walkways and trails which is appropriately interconnected with other modes	Not substantially relevant to ITS.
Be coordinated with metropolitan transportation plans	Statewide ITS elements should be coordinated with metropolitan ITS elements.
Reference, summarize or contain any applicable short range planning studies, strategic planning and/or policy studies, transportation need studies, management system reports and any statement of policies, goals and objectives regarding issues such as transportation, economic development, housing, social and environmental effects, energy, etc., that were significant to the development of the plan	ITS strategic assessment, corridor or subarea studies that involve ITS, ITS policy statements should be referenced or incorporated into the transportation plan. ITS-related plans should be packaged in such a way that certain summary elements could be easily incorporated into the transportation plan.
Reference, summarize or contain information on the availability of financial and other resources needed to carry out the plan	Any financial resources that are generated through ITS applications (e.g. from private sector, user fees, etc.) should be included.

Exhibit 3-2. Requirements for Metropolitan Transportation Plans and Considerations for ITS

Requirement	Considerations for ITS
Include both long-range and short-range strategies/actions that lead to the development of an integrated intermodal transportation system that facilitates the efficient movement of people and goods.	Even though many ITS actions may be short-term to mid-term, they should be included in the transportation plan. The plan covers all time periods.
Identify the projected transportation demand of persons and goods in the metropolitan planning area over the period of the plan	Estimates of benefit for ITS should take into account the future, not just the present.
Identify adopted congestion management strategies	ITS is one of a number of congestion management strategies, oriented toward the more efficient use of existing facilities.
Identify pedestrian walkway and bicycle transportation facilities	Not substantially relevant to ITS.
Reflect the consideration given to the results of the management systems	Any ITS strategy evaluation and project recommendations conducted through the management systems should be reflected.
Assess capital investment and other measures necessary to preserve the existing transportation system and make the most efficient use of existing transportation facilities to relieve vehicular congestion and enhance the mobility of people and goods	ITS could represent one form of capital investment to preserve and make most efficient use of the existing transportation system.
Include design concept and scope descriptions of all existing and proposed transportation facilities in sufficient detail in nonattainment and maintenance areas to permit conformity determinations.	If ITS is to be used as an element of demonstrating transportation conformity, it must be specified in sufficient detail to be evaluated under those requirements.
Reflect a multimodal evaluation of the transportation, socioeconomic, environmental, and financial impact of the overall plan, including all major transportation investments	To the extent possible, the ITS elements should be included in the transportation, environmental, and financial evaluation. ITS is not generally relevant to socioeconomic factors.
Include a financial plan that demonstrates the consistency of proposed transportation investments with already available and projected sources of revenue.	ITS elements will need to be costed and balanced against total revenue. ITS will need to include operations and maintenance elements.

DEVELOPING ITS

The metropolitan transportation plan expresses a metropolitan area's long term

ELEMENTS OF THE TRANSPORTATION PLAN: THE BIG PICTURE

plan for transportation (at least 20 years). The plan must be financially constrained, requiring an assessment of all reasonably available sources of revenue. Costs must include operations and maintenance costs. There are three ways that ITS could be considered for inclusion in the plan:

- As an integrated element of other transportation strategies, without a significant identity of its own. This approach would view ITS technologies primarily as enhancements to other transportation strategies. For example, a real-time transit information system is an enhancement to schedule information systems already in place.

- As a distinct element, discussed in parallel with other transportation strategies such as lane additions, high occupancy vehicles, and transit. For example, there could be an alternative that specifically emphasizes ITS, in which ITS would be a major transportation theme (although not to the exclusion of other strategies). This might be appropriate for metropolitan areas that are well-developed, where possibilities for new highway capacity are limited.

- Both as a distinct element and integrated with other strategies. This approach seems most appropriate because some ITS strategies do not fit within the umbrella of other strategies (e.g. a freeway traffic control and information system tends to be viewed as an operational strategy in its own right). However, other ITS strategies can be viewed primarily as enhancements, such as the transit information example provided above.

The third approach is the more comprehensive of the three and accomplishes two objectives: it helps ITS to stand out as an important transportation feature in and of itself, and it allows ITS to distinguish itself as an important value-added feature of other transportation strategies. Because ITS is not currently included at all in many transportation plans, any of the above three approaches would tend to be an improvement. However, ITS components should be viewed as tools to help deal with a range of multimodal transportation problems, not merely as an effort to find technology applications for transportation. The planning process is to be problem-driven or needs-driven. The failure to show a clear connection between transportation problems and ITS solutions may be one of the reasons that ITS is not readily accepted in some political and public circles.

"The failure to show a clear connection between transportation problems and ITS solutions may be one of the reasons that ITS is not readily accepted in some political and public circles."

There are several examples of ITS being explicitly considered in a metropolitan transportation plan. In Southern California's 1994 Regional Mobility Element (RME) of the Regional Comprehensive Plan (the RME is the region's metropolitan transportation plan) by the Southern California Association of Governments (SCAG), ITS was explicitly included in several ways:

- ITS was one of several strategies in a group of Advanced Transportation Technologies (ATT). Others included zero emission vehicles, alternative fuel vehicles, telecommunications, and advanced shuttle transit (which would include ITS features).

- SCAG formed a task force composed of local elected officials and Caltrans to assist in preparing ATT options for inclusion in the RME.

- The use of ATT was identified as one of 10 criteria for inclusion of projects into the RME (a benefit to other projects, but not a required feature).

- Objectives and strategies for the group of advanced transportation technologies were formulated and stated.

- References were made to other ITS-related studies such as the Statewide Smart Corridor Study.

- An estimate of finances to be devoted to ATT strategies was specified ($15 billion to $29 billion over 20 years, but tied to revenue believed to be obtainable from a market incentives program).

Many agencies are only now grappling with the realities of long range planning under financial constraint. As indicated in Chapter 2, states and regions are being held more accountable to present a realistic picture to their constituents regarding the projects and programs that are buildable and operable with the resources available. In some cases, however, agencies are also creating a visionary element or a separate vision plan or needs plan. This is an important consideration for ITS. Many of those involved with ITS believe there needs to be a strong visionary element when crafting plans for ITS. Being visionary does not mean that one should strive for a "gold-plated" ITS plan, nor does it mean that the vision is detached from problems and needs. Rather, it recognizes that one needs to think beyond the limitations of financial constraint initially, to be comprehensive and inclusive of the opportunities ITS affords.

> *“ Many of those involved with ITS believe there needs to be a strong visionary element when crafting plans for ITS.”*

The case for a vision planning as input to the transportation planning process is compelling. The reasons for vision planning as related to ITS include:

- Documents strategies and approaches that were considered before the plan was financially constrained. Ideas may have been generated in the process of plan development that should be taken up as issues in a subsequent transportation plan. Visionary thinking should not need to be reinvented each transportation plan iteration.

- Provides a basis for addressing contingencies in the transportation plan. For example, a better approach to transportation may not have been useable in the financially constrained plan because of the uncertainty surrounding other related events, such as approval of a project that may have allowed a major financial savings to an ITS communications system.

- Provides a basis for anticipating problems beyond the typical 20-year horizon.

- Provides a foundation for legal or legislative work that may be needed to advance innovative transportation opportunities. For example, a visionary element may be highly desirable but cannot be achieved without a change in state law or local policy.

- The development of the ITS regional architecture (described in Chapter 5) needs to be inclusive of all ITS strategies that could occur, not just those that fit within the financially constrained transportation plan.

- If costs of implementation should be lower than expected or the amount of funding available higher than expected (e.g. if a major project is dropped from the plan), the vision plan can provide ready candidates for replacement.

It is appropriate for ITS to have a strong role in both the financially constrained transportation plan (a necessity) and in long range vision planning. Exhibit 3-3 shows the general relationship between them:

- State and regional policy provide the overall direction. Consideration of ITS must take place in the broader policy context.

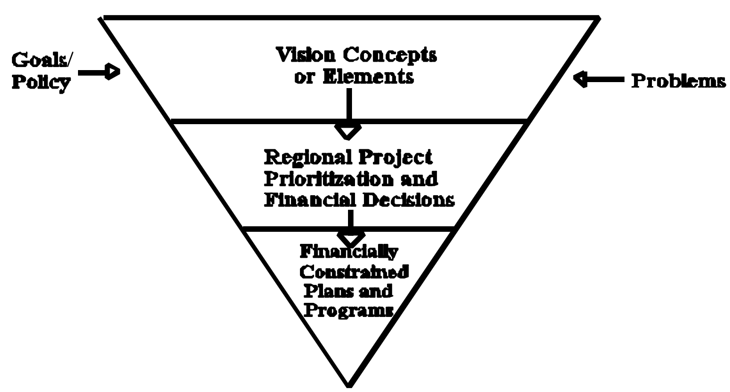


Exhibit 3-3.

Relationship Between Vision Concepts and Financially Constrained Plans and Programs in Metropolitan Planning

- A wide range of ITS strategies could be considered as part of the vision for ITS. However, the process of setting priorities and making decisions at the regional level narrows down the projects and programs to those that will fit within a financially constrained transportation plan.

- An ITS strategic assessment is a possible tool in creating the vision for ITS in a region. However, it is an option, not a requirement.

The level of formality in evaluating metropolitan transportation plan projects and programs varies widely among regions. In virtually all cases, the evaluation criteria are not so rigid as to limit the flexibility of decision-makers to include and exclude projects for political reasons or for balancing out projects modally and geographically. Thus, for ITS to be well-represented at the transportation plan level requires that ITS be elevated in its visibility among elected officials as well as agency staff. The remainder of this chapter illustrates how ITS can fit into specific elements of the transportation plan.

At the statewide level, plans tend to be more at the policy level. Financial constraint is not a requirement. However, financial constraint is a requirement of the statewide TIP.

> *"For ITS to be well-represented at the long range plan level requires that ITS be elevated in its visibility among elected officials as well as agency staff."*

ITS-RELATED GOALS, OBJECTIVES, AND POLICIES

Goals, objectives, and policies represent the underpinnings of plans and programs in transportation planning. They express the direction to be taken for providing transportation facilities and services in the future. Goals, objectives and policies are commonly drawn from the community vision for the future.

Examples of ITS-Related Policy Statements at the State Level

In an example at the state level, the statewide transportation plan for New York State, "The Next Generation. . . Transportation Choices for the 21st Century" contains a number of policy statements related to ITS. They are organized by chapter:

Transportation Infrastructure Chapter

- Test new technologies and, where feasible, replace or update parts of the existing transportation system.
- Incorporate new technologies into the operation and maintenance of the transportation system where cost-effective.

Mobility Chapter

- Expand the institutional framework necessary to provide a single electronic identification tag for use on all tolled highways, bridges and tunnels.
- Create the institutional framework in metropolitan areas necessary to carry out incident management programs.
- Provide Intelligent Transportation Systems in metropolitan areas.

- Provide electronic toll collection at tolled bridges, tunnels, and on the Thruway.
- Set up incident management programs in metropolitan regions.
- Reduce the number of highway lanes needed through operational and demand management improvements.

The State of Maryland Transportation Plan expresses a set of six vision statements, one of which deals with innovative technology:

> "Innovative technology will also play a central part in providing efficient and convenient services and increasing the information travelers have about the transportation system. Technological improvements, such as Intelligent Transportation Systems (ITS) will monitor traffic, identify problems, and alert drivers to alternatives through an extensive network of variable message signs and radio broadcasts. To assist transit users, an Automatic Vehicle Locator System (AVL) will enhance service, reliability, and customer service. "Universal" farecards will allow commuters to transfer to different transit modes without buying a new ticket. The Department will cooperate with local governments and businesses to develop telecommuting programs that allow commuters to eliminate, reduce, or shorten their trips."

In addition, the Maryland plan expresses five sets of goals: travel, economic development/growth management, environmental, intermodal, and financial. The goals that may have some relationship to ITS are listed in Exhibit 3-4. A similar set of goals, objectives or vision statements could be conceived at the metropolitan level.

ITS EMPHASIS RELATED TO CHARACTERISTICS OF A REGION

It is the responsibility of each state or metropolitan area to express its own vision for the future. However, a variety of characteristics of the state or region tend to shape these visions. A mature area may tend to express its transportation vision primarily to address the efficiency of the existing infrastructure rather than major infrastructure expansion. A growing area may have a different overall focus as they attempt to keep pace with growth.

> *The role of ITS needs to be shaped in light of these factors. There is no "one-size-fits-all" solution.*

There is no single approach to ITS. States and metropolitan areas vary significantly in terms of their social fabric, geographic characteristics, transportation and traffic characteristics, economies, and many other factors. The role of ITS needs to be shaped in light of these factors. There is no "one-size-fits-all" solution. Hence the need for ITS-related planning.

Exhibit 3-4. State of Maryland Transportation Plan Goals Related to ITS

TRAVEL GOAL

- Maintain a transportation system that accommodates both intrastate and interstate travel and commerce.
- Provide and maintain an efficient highway network for the movement of goods, interstate travel, and for trips not made by alternative modes.
- Provide a network of high occupancy vehicle lanes and busways with access to park and ride facilities.
- Enhance the safety, comfort, and convenience of existing transit services to encourage passenger growth.
- Manage travel demand by providing or supporting programs and services to encourage use of transit, vanpools, and carpools to reduce trips and the growth in vehicle miles traveled.
- Develop and implement Intelligent Transportation Systems (ITS) to create safer roads and better informed travelers through technologies such as congestion monitoring; automatic accident alert systems; on-board navigation; and weighing and inspection of commercial vehicles while in motion.

ENVIRONMENTAL GOAL

- Plan transportation improvements that maintain or improve air quality, consistent with requirements of the Clean Air Act Amendments of 1990.
- Undertake energy conservation within the Department and plan, design, and construct all transportation projects in a manner that promotes energy-efficient travel behavior.

INTERMODAL GOAL

- For freight, provide and maintain rapid and efficient access to transportation terminals, especially the Port of Baltimore, Baltimore-Washington International Airport, and rail and truck terminals.

Exhibit 3-5 lists a variety of characteristics of metropolitan areas and how these characteristics might influence the approach to ITS. The purpose of this exhibit is to illustrate possible influences on the direction of ITS. It is <u>not</u> prescriptive. There are situations in which one metropolitan area that has similar characteristics to another has an entirely different approach to ITS. In general, however, the factors and characteristics in Exhibit 3-5 may help point to ITS solutions, to integration with other strategies, or to an appropriate phasing of an ITS program. Agencies should consider how these factors relate to the ITS decisions they must make at the state or local level. Also, these emphases can be reflected in goals, objectives and policies in the transportation plan.

Exhibit 3-5. Characteristics of Metropolitan Areas and How They May Influence ITS Deployment

CHARACTERISTIC	CONSIDERATIONS FOR ITS DEPLOYMENT
Metro Area Size - Large	- Tends to have higher levels of congestion, with greater potential benefits from ITS. - Bus system will be larger and more complex operationally. Should result in greater benefit for transit management systems, such as AVL and automated dispatching. - Freeways typically operating closer to capacity for larger numbers of hours. - Impact of incidents will be greater under these conditions. Rapid clearance policies will be particularly important. - Navigation within and through the area will be more difficult for unfamiliar drivers. Traveler information needs to recognize the complexity and devise strategies for route diversion Information system needs to be kept simple for travelers to understand.
- Medium	- Congestion level will likely be lower, but still significant. A core set of ITS applications will still likely be warranted - Emphasis on ITS will be dependent on special characteristics of the region (e.g. tourism area, freight distribution area, etc.)
- Small	- ITS will likely be warranted for "niche" areas, relating to special characteristics of the area. - Benefits from widespread application will be reduced. - If mobility is primarily dependent on a single facility (i.e. a single freeway through the area) ITS programs will likely focus on the corridor through which that facility passes. - In some smaller areas, major generators may dominate (universities, tourist attractions, etc.) and these will likely be focal points of ITS as well.
Metro Area Growth Rate - Rapid	- Transportation infrastructure is likely expanding to keep up with growth. ITS should be planned in concert with other infrastructure to economize. - Potential additional funding exists from private sector as areas are developed.
- Low	- Opportunities for innovative financing may be more limited. - If existing communications infrastructure does not exist, wireless technologies may be more of a consideration, or leased communications lines as opposed to new dedicated communications lines.

CHARACTERISTIC	CONSIDERATIONS FOR ITS DEPLOYMENT
Right-of-way Availability - Ample	- Roadway infrastructure is expandable. Communications systems should be planned in close coordination with infrastructure planning. - There may be less incentive to deploy ITS immediately unless other financial constraints make infrastructure expansion unlikely in the near term. A regional philosophy against highway expansion may also argue more for an ITS approach.
Right-of-way Availability - Limited	- Limited options on roadway infrastructure expansion may increase potential for ITS deployment. - Creative solutions to communications may be required if communications corridors are restricted. - Limited right-of-way may mean that shoulders are being or will be used for travel lanes. The importance of incident management increases under these conditions. - Regions typically also look more toward transit and TDM under these conditions. This may provide an opportunity for transit-related ITS. - Incident access by emergency vehicles may be limited. Operational plans for gaining incident access should be a part of strategy development.
Existence of Parallel Routes - Numerous	- This is an ideal opportunity to showcase traveler information systems. Strong, competent operational support will be needed to deliver an effective traveler information system and maintain the public's confidence. - Opportunities may also exist for dynamic routing of transit vehicles.
- Limited	- Pre-trip traveler information will be more important than for areas that have ample parallel routes. - Incident management will take on a more important role, particularly incident response and clearance. - En-route traveler information will be less useful, but probably still important.
Topographic Features - Major rivers	- River crossings are typically a critical link to regional mobility. Additional surveillance is normally warranted to provide rapid response to emergency conditions. - Shoulder access on bridges is usually limited. Incident response plans need to be in place, and could include automated features such as lane control. - Traveler information needs to be focused at specific points where travelers will make decisions on which bridge to use. It is difficult to use information once committed to a specific river crossing. - Special features may exist on some bridges, such as tolls or HOV strategies. ITS should be designed to support these other features.

CHARACTERISTIC	CONSIDERATIONS FOR ITS DEPLOYMENT
- Mountains or hilly terrain	- Mountains and hills may limit the availability of parallel routes. Incident response and clearance will need to be emphasized. - Additional surveillance may be warranted for mountain passes or other areas where mobility is dependent on a single facility. Safety warning and environmental sensing may increase in importance.
- Lakes and smaller rivers	- The roadway system may be fragmented or discontinuous, due to these natural barriers. Traveler information strategies will need to be supported with alternate route plans that make sense for both familiar and unfamiliar drivers.
Special Generators - Tourist areas	- Tourist areas have many unfamiliar drivers. Traveler information systems are often appropriate, and can be tied to the specific needs of the tourists. - Opportunities may exist in conjunction with tourist operators to fund ITS applications. - ITS should be tied in with any special transportation modes serving the area, but most access will likely be by auto.
- Airports	- Traveler information systems should be oriented to specific needs of airport travelers: parking, weather delays, specific traffic management needs, etc. - ITS applications can focus on major gateways to the airport. - Electronic collection of parking fees is an ideal application to increase efficiency.
- Stadiums, convention centers, event centers	- ITS can focus on major entry and exit points. - Opportunities to automate certain traffic management features should be examined, particularly demand-responsive traffic signal operations. These types of applications typically perform better when integrated into facility planning. - Traveler information can focus primarily on parking. - Funding opportunities for ITS exist by integrating them with other information needs such as event dates.
- Universities and colleges	- Much of the traveler information emphasis can focus on visitors for sporting events, graduations, orientation, etc. It could also be important for areas with commuter-related congestion. - ITS applications may exist in parking management, both for information and access control/payment. - ITS may be planned in conjunction with security features to improve cost effectiveness. - Universities typically are well served by transit. Efficiency may be increased through electronic fare collection and transit information systems.

CHARACTERISTIC	CONSIDERATIONS FOR ITS DEPLOYMENT
Weather - Snow/ice areas	- Commercial radio provides substantial coverage on days when snow/ice impacts transportation. ITS may enhance this coverage through surveillance technologies.
- Areas of frequent rain, fog, and dust	- Automated speed advisory systems could help in reducing accidents during these time periods. Normally, these will need to be targeted on specific locations that have historically been problems.
Transit Orientation - Extensive rail system	- Bus routing will normally be oriented to support the rail system. Major ITS emphasis for this area will be fleet management, transit information, and transfer efficiency.
- Extensive or emerging HOV network	- Many opportunities exist for ITS to support the HOV system. Examples include: automated gate control, ramp metering bypass and traveler information (e.g. at park-and-ride lots). - ITS applications to enhance ridesharing should be strongly considered.
- Major bus system, no HOV or rail	- Capture rates for transit will likely be lower than rail-based system. Bus system must run as on-time and efficiently as possible to maximize capture rate. Fleet management and electronic fare collection will enhance service. - Transit agencies should work with traffic departments to determine feasibility of bus pre-emption and other ways of reducing transit vehicle delays through signalized street networks. - Express bus may be cost-effective for larger metropolitan areas. Attention given to incident management may need to be higher for express bus routes, to maximize person carrying capacity and travel time mobility.
Presence of Toll Facilities - Extensive toll network	- Potential for electronic toll collection is obvious. Economies of scale will allow substantial penetration of transponders into the motoring public. - Congestion pricing strategies may be implementable through ITS. However, the major problems will be political viability.
- Emerging toll network or spot facilities	- Electronic toll collection will still be an appropriate consideration. - ITS could work in conjunction with incentive strategies, such as priority treatments for carpools, etc.
Commercial/ Employment Base - Heavy manufacturing and distribution	-Truck traffic volumes will be high. Electronic credentialing will improve efficiency of movement into and through the area. - Substantial opportunities exist for ITS near intermodal terminals. Information systems can be designed to support the goods movement industry.
- Major business park/office employment	- ITS should be designed to support transit and TDM strategies that would reduce or manage demand into these commuting areas.

ITS-RELATED STAKEHOLDER INVOLVEMENT

Effective applications of ITS cross modal and jurisdictional boundaries. This elevates the importance of broad stakeholder involvement, including parties that have not traditionally been at the planning table. Examples may include: communications system providers (to assist in defining cost-effective communications linkages), operations engineers (to provide a reality check to the feasibility and cost of planned systems) and a mix of state and local agencies (to coordinate traffic and transit movements between state and local systems). Many of these agencies do not commonly participate in transportation plan development. However mechanisms can be found (such as ITS strategic assessments or MPO subcommittees) to solicit their involvement.

DEFINING PROBLEMS AND CAUSES

A transportation plan has as its foundation an understanding of the problems it is trying to address. It is important to think beyond the surface-level problem to the underlying cause(s) so that the potential solutions can be better tailored to each situation. In many cases, this level of analysis cannot be conducted at the metropolitan transportation plan level. The problem/solution paradigm is easier to address at the corridor/subarea level. The results of corridor/subarea studies and other special studies can then be brought into consideration at the metropolitan plan level. However, a comprehensive identification of problems and needs of the plan level is desirable.

ISTEA places substantial emphasis on the management of travel demand and operational efficiency, not just on building new capacity. The transportation plan is intended to reflect this philosophy. Ideally, all those participating in the development of the plan should have a view consistent with this philosophy. Inevitably, however, members will have modal biases or are expected to serve as advocates for certain positions or types of improvements. This is one of the ways that the planning process has pursued the implementation of multiple modes and strategies; it is, in large part, an advocacy process. Even though a problem-solving and needs-based orientation is desirable, the advocacy process is unlikely to disappear.

> *"One of the reasons ITS has been overlooked as a serious element of many transportation plans is that there has not been a clear assignment of responsibility for ITS at that level."*

One of the reasons ITS may be overlooked as a serious element of many transportation plans is that there has not been a clear assignment of responsibility for ITS at that level. While this has not been a problem where there has been substantial dedicated funding for ITS, a lack of advocacy in the transportation planning process in the future may result in ITS being overlooked. Advocating ITS does not mean an unyielding insistence on ITS as the premier strategy for an area. It does mean that ITS is brought in as a consideration during all appropriate phases of the planning process, including developing the plan. Following is a list of activities that may be appropriate in advancing the consideration of ITS within the context of the transportation plan:

- Ensure that ITS is a consideration as a major transportation strategy, where appropriate.

- Ensure that ITS is a consideration as an enhancement to other strategies.
- Provide information to staff and MPO board members on available technologies, including examples from other areas.
- Provide information on the costs and potential benefits of ITS
- Write an ITS section for the transportation plan.
- Write an ITS-related article for the regional planning newsletter
- Provide ideas for the funding of ITS.
- Provide information that would allow for ITS projects to be considered in the prioritization and financial analysis activities of the transportation plan.
- Draw appropriate players together to coordinate ITS planning and implementation.

In a number of areas, ITS subcommittees have been formed under the transportation advisory committee (usually composed of agency technical staff), to provide input and guidance in the area of ITS. For example, in the Orlando Urban Area Metropolitan Planning Organization Committee/Subcommittee structure chart (Exhibit 3-6), there are currently three committees that report directly to the MPO board on a monthly basis, the Bicycle Advisory Committee, the Transportation Technical Committee, and the Citizens Advisory Committee. Seven subcommittees report to the TTC, one of which is the Intelligent Transportation System subcommittee. The membership of the ITS subcommittee (12 members) includes:

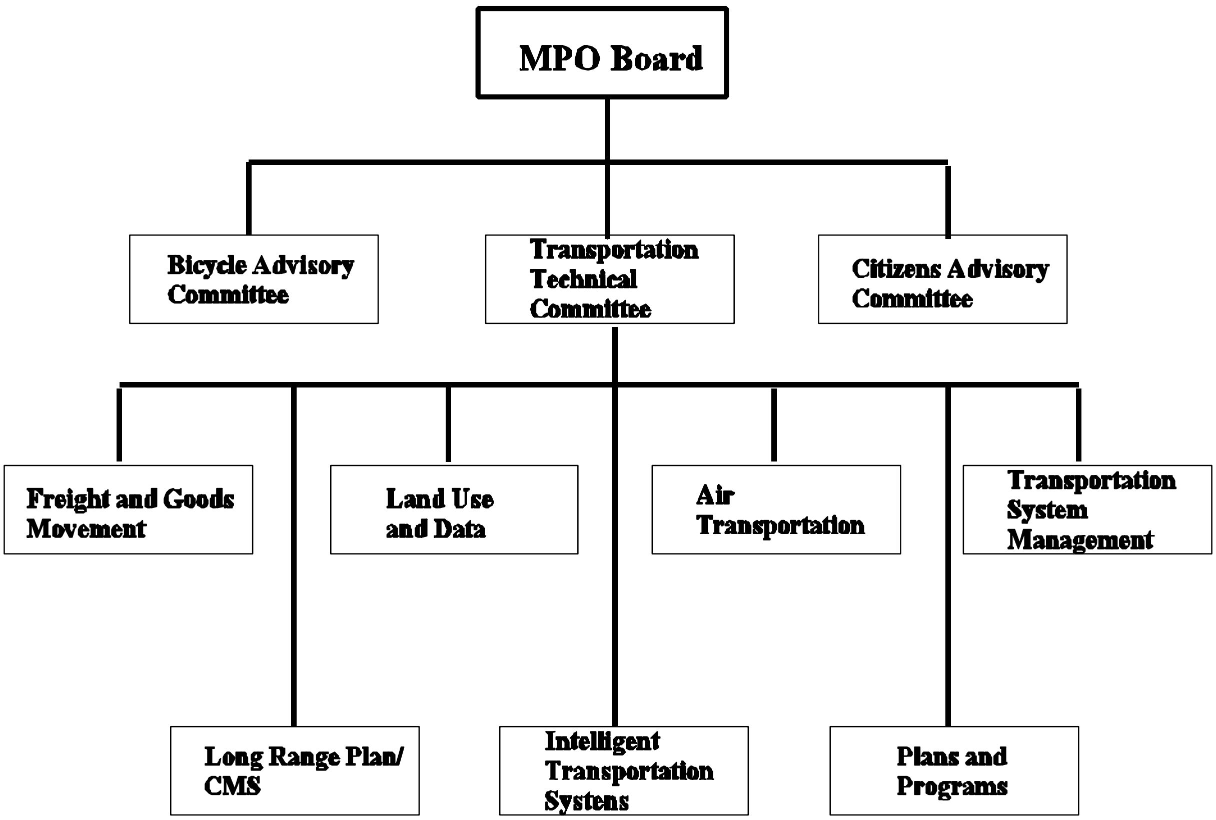
- Selected city representatives
- Three counties
- State DOT
- Transit provider
- Expressway (toll) authority
- Airport authority

The ITS subcommittee deals with ITS issues that flow through the MPO, including input to the transportation plan. The subcommittee is also overseeing the development of the region's ITS strategic assessment (ITS Early Deployment Project). Additional stakeholders are being brought in through this process.

The selection of a chairperson for the ITS subcommittee is a critical decision. This individual will frequently become the spokesperson for ITS priorities, expressing the options available and their potential benefits. In effect, this individual may become the "ITS champion" (on a regional basis) that is often needed to see projects through the planning phase to final implementation. Often, the right choice will be apparent from prior activities. Important characteristics include such things as: having a regional view, knowledge of the ITS subject area, articulate, respected by peers and elected officials, and time available to emphasize ITS.

The importance of convincing top MPO management (e.g. executive directors and board members) of the value of ITS cannot be overstated. The Metro-Dade MPO (Florida) incorporated $85 million in ITS improvements into their 1995 Long Range Plan Update. Staff attributes this to having a director who has been involved with ITS and county commissioners who appreciate the ability of ITS to maximize current transportation operations. This agency built off the development of I-95 corridor work that is nearing completion.

Exhibit 3-6. Example MPO Leadership Structure, with ITS Representation (Source: Orlando, Florida MPO)



DEFINING AND EVALUATING ITS ELEMENTS IN THE TRANSPORTATION PLAN

Defining ITS Elements

A metropolitan transportation plan is based on regional transportation needs and an evaluation of the effectiveness of possible transportation projects and programs in meeting those needs. Transportation projects and programs are typically evaluated in one of two ways:

- Through a top-down examination of alternatives
- Through a bottom up submission of projects and evaluation using a criteria-based analysis

A third approach involves the inclusion of projects through political power, an approach that is more difficult under ISTEA, but still very much alive in most states and metropolitan areas. In most metropolitan areas, combination of all three approaches is used. The two technically-oriented approaches are described below.

Examination of Alternatives

Transportation plans are often developed through examining a set of alternatives. Typically, alternatives revolve around major themes. Examples would include a transit emphasis alternative, an HOV emphasis alternative, or a highway capacity emphasis alternative. The transportation plan could also incorporate an ITS emphasis alternative. Typically, these alternatives are developed as broad program packages, and individual projects are often not examined individually within those packages (although information could be forwarded through other studies, such as major investment studies, or in the case of ITS, through an ITS strategic deployment plan). This can provide more flexibility for political input in the inclusion of individual projects.

> *"Little experience exists anywhere in the U.S. with respect to evaluating ITS benefits through the long range plan."*

Expressing ITS-emphasis as one of several alternatives would require that ITS be evaluated at the same level of detail as major highway and transit alternatives. Another option is to view ITS strategies as enhancements to other alternatives and to evaluate them as an integrated element of the others. In either case, the evaluation of ITS in the same framework as other strategies (such as in a travel demand model) is quite difficult. Little experience exists anywhere in the U.S. with respect to evaluating ITS benefits through the transportation plan. A subsequent section presents a commentary on the analytical evaluation of selected ITS strategies within the framework of the transportation plan.

Criteria-Based Analysis

Another systematic approach to developing and evaluating projects for the transportation plan is based on the examination of individual projects against a set of criteria. The criteria could vary in type and number. They would likely resemble the type of criteria used for the development of the Transportation Improvement Program (TIP - see discussion at the end of this chapter). Because of the number of projects being considered, they would likely be more qualitative than quantitative. Projects for consideration in the transportation plan would generally be submitted by state and local agencies, transit agencies, or other project "sponsors." Sources from which potential transportation plan projects could be drawn include:

- Projects in the existing transportation plan
- Major Investment Studies
- Other corridor and subarea studies
- ITS Strategic Assessments
- Local or subregional transportation plans
- Other individually conceived projects

In some cases, the application of the criteria could be supported by data from the studies in which the projects were generated. In other cases, no specific data on the project may be available. Where no data are available from existing studies, information can sometimes be obtained from research studies or other generalized information on particular project types. In the case of ITS, information on demonstrated ITS benefits provided in Chapter 2 can be used as support for the application of certain criteria.

In a criteria-based approach, ITS needs to be examined across the same criteria to which other types of projects would be subject. One of the considerations brought in by ITS is to make the criteria sensitive to the types of non-traditional benefits introduced by ITS. For example, in addition to criteria such as delay reduction and safety improvement (which are addressed by many of the ITS strategies), criteria such as operational efficiency or management efficiency would be areas where ITS would tend to show a significant contribution.

EVALUATING ITS STRATEGIES IN THE TRANSPORTATION PLAN

Analytical tools that can adequately examine the benefits of ITS strategies are still in the formative stages. Chapter 6 provides an extended discussion of the evaluation of ITS strategies using tools that are typically available to the transportation planning and engineering community. The basic approach taken in this Handbook is to provide insights into how the most reasonable estimates of ITS benefits can be derived for specific applications using <u>existing, available tools</u> and <u>without an inordinate investment in evaluation</u>. It is recognized that agency budgets for studies and evaluation are limited. It is important to understand that reasonable estimates of benefit can often be obtained without a large, costly undertaking. As more sophisticated tools are introduced, more refined answers can be obtained. But even if more sophisticated tools are available, many agencies will either not have the expertise to use them, or their use will not be possible within the time and cost constraints of the agencies conducting the studies.

There are three generic approaches to ITS evaluation that are currently available: sketch planning analysis, travel demand modeling, and traffic simulation. Exhibit 3-7 indicates that the travel demand modeling and sketch planning approaches are appropriate for consideration within the context of the transportation plan. However, if a regional transportation conformity analysis is required, ITS effects will normally need to be incorporated into the travel demand model, because the air quality models use the travel demand model's outputs. Thus, the ideal approach for evaluation associated with the transportation plan is to account for as many of the ITS effects as possible into the travel demand model.

Exhibit 3-7. Applicable Analysis Tools for Evaluating ITS Strategies in the Transportation Plan (highlighted row)

	Travel Demand Model	Traffic Simulation	Sketch Planning	Emissions Inventory Models	CO Hot Spot Models
Transportation Plan	U		U	U	
Plan and TIP Conformity	U			U	
ITS Strategic Assessment	U		U	U	
Corridor/Subarea Study	U	U	U	U	U
Isolated location		U	U		U

Chapter 6 and Appendix E discuss the use of travel demand models for evaluating selected ITS strategies. These procedures are included in a separate chapter, because travel demand modeling may be used for ITS strategy evaluation in other contexts as well (e.g. within a corridor study). It is recognized that travel demand models are not as sophisticated in treating even the more traditional strategies as many planners would like. Procedures for evaluating ITS within travel demand models are included to provide agencies with at least some guidance, while recognizing the limitations of the tools. Where a region has a more sophisticated approach, they are encouraged to use it.

> *"Procedures for evaluating ITS within travel demand models are included to provide agencies with at least some guidance, while recognizing the limitations of the tools."*

THE TRANSPORTATION PLAN, TRANSPORTATION CONFORMITY, AND ITS

One of the major elements of the planning process in metropolitan areas that are nonattainment or maintenance for transportation-related pollutants is that the transportation plan and TIP must conform to the State Implementation Plan (SIP), pursuant to the Clean Air Act Amendments (CAAA) of 1990. One element of the conformity test is that the emissions forecast to occur be within the emissions "budget" of the State Implementation Plan for air quality.

Regional emissions estimates are obtained by conducting an analysis of the outputs of the regional travel demand model (primarily speed and volume) in conjunction with emission rates. There are two possible levels to treat ITS within this framework:

C If an agency intends to derive an air quality benefit from ITS strategies and to use that benefit in passing the conformity test, a defensible methodology needs to be used to generate those estimates. Whether the above procedures, or alternate procedures, will be sufficiently defensible needs to be discussed with the appropriate authorities. Even if an agency does not intend to use ITS strategies in passing the conformity test, analysis of certain projects may be requested to identify their effects on the results. The analysis for conformity purposes may be more rigorous than air quality analyses for merely estimating benefits, as conformity analysis is a legally required function and tends to be scrutinized fairly carefully.

- Air quality analysis may be desired for other reasons, such as gauging the overall benefit of the ITS program. The analysis requirements for such a purpose may be more flexible, and possibly can be more reliant on sketch planning techniques.

PROJECT PRIORITIZATION

As indicated earlier, metropolitan transportation plans must now be financially constrained. The inclusion of all desired ITS projects in the plan may not be possible, just as the inclusion of all other desired projects is not normally possible. Although there may be an ultimate vision of the metropolitan ITS program, there should also be a sense of priorities to guide the development of the ITS elements of the financially-constrained plan, based on the overall ITS vision. Some of the factors to be considered in developing these priorities include:

- Urgency of need for the project.
- Project effectiveness versus cost.
- Sequencing as related to other non-ITS projects (e.g. Is it best if ITS implementation is done at the same time as a construction project?).
- Type of funds available and their applicability to ITS.

If the long term ITS vision is contained in an ITS strategic assessment, or similar document, separate from the transportation plan, a sense of priority should be available from that document. If not, additional information may need to be obtained or those parties with a vested interest in ITS may need to be involved in further discussion.

Financial constraint for ITS within the metropolitan transportation plan can also be considered through either geographic or functional approaches:

- Geographic: Selection of specific corridors, subareas, transit routes, etc. for implementation. Prioritization information would need to be arranged geographically. An example of this is California's Statewide Smart Corridor study. Potential smart corridors were evaluated and ranked in priority order (without reference to financial constraint), as illustrated in Exhibit 3-8. The highest priority Smart Corridors can be considered in the financially constrained transportation plans of the various regions.

Exhibit 3-8. Example Statewide ITS Project Prioritization (Source: Smart Corridor Statewide Study, Caltrans)

District/ Corridor	Description	B/C Ratio	Score	Initial Cost ($ Millions)	10 Year O&M Cost ($ Millions)	Annual Benefits ($ Millions)
7	38 - I-405 between I-110 and I-10	9.94	714	$17.4	$18.6	$35.8
4	15 - Route 980/580 between Route 8880 and Powell St.	9.01	783	11.4	10.8	20.0
7	4 - I-5 between I-605 and Route 60	8.96	766	11.7	12.3	21.6
7	2b - Route 60 between I-5 and I-605	8.45	621	11.0	13.8	21.0
7	40 - I-405 between I-10 and US 101	8.27	721	8.8	11.4	16.7
12	8 - I-405 from Route 22 to I-5	8.06	668	20.7	21.7	34.1
4	1 - Route 101 between Blossom Hill Rd. and Route 237	7.75	606	23.6	20.3	34.1
4	17 - Route 80 between Powell St. and San Pablo Ave.	7.67	567	8.9	8.4	13.2
11	2 - I-8 from I-5 to I-15	5.71	711	19.3	17.6	21.1
7	20 - Route 91 between I-10 and Beach Blvd.	5.04	614	16.7	17.0	17.0
4	22 - Route 280 between Magdalena Ave. and Route 101	4.33	502	24.6	19.3	19.0
7	27 - I-110 between I-405 and I-10	3.93	731	14.3	14.9	11.4
7	22 - US 101 between Valley Circle Blvd. and I-5	3.88	784	19.0	18.9	14.7
8	10 - Route 91 between Maple St. and La Sierra Ave.	3.62	562	7.6	9.6	6.2
12	4 - Route 55 from I-405 to Route 91	3.41	600	12.7	13.4	8.9
7	1 - I-5, I-10, US 101 and I-110 (downtown L.A. ring)	3.03	610	19.4	15.4	10.6

- Functional: Selection of a more limited set of ITS applications (e.g. including incident response elements and network traffic control system elements while excluding ramp metering and freeway surveillance). Prioritization information would need to be arranged to enable the selection from among functions, sometimes involving decisions between modes.

Both geographic and functional prioritization can be difficult. If geographic, competition will be among cities or subregions. If functional, competition may exist among transportation agencies. In many cases, however, the recognition of a project and placement on a list, along with continuing pursuit of additional funds, may make it easier for an agency to accept the failure of a project to make the financially constrained list. The speaks to the value of a vision plan for ITS in addition to a financially constrained plan.

There are a variety of ways of prioritizing projects, ranging from a heavy reliance on benefit/cost analysis, to weighted criteria. The determination of projects for the transportation plan has not been particularly systematic in the past. More work has been done by agencies on project selection criteria for the TIP. Many agencies tend to use a weighted criteria method for the TIP, and could apply that to the financially constrained transportation plan as well. One of the major questions concerning the transportation plan project selection is how the general criteria used for selecting among all the candidate projects will treat the unique features of ITS projects. The Baltimore MPO developed the following criteria and weights for use in selecting projects for the TIP. These could be typical of those in many metropolitan areas, where selection criteria are used:

- Preserves existing regional transportation system (15 points)
- Implements State Implementation Plan Transportation Control Measures (12)
- Facilitates alternative travel modes (12)
- Implements TSM strategies (10)
- Improves level of service (9)
- Provides new or improved capacity (8)
- Improves pedestrian/bicycle safety and access for transportation (8)
- Provides system continuity between logical points (7)
- Enhances environmental efforts (6)
- Preserves future right-of-way corridors (6)
- Permits timely advancement of transportation projects (5)
- Implements ISTEA transportation enhancement activities (2)

ITS relates well to many of the above criteria, particularly those with the higher point scores. To the extent possible, even weighted criteria should be supported by data. The data can be used to ensure that the relative points assigned are based on a reasonable base of knowledge.

If the prioritization is being conducted within the confines of ITS alone, the criteria can be more tailored to the unique characteristics of ITS. The following criteria were used in prioritizing potential smart corridors on a statewide basis in California and may be worthy of consideration in evaluating other major ITS projects:

- C Freeway capacity/congestion level (weighting factor 24)
- C Surface street capacity/congestion (21)
- C Local/regional commitment (13)
- C Land use compatibility (11)
- C Accident/incident history (9)
- C Environmental (7)
- C Number of jurisdictions (fewer means less complexity and higher rating (6)
- C Part of a larger system (4)
- C In-place control features (3)
- C Data availability (2)

This resulted in a prioritized set of smart corridors, which are now referenced in the Los Angeles region's transportation plan.

Estimating Transportation Plan Costs and Funding Mechanisms

A financially constrained transportation plan requires that cost estimates be provided for both one-time construction costs and for ongoing operations and maintenance costs. ITS can add significant costs in the areas of operations and maintenance and are therefore as important to plan's costing as construction costs.

The appendices of this handbook present data and methodology for developing planning-level costs for ITS. It does not present engineering-level cost data. The planning level costs are approximate and do not consider a number of variables that may influence the ultimate cost of implementation. In addition, technology is changing rapidly, and the costs incurred could also change significantly, in some cases providing cost reductions. Great care should be undertaken to understand the conditions in which costs are being estimated and how those costs may vary from the norm. Funding mechanisms are also treated in Chapter 5 and the appendices.

DOCUMENTATION OF ITS IN THE TRANSPORTATION PLAN

The approach to documentation of ITS in the transportation plan may vary depending on whether ITS is treated as a separate and distinct element or as an integrated element, as discussed in a previous section. If ITS is treated as a distinct element, a typical outline of an ITS section could include the following:

- C Overview of ITS
- C Role of ITS in regional transportation
- C Existing ITS Program
- C Proposed ITS Program
    - ITS Vision for the future
    - ITS Projects
    - Benefits and Costs
    - Funding
    - Implementation responsibility

The above information does not need to be extensive. In fact, portions of an ITS strategic assessment would likely be extracted and incorporated into the transportation plan. The section should concisely and clearly lay out the elements of the program and how it should be accomplished. The alternative approach is to incorporate ITS throughout various sections of the document. Arguably, this would be the more integrated approach, and could foster greater coordination with other modes of travel. However, there is no requirement for either approach, and each state or metropolitan area has choices for how to incorporate in transportation plan documentation.

FOLLOWTHROUGH FOR ITS ELEMENTS OF THE PLAN

In one sense, inclusion of an ITS project or program in the transportation plan is merely the beginning. Sustained follow-up is needed to see projects through to implementation. The following actions should be considered:

- Ensuring that long range plan ITS projects are forwarded to the transportation improvement program at the appropriate time.
- Ensuring that a subcommittee (such as an ITS subcommittee as discussed earlier), agency, or individual has responsibility for taking ITS projects through followup steps.
- Procuring funding.
- Continuing to provide information to elected officials and the public on ITS.

ITS IN THE TRANSPORTATION IMPROVEMENT PROGRAM

Like the metropolitan transportation plan, the metropolitan and statewide TIPs must be financially constrained. ITS projects included in the TIP could come from several sources:

- An action plan generated through the ITS Strategic Assessment or other mechanism.
- An action plan or set of projects generated through a corridor or subarea study (of which ITS is a part).
- A prioritization and project selection process conducted as part of TIP preparation.

All of the above activities need to be coordinated with the transportation plan.

As discussed earlier, agencies have typically developed a more thorough set of procedures for TIP prioritization than for transportation plan project prioritization. Prioritization criteria were discussed under the transportation plan.

Project descriptions for the TIP are usually more extensive than those associated with the transportation plan. The following information would typically be included for each TIP project:

- Sufficient descriptive material (i.e. type of work, termini, length, etc.) to identify the project or phase.

- Estimated total cost.

- The amount of Federal funds proposed to be obligated during each program year.

- For the first year, the proposed category of Federal funds and source(s) of non-Federal funds.

- For the second and third years, the likely category or possible categories of Federal funds and sources of non-Federal funds.

- Identification of the agencies responsible for carrying out the project.

Exhibit 3-9 shows an example of a description of an ITS project in a statewide TIP (STIP) in Maryland. Projects proposed in an area that is nonattainment or maintenance for transporation-related pollutants can only be included in the STIP if the projects are found to conform, or are from a metropolitan TIP that conforms, to the State Implementation Plan for air quality.

MD STATE HIGHWAY ADMINISTRATION - PRINCE GEORGE'S COUNTY - INTERSTATE CONSTRUCTION PROGRAM

PROJECT: US 50; John Hanson Highway

DESCRIPTION: Install advanced traffic management system along US 50 from I-95/I-495 (Capital Beltway) to MD 70. This equipment will include variable message signs, closed circuit television, pavement condition sensors, traffic detectors, fiber optics, traveler's advisory radio, median barrier gates and supplemental signing.

JUSTIFICATION: This segment of US 50 experiences congestion problems during morning and evening peak periods. Congestion also results from accidents and special events. This project will provide tools for managing congestion in this area.

ASSOCIATED IMPROVEMENTS:
US 50, west of I-95/I-495 to west of the Patuxent River Bridge
US 50, west of the Patuxent River Bridge to west of South Haven Rd.
US 50, Interchange at Columbia Park Road (D&E Program)
STATUS: Construction to begin during budget fiscal year.

FUNCTION:
State - Principal Art.
Federal - Interstate
STATE SYSTEM: Primary
DAILY TRAFFIC:
Current (1993): - 84,500
Projected (2015): 128,400

SIGNIFICANT CHANGE FROM FY 94-99 CIP:
Added to the Construction Program
Federal Funding by Year of Obligation

PHASE	FFY 95	FFY 96	FFY 97	FFY 98	FFY 99-00	FEDERAL CATEGORY
PP	0	0	0	0	0	-
PE	0	0	0	0	0	-
RW	0	0	0	0	0	-
CO	15,380	0	0	0	0	IS

Project Cash Flow
Potential Funding Sources: x Special x Federal _ General _ Other

Phase	Total Est. Cost	Expended Thru 1994	Current Year 1995	Budget Year 1996	1997	1998	1999	2000	Six Year Total	Bal. to complete
Planning	0	0	0	0	0	0	0	0	0	0
Engrg.	0	0	0	0	0	0	0	0	0	0
ROW	0	0	0	0	0	0	0	0	0	0
Constr.	15,380	0	0	9380	0	0	0	0	15,380	0
Total	15,380	0	0	9380	0	0	0	0	15,380	0
Inflated	15,995	0	0	9735	0	0	0	0	15,995	0

Exhibit 3-9. Example ITS Project Description in a Transportation Improvement Program (Source: Maryland State Highway Administration)

4. ITS CONNECTIONS TO CORRIDOR/SUBAREA STUDIES

As indicated in Chapter 2, corridor and subarea studies represent an important part of the planning process where more specific decisions are made on project design concept and scope. In almost all cases, there is substantial public and agency involvement, as projects typically can impact businesses, neighborhoods, and the environment. This is particularly true for major investments which may require preparation of a major investment study or Environmental Impact Statement. It is not the purpose of this chapter to provide a comprehensive review of the process of conducting corridor and subarea studies. Rather, the focus is on the treatment of ITS within the context of these studies. Major investment studies will be used as an example of a corridor/subarea study framework for purposes of discussion here. In many cases, ITS is either an afterthought in these types of projects or its role is not acknowledged. Inclusion of ITS as an integrated element of corridor/subarea studies opens up numerous opportunities, including:

- Substantial cost savings in ITS implementation.
- Potential cost savings in infrastructure if the appropriate ITS application can be designed as an alternative or companion to other improvements.
- A more effective overall project in improving mobility.
- A mechanism for monitoring and improving operations.

This does not necessarily mean that every corridor/subarea analysis will result in an ITS application. It does mean that ITS will have been considered in parallel, with the intent of integrating multiple modes and techniques into a cohesive transportation package.

OVERVIEW OF A CORRIDOR/SUB-AREA STUDY (with excerpts from the MIS Desk Reference, FTA and FHWA)

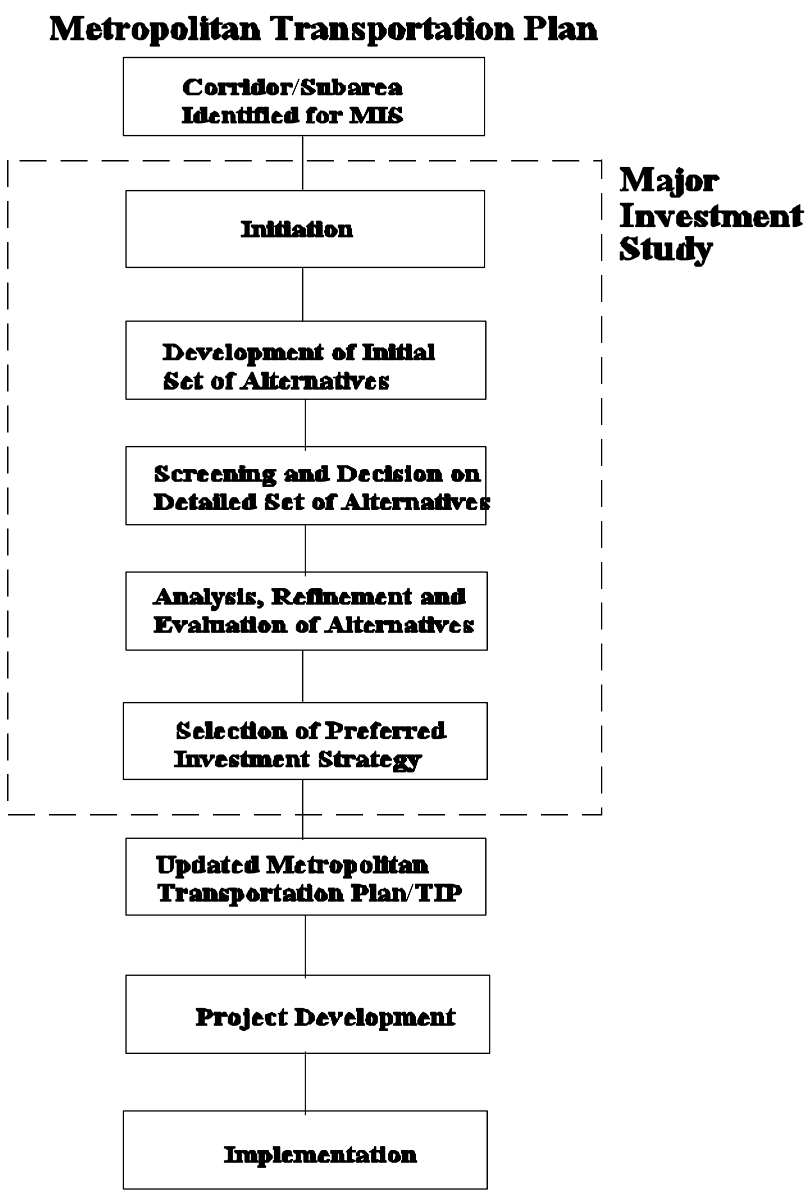
A typical process of conducting a major investment study is illustrated in Exhibit 4-1 (based on guidance provided by FTA and FHWA). Five generalized steps can be defined:

- Study initiation: Includes the development of the work plan, definition of problems and needs, and definition of goals and objectives. The work plan should indicate the consideration of a broad range of strategies. ITS strategies should be in the list to be considered.
- Development of initial set of alternatives. This would also include the definition of evaluation criteria by which the alternatives may be compared, and establishment of evaluation methodologies. Methods for evaluation of ITS or estimation of ITS benefits should be discussed.
- Screening and decision on detailed set of alternatives.
- Analysis, refinement, and evaluation of alternatives. ITS strategies may need to be defined in greater detail, just as major highway and transit

alternatives would need to be defined. They should be identified at a level that benefits and costs can be estimated.

! Selection of preferred investment strategy. ITS strategies may be recommended in conjunction with other major highway or transit improvements. In transportation management areas designated as nonattainment for ozone or carbon monoxide, Federal funds may not be programmed for a highway project that will result in a significant increase in carrying capacity for single occupant vehicles unless the project results from a congestion management system. Such projects must incorporate all reasonably available strategies, such as ITS, to manage the facility effectively.

Exhibit 4-1. Phases of a Major Investment Study and Relationship to the Planning Process (Source: MIS Desk Reference)



All of this technically-oriented information is then passed on to the decision making process, which involves a combination of both institutional and technical issues. Project costing is more definitive in the corridor/subarea context than when conducted for the metropolitan transportation plan, but costs are still at a planning level. Funding sources are also identified, including those that are used in competition with projects and programs in other geographic areas as well as funding that may be more site-specific (e.g., creating a special transportation district for the funding of a major element of the corridor plan).

The remainder of this chapter discusses the steps within the corridor/subarea planning process in the context of how an MIS document may be organized. Areas where ITS should be given consideration are highlighted. Chapter 6 provides more detailed information on the evaluation of ITS projects using the three types of evaluation tools discussed above.

STRUCTURE OF AN MIS DOCUMENT

Although the way in which MISs are performed is flexible, most MIS documents have similar, well-defined structures. The following represent a typical organization of a document and how ITS could be considered in each section:

! Purpose and Need: What problems does the preferred alternative address? Statements on ITS would be included to the extent that ITS addresses the defined problem(s).

! Alternatives Considered: Where included as an alternative or part of an alternative, significant ITS elements would be discussed as part of the description of alternatives. It is possible and perhaps likely that ITS would be included in some form as an element of all alternatives.

! Affected Environment: The physical and environmental background of the study area would be discussed. Existing and planned ITS deployments would be identified.

! Transportation Impacts: ITS alternatives or elements would be discussed in terms of their transportation impacts and benefits, along with the impacts and benefits of other features of the transportation alternatives.

! Environmental Analysis and Consequences: Contributions of ITS to the improvement of or impact on the environment would be documented along with the impacts of other elements of alternatives. The level of sophistication of the analysis and documentation would vary widely depending on the significance of the ITS elements and availability of analysis tools. If ITS elements were common among all alternatives, little analysis would likely be conducted.

! Cost and Financial Analysis: ITS implementation and operating costs would be estimated for inclusion in the overall costs.

! Comparative Benefits and Costs: ITS would be included in assessments of effectiveness, efficiency, equity, etc., as appropriate.

Other types of corridor or subarea studies would have similar report organizations. The remaining sections of this chapter discuss selected MIS topics and the relationship of ITS to those topics.

DEFINING PROBLEMS: PROJECT PURPOSE AND NEED

A corridor or subarea is the realm in which specific problems can be most easily identified. Specific problems are more difficult to identify at a regional level. However, a problem identification phase at the regional level may be one of the means of triggering an MIS or other corridor/subarea study.

A purpose and need statement in a MIS document is one of the most important chapters. It provides the foundation for explaining to the public and decision-makers why a project is necessary and how the preferred alternative addresses the problems. Failure to provide a convincing case of the need for the project is one of the more common reasons why projects involving Federal funds may not be approved or may be successfully litigated. Although a purpose and need statement may not be required for other types of studies, a clear statement of the problem remains as an important element.

> *"Failure to provide a convincing case of the need for the project is one of the more common reasons why projects involving Federal funds may not be approved or may be successfully litigated. "*

Problems can be classified in several broad categories. Most of the problems related to ITS fall into congestion, safety, or environmental categories. One helpful way to illustrate or summarize problems in a corridor or subarea context is to present a map graphic highlighting the problems. The problem areas can also be listed. A more generic list is provided in Exhibit 4-2. It is a list of problem areas (not necessarily all possible problems) developed as part of the National ITS Architecture. It illustrates how technology-based approaches relate to a variety of problem types and to traditional transportation solutions. Making the connection between ITS and the specific problems to be addressed is important in conveying what ITS can do. Citizens, businesses and elected officials tend to think in terms of "here is a problem, let's fix it." This structure directly addresses that line of reasoning.

It is important to remember within this structure that agencies must deal not only with problems that are recurring (e.g. congestion due to geometric deficiencies) but problems that are non-recurring. These are more difficult to illustrate on a graphic.

Exhibit 4-2. Relationship Between Problems, Conventional Approaches and Advanced Technology Approaches (Source: National ITS Architecture Implementation Strategy)

Problem	Possible Solutions	Conventional Approach	Advanced Systems Approach	Supporting Market Packages

Traffic Congestion	Increase roadway capacity (vehicular throughput)	C New roads C New lanes	C Advanced traffic control C Incident management C Electronic toll collection C Corridor management C Advanced vehicle systems (Reduce headway)	C Surface street control C Freeway control C Incident management system C Dynamic toll/parking fee management C Regional traffic control C Railroad operational coordination C Advanced vehicle longitudinal control C Automated highway system
	Increase passenger throughput	C HOV lanes C Car pooling C Fixed route transit	C Real-time ride matching C Integrate transit and feeder services C Flexible mode transit C Personalize public transit	C Dynamic ridesharing C Multi-modal coordination C Demand response transit operations
	Reduce demand	C Flex time programs	C Telecommuting C Other telesubstitutions C Transportation pricing	C Dynamic toll/parking fee management
Lack of mobility and accessibility	Provide user-friendly access to quality transportation services	C Expand fixed-route transit and paratransit service C Radio and TV traffic reports	C Multi-modal pre-trip and en-route traveler information services C Respond dynamically to changing demand C Personalized public transportation C Common, enhanced fare card	C Interactive traveler information C Demand response transit operations C Transit passenger and fare management
Disconnected transportation modes	Improve intermodality	C Inter-agency agreements	C Regional transportation management systems C Regional transportation information clearinghouse C Disseminate multi-mode information pre-trip and en-route	C Regional traffic control C Multimodal coordination C Interactive traveler information
Severe budgetary constraints	Use existing funding efficiently	C Existing funding authorization and selection processes	C Privatize market packages C Public-private partnerships C Barter right-of-way C Advanced maintenance strategies	C Transit maintenance
	Leverage new funding sources		C Increased emphasis on fee-for-use services	
Transportation following emergencies	Improve disaster response plans	C Review and improve existing emergency plans	C Establish emergency response center (ERC) C Inter-network ERC with law enforcement emergency units, traffic management, transit, ...	C Emergency response C Incident management system C Emergency routing

Traffic accidents, injuries, and fatalities	Improve safety	C Improve road- way geometry C Improve sight distance C Traffic signals, protected left hand turns at intersections C Grade separate crossings C Driver training C Sobriety check points C Lighten dark roads to improve visibility/better lighting C Reduce speed limits/post warnings in problem areas	C Partially and fully automated vehicle control systems C Intersection collision avoidance C Automated warning systems C Vehicle condition monitoring C Driver condition monitoring C Driver vision enhancement C Advanced grade crossing systems C Automated detection of adverse weather and road conditions, vehicle warning, and road crew notification C Automated emergency notification	C All advanced vehicle safety system market packages C Intersection collision avoidance C In-vehicle signing C Vehicle safety monitoring C Driver safety monitoring C Driver visibility improvement C Standard railroad grade crossing C Advanced railroad grade crossing C Network surveillance C Traffic information dissemination C In-vehicle signing C Mayday support

Sometimes pictures convey this meaning more effectively. For example, the Incident Management Study for the Louisville, Kentucky region placed photographs of major incidents and a summary of the newspaper report at the beginning of each chapter. This approach brought back to memory some of the major events that made the study necessary and personalized the statistical evaluation.

DEFINING RELEVANT ITS STRATEGIES

One of the main reasons for specifically defining recommended ITS strategies in a corridor/subarea study is to connect with one or more specific problems or opportunities. Exhibit 4-3 listed the association of ITS strategies (market packages) with transportation problems. It does not attempt to illustrate the full set of other potential solutions, nor does it necessarily cover all potential problems. Note that the strategies are identified by the user service with which they are associated.

It is also helpful to understand which strategies have application in a corridor. Some strategies, such as electronic fare collection or AVL systems, may only be practical when applied at the regional level. Bus pre-emption systems are much more a corridor-oriented strategy.

Potential ITS applications can be envisioned not only as a response to a specific problem, but an opportunity to improve efficiency, provide better service, or increase comfort and convenience. One example is with transit management systems such as automatic vehicle location (AVL) and associated dispatching capabilities. Although AVL may ultimately provide better service to transit patrons, one of the principal reasons for considering AVL is for internal operating efficiency. Electronic fare payment can be thought of similarly as a benefit both to the transit patron and to internal operations. Neither of these ITS strategies are easily connected with a specific problem of congestion or safety on a specific facility. However, they primarily present opportunities to make operation more efficient. In the process, they may directly affect the customer through improved schedule adherence and improvements in travel time and travel time reliability.

A typical corridor study involves addressing problems with a coordinated package of transportation strategies. ITS strategies may become a consideration in the following ways:

- May be the most cost-effective way of addressing a problem.

- May represent a mitigation of a problem that is not completely solved by the major investment or of a secondary problem that is created by the major investment.

- May represent a solution or partial solution to a problem that cannot be addressed in other ways (e.g. if lane additions are prohibitively expensive).

- May represent part of the traffic management strategy during construction of the major project. This is a frequent role for ITS.

Specific decisions on the appropriate ITS strategies to consider are part of the creative process of corridor/subarea analysis and evaluation. The chapter on ITS evaluation provides additional insights into how some of these decisions might be made.

EVALUATION CRITERIA

Many corridor/subarea studies are structured to use a set of criteria as the basis for making decisions on the most cost-effective program of improvements. These criteria normally include an extensive list of environmental criteria in addition to those involving congestion, safety, and other transportation benefits. The criteria are normally created through extensive multi-agency discussion and, in many cases, public involvement.

Exhibit 4-3 shows a list of criteria that was used for an MIS in the St. Louis area. ITS strategies are most likely to show benefit for those criteria related to delay and safety. Although some of the criteria may, on the surface, seem not to be relevant to ITS, it is important to note that the <u>absence</u> of impact may make ITS attractive as an alternative or enhancement to an alternative; in other words, the lack of negative impact can be a strength of ITS. Examples could include environmental factors such as biology, displacements, wetlands, etc.

> *"... the <u>absence</u> of impact may make ITS attractive as an alternative or enhancement to an alternative; in other words, the lack of negative impact can be a strength of ITS."*

AGENCY AND PUBLIC INVOLVEMENT

In a MIS, the transportation problem is often so significant and the need so great that ITS is not considered as a primary solution. Consequently, ITS will not normally be the focal point of public involvement in these situations. ITS also tends to be less controversial and less of an impact: it does not take property, it does not threaten endangered species, and does not impact wetlands. This means that the public concern (and subsequent public attention) will be less than with strategies that have less impact.

Interviews with agencies that have conducted ITS strategic assessments (i.e. early deployment planning studies) have, for the most part, indicated that the public provided little input, even when public involvement was attempted. This likely stems from the fact that ITS has relatively little direct impact outside the transportation right-of-way. However, some issues concerning ITS may surface, depending on the strategy. These questions must be addressed to minimize the chance of elimination or detrimental alteration of a planned ITS component.

Objections that have been known to surface, and suggested approaches to those issues, are listed in Exhibit 4-4. The fact that these questions can arise indicates areas where ITS-related public involvement may be needed. If a public involvement program is already in place as part of the corridor/subarea study, the ITS-related outreach can occur along with that program. ITS could capture added public support in cases where it eliminates the need for improvements that would have significant impact. New public involvement efforts should follow principles and practices for effective outreach programs such as those in the MIS training course sponsored by FTA and FHWA.

Exhibit 4-3. Sample Evaluation Criteria from a Major Investment Study (Source: St. Louis River Crossing MIS)

GENERAL CATEGORY	CRITERIA	MEASURE
Goals	Corridor specific Public opinion	Qualitative discussion (3-point ranking)
Service Effectiveness	Peak period delay	Minutes
	Peak period queue length	Miles
	Peak period speed	Miles per hour
	Traffic reduction	Average daily traffic Single occupancy vehicles
	Mode split	Percent LRT, bus, auto (2+ and SOV)
	Level of service	A through F
	Accident reduction	Number of accidents by type Total cost of reduction
Environmental Effectiveness	Criteria pollutants	
	Greenhouse gas emissions	
	Noise sensitivity	Number of areas unable to be mitigated
	Fuel consumption	Barrels of oil saved
Cost-effectiveness	Capital cost per mile	Dollars per mile
	O&M cost per mile	Dollars per mile
	Annualized total cost per trip-maker	Dollars per trip maker
	Total life-cycle cost	Millions of dollars

Land use	Land taken	Acres
	Displacements	Number of dwelling units taken
	Conformity with existing land use	Qualitative discussion
	Growth inducement	Qualitative discussion

Exhibit 4-4. Common Issues About ITS That Might Be Raised by the Public, and Possible Responses

Issue	Possible Response
Ramp metering more severely impacts cities closer in than those farther out	1. Ensure that ramp metering is approached as a system, with as much coverage as possible 2. Ramp metering also benefits individual ramps by making merging easier and safer
Ramp metering will increase my trip time by delaying me at on-ramps	1. Delays will only be several minutes at a maximum 2. The system will release additional vehicles if delays become excessive
CCTV system will be used to "spy" on areas other than the streets	Rules will be instituted to ensure that operators are not inappropriately using cameras. Police may use cameras in emergencies.
"Hackers" may be able to use variable message signs, or operators will misuse them	Sign operation is password protected. Any abuse will be dealt with quickly.
Alternate routing for incident management will take traffic through my area	Traffic will come through your area anyway. It will be better to have designed to accommodate it than to let it occur randomly.
I can never believe what the signs say	Agency must maintain quality of information as a top priority, or confidence in system will be difficult to maintain.
Traffic signal optimization through this street will reduce my business. We want to slow traffic down.	Work with businesses and elected officials to create a set of timing plans that maximizes throughput while controlling speed.
AVI toll information may be used to track my location	It is not mandatory that you use a toll tag The financial information will be treated as confidentially as other financial information such as phone bills, etc.

EVALUATING ITS STRATEGIES AND BENEFITS

A subarea or corridor study provides the opportunity to look at the benefits and tradeoffs of all strategies, including ITS, at a more detailed level than is possible in a transportation plan or strategic assessments. For major investments, a travel demand forecasting model will ordinarily be one of the principal means of evaluation. Unfortunately, travel demands models in their current form are limited in their ability to evaluate ITS strategies. Chapter 6 discusses adjustments that might be made in model parameters to generally reflect the possible impacts of selected ITS strategies. Analysts should understand that the basis for making these adjustments is limited and that they need to be careful not to imply more accuracy than actually exists. Nevertheless, there may be situations in which the inclusion of ITS effects into travel demand models may be appropriate.

A corridor or subarea study offers an opportunity to employ techniques that are more sensitive to the types of changes in traffic flow and travel behavior than would be possible in a regional framework (such as the evaluation of strategies in the metropolitan transportation plan). Traffic and transit simulation models have been developed to deal with some of these types of changes. Unfortunately, simulation models are far from being developed enough to evaluate all ITS strategies. Although some ITS strategies can be simulated directly, and others can be simulated indirectly (i.e. through changes in model parameters that approximate the strategy's effect), analysts will still need to resort to sketch planning techniques for some of the ITS strategy evaluations. In addition, the time and financial resources to employ simulation models may not exist, even for a major study. Therefore, it is important to recognize that sketch planning techniques may still be a critical element of the overall evaluation framework for corridor/subarea studies.

> *"A subarea or corridor study provides the opportunity to look at the benefits and tradeoffs of all strategies, including ITS, at a more detailed level than is possible in a transportation plan or ITS strategic assessment."*

Chapter 6 discusses the full range of analytical approaches to evaluating ITS in subarea and corridor studies. With respect to how ITS is evaluated, there is little difference in analysis techniques between approaches for MIS projects versus other types of corridor and subarea studies. The difference in technique lies in the amount of detail the analyst requires and the budget available for analysis. Descriptions of available simulation models are provided in Appendix D.

ITS COSTING

One of the advantages of a corridor/subarea evaluation is that ITS elements can often be specified more explicitly, enabling more accurate costing. In addition, the physical characteristics of the corridor are also documented in more detail, so that factors such as the specific approach to communications infrastructure can be taken into account.

Procedures for developing planning-level cost estimates for ITS are discussed further in Chapter 5. For a corridor-subarea study, the cost estimates need to be consistent with the cost estimates for other alternatives or combinations of alternatives being considered. Ideally, this should involve a life-cycle costing approach. A major source of cost data is the *Cost Analysis* document from the National ITS Architecture. In addition to capital costs, it provides information on anticipated service life and on maintenance and operating costs. The document is available on the National ITS Architecture CD-ROM, available through the Federal Highway Administration.

DEVELOPMENT OF RECOMMENDATIONS AND IMPLEMENTATION PLAN

The estimation of user benefits, fuel consumption, and air quality impacts represent one element of the evaluation of ITS in a corridor context. The full evaluation requires the assessment of ITS against a set of criteria (examples provided earlier), balanced against system costs. Some of this additional evaluation of benefits and impacts may be qualitative. Some may have to do with agency internal operating efficiency rather than a direct impact on the public. The ground rules for evaluation are normally established within each study. The role of ITS will be dependent on how ITS measures up to those groundrules.

The phasing of ITS elements is important in two respects:

- Phasing in coordination with other corridor improvement activities. Cost savings can sometimes be realized if ITS can be implemented along with certain infrastructure improvements (e.g. communications in conjunction with bridge structures, and roadway construction).

- Phasing in coordination with other ITS improvements. The corridor in which the study has been conducted may be part of a larger ITS program that must be phased. For example, a regional control center may need to be in place before corridor ITS improvements can be instituted.

- Early implementation of ITS can enhance operational efficiency, possibly delaying the need for more extensive improvements.

INTEGRATION OF FINDINGS INTO OTHER PLANS AND PROGRAMS

The results of corridor/subarea evaluations may be forwarded to other planning activities. The most important ways to reflect the outcome of corridor-level evaluation include:

- Projects should be forwarded for consideration to the transportation plan

- Short term projects should be forwarded to the TIP at the appropriate time

- Information should be provided to an ITS strategic assessment for consideration in the next update

- Local agencies should reflect their responsibilities in local government plans.

- Related state agencies (e.g., police) should reflect their commitments in their own planning documents

The inclusion of information developed at one level of planning activity into another is part of the essence of integrating ITS into the transportation planning process. It represents an ongoing, iterative process that will improve the likelihood of successful ITS implementation.

5. STATEWIDE OR REGIONAL ITS STRATEGIC ASSESSMENTS

OVERVIEW OF ITS STRATEGIC ASSESSMENTS

An ITS strategic assessment for a state, metropolitan area, or region is a study designed to address regional ITS issues, including the development of a framework for ITS deployment in the area or region. This framework is not only technological, but also incorporates the institutional and operational elements needed for ITS to function as an effective, integral part of the total transportation system. A strategic assessment will normally result in identification of a set of ITS elements to be implemented over time, aimed at achieving specific transportation goals and addressing needs. An ITS strategic assessment, is similar to the ITS Early Deployment Plans that have been conducted in a number of areas. The strategic assessment should:

- Define ITS user services and/or market packages designed to address specific objectives, meet customer needs, and address specific problems in a planning context on a regional basis;

- Define a regional framework, including a regional ITS architecture, that will serve as the guide for long term implementation of ITS in the area; and

- Establish a plan for funding, phasing, managing, integrating, and operating the ITS elements that are to be implemented within the region.

There are several important points to remember in conducting an ITS strategic assessment:

- **It is <u>not</u> a requirement.** It is merely a planning tool or approach to developing a framework for long term ITS implementation consistent with the area's transportation plan.

- **No single approach is the only "right" approach**. There are a variety of ways of going about a strategic assessment. The information in this chapter provides a number of ideas regarding how to structure an effective ITS strategic assessment.

- **A strategic assessment may need to be updated over time, as conditions change** (e.g. institutional structures, technology costs, etc.). Some regions may have already conducted an ITS strategic assessment (usually under the FHWA ITS Early Deployment Planning Program) and will be mainly concerned about updating their efforts periodically.

- **The name given to an ITS strategic assessment by state, regional, or local agencies is their own choice.** That term is used here because the process is strategic (i.e. deals with strategy, both long term and short term), and involves making an assessment of where agencies are and where they are going with respect to ITS. The term conveys the fact that there are a variety of ways to go about the process that ultimately results in a framework for utilizing ITS to meet transportation needs on a regional basis. Many agencies have called the results of such an effort an "ITS Strategic Plan" or ITS Deployment Plan." **Agencies may use any terms that are most appropriate for their region or state.**

In addition, an ITS strategic assessment is most effective when considered as an integral part of the metropolitan or statewide transportation planning processes. An ITS strategic assessment must both feed and be fed by other transportation planning and programming activities (e.g. transportation plan, corridor/subareas studies). ITS investments could be developed from a variety of other sources, but ultimately they will need to be integrated into a regional framework.

Why Conduct an ITS Strategic Assessment?

There are multiple reasons why a state or region may find it advantageous to conduct or update an an ITS strategic assessment :

- **Reason 1: Statewide or metropolitan transportation plans may not include the level of detail needed to ensure cost-effective implementation and coordinated operation of ITS.** A more focused effort is usually needed to work out the details of coordinated ITS strategies, communications, operations, and institutional responsibility. However, the assessment must be conducted within the overall guidance and framework of the metropolitan and/or statewide plans and integrated with other strategies.

- **Reason 2: ITS is a critical strategy for maximizing the efficient use of existing and future transportation facilities**. These benefits are often not realized without specific attention devoted to how ITS could be integrated with other transportation strategies.

- **Reason 3: An ITS strategic assessment can be the catalyst for promoting greater consideration of systems management and operations as a part of a region's overall approach to transportation needs.**

- **Reason 4: A strategic assessment provides a mechanism for bringing stakeholders together to address transportation operations and management issues of mutual concern.** It is particularly useful as a way to involve stakeholders who may not ordinarily be involved in other elements of the planning process. Example stakeholder groups that may be difficult to involve under other planning formats include: the communications industry, the trucking industry, certain emergency service agencies, traffic reporting services, and other information service providers.

- **Reason 5: The development of a regional ITS framework will help to coordinate long term implementation of ITS.** It will allow for individual components of ITS to work together and will result in more cost-effective approaches. It will allow for easier integration of systems over time.

- **Reason 6: With limited availability of funds, priority needs for specific ITS projects and programs can be defined within the framework of the area's or region's overall transportation program.** An ITS strategic assessment can be visionary, without financial constraint. However, investment priorities and funding decisions are ultimately made within the broader transportation planning process. Hence, an ITS regional framework will need to be developed that reflects the area's financial resources.

- **Reason 7: Documentation of ITS plans and programs serves as an ongoing communications mechanism for successful, coordinated implementation.**

Relationship of ITS Strategic Assessments to ITS Early Deployment Plans

An ITS strategic assessment may be similar to ITS early deployment planning studies that have been conducted (or are being conducted) in many areas of the U.S. The early deployment plans (EDPs) were intended by FHWA as a way to "jump-start" ITS deployment for a broad cross-section of states and metropolitan areas. Initial guidance provided for EDPs consisted of a series of steps designed to lead agencies through the process of developing an ITS architecture, including ITS projects and programs. The term "early" in EDP is somewhat of a misnomer, as the EDP was intended to cover both short-term and long-term time frames. It is a framework for implementation of ITS well into the future. The term "strategic assessment" is used to reflect the idea that the outcome will be a long term strategy and that there is flexibility in how such an evaluation takes place. **A strategic assessment results in a regional framework for deploying an integrated set of ITS elements over time, consistent with the National ITS Architecture.**

The material presented in the Handbook does not imply that an existing EDP needs to be redone. However, there may be good reasons to update an existing EDP because one or more of the following factors:

- The EDP may not have considered all modes or all geographic areas within a region.

- It may have focused more on a specific project than an overall regional plan or approach.

- The National ITS Architecture, which may not have been available at the time, can be used to guide development of a structured regional framework for ITS implementation.

- The institutional structure may have changed or new players may now be interested in ITS.

- The changing costs of ITS technology may have created new opportunities for ITS that were not available previously.

The discussion in Chapter 5 may apply to both new ITS strategic assessments or to updates of EDPs. The principles and examples are not intended as a "standard" but rather as ideas for how an ITS strategic assessment could proceed. The examples drawn from other areas are intended as illustrative of how agencies have addressed ITS issues in their region.

What Procedures Can Be Used for Initiating a Strategic Assessment?

There are several ways in which an ITS strategic assessment can be incorporated into the overall transportation planning process. It can be:

- Conducted as part of the development or update of metropolitan or statewide transportation plans. In the case of a metropolitan ITS strategic assessment, a committee or subcommittee of the MPO could be assigned the responsibility of oversight. In the case of a statewide assessment, the state DOT would ordinarily be responsible.

- Conducted as a regional-level study targeted toward problems ITS is designed to address (e.g. regional traveler information, regional incident problems, etc.). The results would be considered in the development or update of the transportation plan and TIP.

- Conducted as a corridor or sub-regional special study, the results of which would be considered in the development or update of the transportation plan and TIP.

An ITS strategic assessment for a state or region can be initiated by any agency involved in transportation planning or implementation. Because it is intended as a multi-modal, multi-institutional effort, an ITS strategic assessment should be conducted under an umbrella where significant multi-agency coordination can take place. A metropolitan planning organization or council of governments would be an appropriate lead agency. However, state or local transportation departments could serve as lead agencies as well. A statewide assessment would likely have a state DOT as the lead. In any case, it is essential that a broad cross-section of stakeholders be included for successful deployment and integration of ITS elements. These should include both transportation system users as well as those agencies responsible for providing the services, both public and private.

What Are The Products of an ITS Strategic Assessment?

Not every ITS strategic assessment will be the same. However, documentation will usually be prepared that identifies decisions, implementation approaches, and responsibilities. The documentation would typically include identification of the ITS elements to be implemented, the institutional arrangements to support implementation (including private sector involvement), and an action plan for funding and phasing. **The documentation should be designed so that appropriate sections can be easily incorporated into other planning and implementation documents.** Specific examples are provided later in this chapter.

LESSONS LEARNED FROM PRIOR ITS STRATEGIC ASSESSMENTS AND EDPs

A number of key lessons have been learned from ITS strategic assessment efforts conducted to date. Some of the more important lessons are described below.

Lesson 1 - A realistic assessment of funding is needed.

There is sentiment voiced by some of those who have been involved in ITS strategic assessments that the lack of adequate funding for construction, operation, and maintenance of ITS greatly limits the usefulness of the results. However, it could also be stated, that the strategic assessment is needed precisely because of the lack of and competition for funding. An important lesson for those conducting ITS strategic assessments is to ensure that funding for ITS is comprehensively considered since a constraint in resources is one of the greatest barriers to sustaining ITS over the long term. This requires not only a listing of where funds could possibly be obtained, but a funding strategy that charts a course toward the actual acquisition of those funds. This can be important information for consideration of the total transportation funding package for the metropolitan or statewide transportation plan.

Lesson 2 - An effort should be made in strategic assessments to craft the agreements and partnerships that will sustain ITS implementation.

Transportation history is replete with plans that looked good on paper but lacked commitment to implement them. One of the observations from some of those involved in ITS strategic assessments is that an effort should be made to secure commitments in writing as a direct outgrowth of the strategic assessment process. This provides a sense that elements of the plan are being seriously considered for implementation. It also provides a firm indication of the agencies that have the commitment to move forward. If it should be discovered through this process that agencies will not or cannot make those commitments, the results may need to be adjusted accordingly.

> *"Transportation history is replete with plans that looked good on paper but lacked commitment to implement them."*

Lesson 3 - Make appropriate connections with other elements of the planning process and with other planning documents.

As discussed in Chapter 2, ITS elements must find their way into transportation plans and programs and other planning and implementation documents. An effective way to foster incorporation is to design specific sections of the ITS strategic assessment to be consistent with and part of metropolitan and statewide transportation planning, local comprehensive planning, operations planning, and similar planning activities.

Lesson 4 - Improved interagency communication and coordination is the key to an effective ITS strategic assessment

Many agencies have indicated that an ITS strategic assessment effort or EDP has brought agencies and other stakeholders together that had not been accustomed to interacting on transportation issues. Not only did this level of communication result in a more comprehensive and complete approach to ITS implementation, but it also opened up continuing channels of communication that are bringing long term benefits to operations, management, and ongoing planning activities. The importance of involving elected officials was also noted. Elected officials will ultimately determine whether ITS elements are implemented.

Lesson 5 - ITS must be related to agency functions. The institutional concerns over ITS tend to be considerably more significant than the technological ones.

ITS applications can directly affect agency operation and staff needs. The ability to support these operations is a key consideration of ITS feasibility and acceptability. Traditional agency functions can also be threatened, and strong, tactful leadership is needed to preserve relationships and maintain momentum. The ITS regional framework must identify agency responsibilities and supporting functions to serve as the basis for agency agreements and commitments.

Lesson 6 - Do not commit to specific technologies too early in the process.

Technologies are changing rapidly. As a result, cost-effectiveness relationships may change that will, in turn, affect technology decisions. Legal impediments can sometimes be rectified that will make an option that is currently infeasible highly attractive. For this reason, an ITS strategic assessment can be expected to be somewhat fluid over time. However, the results of a strategic assessment can be more enduring if recommendations on technology are specified at a functional level, leaving room for technological change. ITS implementation actions that are to take place in the near term can be more specific on selection of technology.

> *"Discussions of potential projects are key to bringing stakeholders together and keeping them involved."*

Lesson 7 - An ITS strategic assessment should identify implementable projects, not merely concepts. Discussions of potential projects are key to bringing stakeholders together and keeping them involved.

The strategic assessment should include discussions on potential projects as soon as possible, but not before laying an adequate foundation. Consideration of actual projects is important, because agencies can better relate to a project that will directly affect them than they can to a broad concept. But keep in mind that, although discussions of broad concepts and architectures have less meaning to implementing agencies, these discussions are also needed for successful implementation and interoperability. The priority setting process can be developed through both the strategic assessment and through the priority-setting mechanisms of the transportation plan and TIP.

APPROACHES TO ITS STRATEGIC ASSESSMENTS

The conduct of a strategic assessment and development of the ITS regional framework should follow a structured process to ensure proper coverage of relevant transportation issues, permit key input from transportation stakeholders within the study area, and identify cost-effective and integrated solutions that can evolve as the state-of-the-art progresses. As indicated earlier, there is no single right approach to an ITS strategic assessment, nor does a strategic assessment need to delay the implementation of important ITS projects for which funding is available. However, as discussed in Chapter 2, there are several items an agency should consider to insure that projects being implemented prior to the completion of a regional framework for ITS will be cost-effective and compatible with other projects.

Exhibits 5-1 and 5-2 illustrate two example processes that could be used as a structure for an ITS strategic assessment. Exhibit 5-1 shows the process as similar to the ITS early deployment planning process that has been carried out in a number of metropolitan areas and states. Exhibit 5-2 shows a slightly different process that has a stronger relationship to the National ITS Architecture. These approaches serve as examples, not mandates. Each of these example approaches take place in two phases:

- **ITS concepts definition.** This phase examines the individual ITS elements that should be included in an area's regional framework for an integrated ITS. It includes visionary, top-down planning, as well as bottom-up identification of potential solutions that address specific problems.

- **ITS framework development and implementation plan.** This phase identifies how the individual ITS elements fit and work together. It results in a set of implementable ITS projects and programs, coordinated with non-ITS strategies and prescribes the institutional responsibilities for implementation.

> *". . . there is no single right approach to an ITS strategic assessment, nor does a strategic assessment need to delay the implementation of important ITS projects for which funding is available."*

Both methodologies recognize the lessons learned from prior ITS strategic assessment efforts. Some of the key points that the methodologies incorporate are:

- Inclusion of a visionary element early in the process that helps to define themes around which a regional ITS framework can be tailored to state or local conditions and to transportation or modal emphases that have already been established within the area through the transportation planning process.

- Addressing specific ITS strategies more directly, and earlier in the planning and project development process than previously done. This can be done in the framework of either ITS user services (strategies with a customer-orientation) or ITS market packages (strategies with an equipment orientation). Although addressing specific ITS strategies early in the process helps to engage the stakeholders at the level they

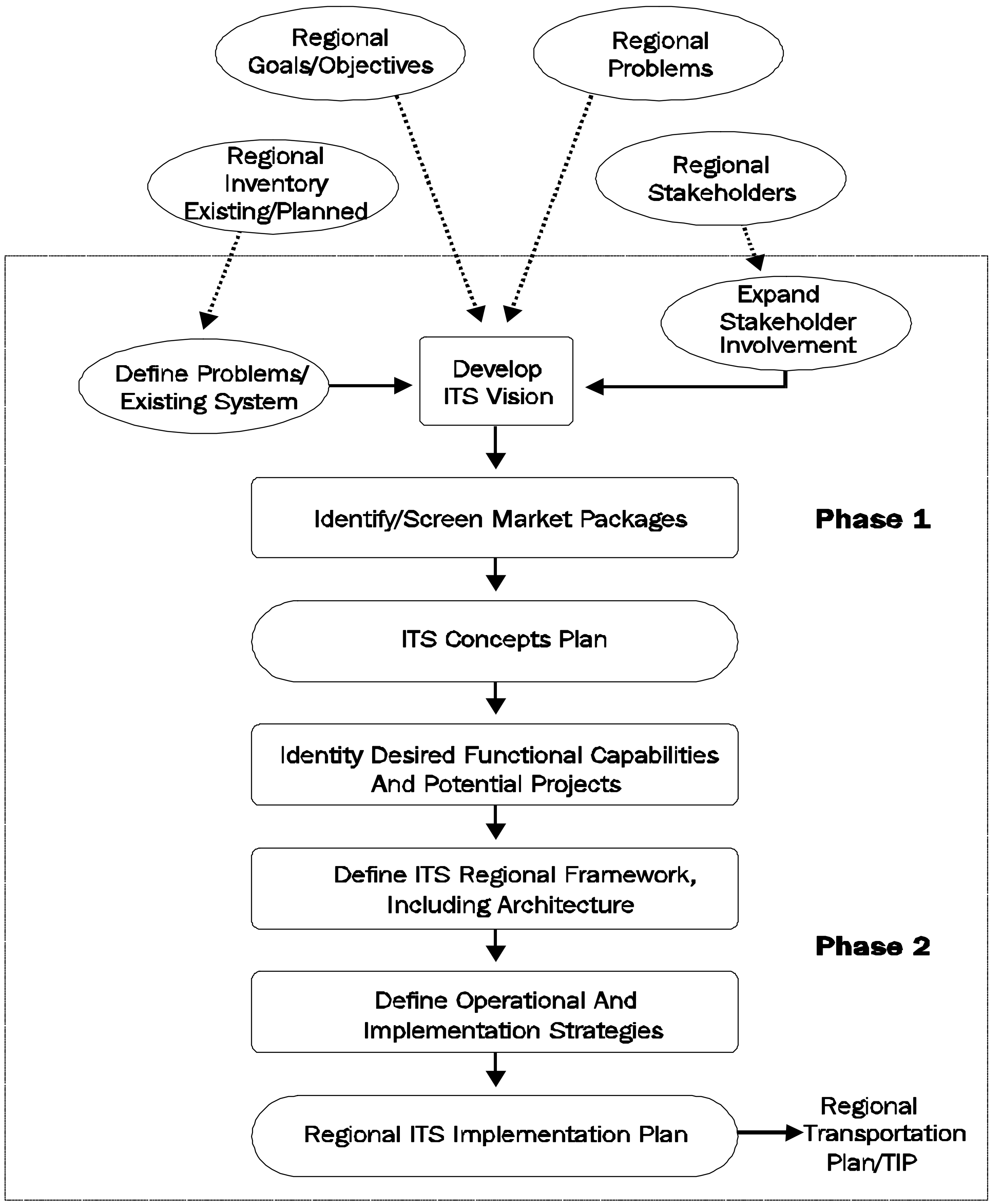


Exhibit 5-1. Example 1 of an ITS Strategic Assessment Process

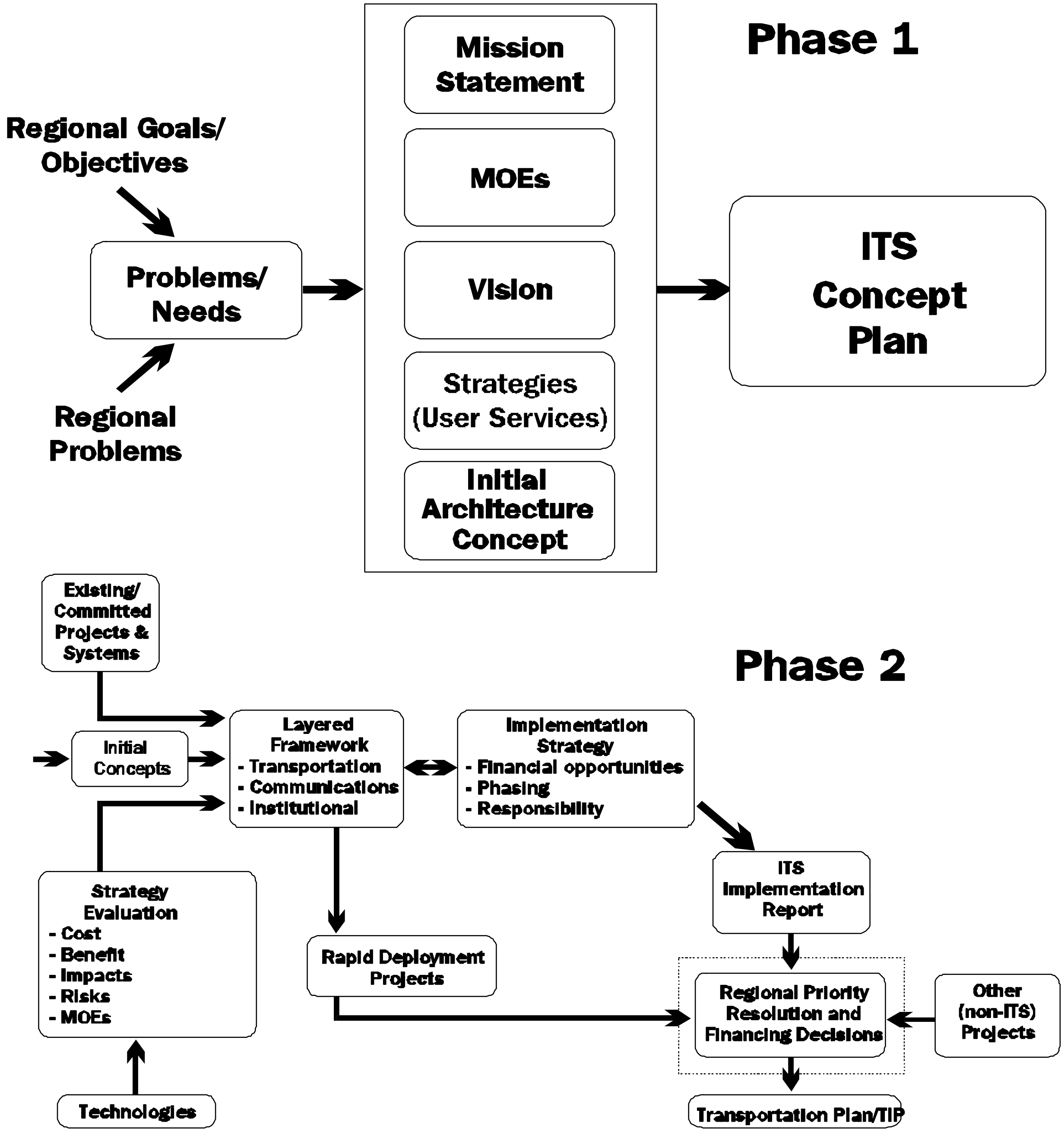


Exhibit 5-2. Example 2 of an ITS Strategic Assessment Process

are most interested in, the strategies need to be tied back to goals and objectives defined in the overall transportation planning process.

- Taking advantage of the National ITS Architecture to minimize the work effort and to streamline decisions made.

- Assuring that vital linkages are recognized early in the concept development stage and carried forward into the systems development and implementation stages.

- Preparing the strategic assessment in a way that supports the overall planning process, including the transportation plan and the TIP.

Statewide versus Metropolitan ITS Strategic Assessments: Most ITS strategic assessments will be conducted at the metropolitan level, because a large percentage of travel within a metropolitan area is self-contained. Even where a metropolitan area cross state boundaries, the ITS strategic assessment and regional framework should encompass the metropolitan area, at a minimum. ITS strategic assessments can also be considered for logical corridors between metropolitan areas, or even across multiple states. These would be appropriate where continuity of information or operation is of concern. Statewide plans are sometimes a particular consideration for state departments of transportation to develop a consistent and cost-effective approach to ITS. A statewide assessment may have less emphasis on development of a framework and more on funding, administration, and standards. The format for the development of ITS strategic assessments presented here can be adapted to any of these conditions.

A summary of the process under each of the two approaches is provided below. **The approaches are not intended as rigid steps, but describe the types of considerations that may go into a strategic assessment and their general order of performance.** A key to success is the inclusion of a broad cross-section of stakeholders. Both approaches can be thought of in two phases: a first phase to develop the overall ITS concepts, and a second phase to identify specific projects and develop a regional plan for implementation.

Example Approach 1

- Define Problems, Existing System, and Established Goals. This activity links the ITS effort directly to established, agreed-upon regional transportation goals. It also defines the problems that ITS should address and provides the existing ITS inventory base upon which the the ITS regional framework will be built.

- Expand Stakeholder Involvement. This activity sets the institutional stage for the remainder of the strategic assessment effort. Stakeholders will have already been identified within the overall planning process, but additional stakeholders with specific ITS interests will likely need to be included to facilitate consensus-building.

- Develop ITS Vision. This activity helps to define the "big picture" approach to ITS for the state or region. The ITS vision sets the direction of the planning effort by defining areas of emphasis, themes, and priorities. It answers the question: "How could ITS help meet the region's transportation needs?" It is an initial "top down" look at what ITS could do, which will be married with the "bottom up" process conducted in the following steps.

- Identify/Screen Market Packages. The market packages can be examined against the goals, objectives, and problems defined in a screening process. This screening is not location specific.

- Develop Regional ITS Concept Plan. This results in a set of potential market packages or user services that may be appropriate for specific locations within the state or region. Based on the goals and objectives, and on the screened market packages, more specific performance criteria are identified. These will be used to evaluate the potential value and feasibility of market packages.

- Identify Desired Functional Capabilities and Potential Projects. This expresses in more detail what the stakeholders desire the system to do. The information can be drawn from material developed as part of the National ITS Architecture work, enhanced with additional information that may have been developed locally. Initial projects are identified, covering specific geographic areas.

- Define Regional Framework, Including Architecture. This activity identifies the relationship between the local decisions on market packages and the National ITS Architecture. This step will also define technologies to be applied (for short-term or early-start projects only) within the framework of the regional architecture.

- Define Operational and Implementation Strategies. This activity defines approaches to deployment, operations, and maintenance, including institutional and financial arrangements. It is necessary to ensure that the entire plan will be operable and that agencies are prepared to take responsibility for operation and maintenance.

- ITS Implementation Plan. Some agencies may choose to call this their ITS Strategic Plan. This activity documents the ITS projects and programs to clearly define the action-oriented ITS implementation plan for inclusion in the next updates of the transportation plan, TIP, and other planning documents. It documents the plan for funding, phasing, operating, and maintaining the ITS applications.

Example Approach 2

- Define Regional Transportation Problems and Needs. This builds, if necessary, on problems, goals, and objectives already defined at the regional level through the overall planning process.

- Develop Mission Statement, Measures of Effectiveness, Vision for the Future, Applicable ITS Strategies, and Initial Architecture Concept. This series of parallel, iterative activities results in identification of potential ITS solutions to an area's transportation problems. The initial architecture concept is a "back of the envelope" architecture concept that could serve as the starting point for the full architecture development in phase 2. This activity could become part of phase 2, if desired.

- ITS Concept Plan. This represents the documentation of recommended ITS elements that will help address existing and future transportation needs identified through the overall planning process.

- Strategy (market package) Evaluation. This includes a quantitative and/or qualitative evaluation of the effectiveness of the ITS strategies to be considered in the ITS regional framework.

- Layered Framework (regional architecture development). This represents the core of the process for ensuring regional integration of ITS elements based on the National ITS Architecture. It takes place at three levels: transportation (the physical components), communications (how the physical components exchange information), and institutional (which agencies are responsible). This is an iterative process that may have multiple solutions.

- Implementation Plan. This activity defines approaches to deployment, operations, and maintenance, including institutional and financial arrangements. It is necessary to ensure that the entire plan will be operable and that agencies are prepared to take responsibility for operation and maintenance.

- ITS Implementation Report. This activity documents the ITS projects and programs to clearly define the action-oriented ITS implementation plan for inclusion in the next updates of the transportation plan, TIP, and other planning documents. It identifies agency responsibilities, implementation schedules, and funding needs. It documents the plan for operating and maintaining the ITS applications.

The remainder of Chapter 5 describes principles for conducting an ITS strategic assessment. It uses the structure of Approach 1, identified in Exhibit 5-1. However, most of the principles are equally applicable to Approach 2. The difference is primarily in the packaging and terminology. In either case, the process is not intended to be rigidly applied to all situations; rather, it should be adapted to meet local needs and resources. There is no single approach to all ITS strategic assessments. Exhibit 5-3 amplifies Exhibit 5-1 by listing products that could be generated by each element of an ITS strategic assessment.

Exhibit 5-3. Possible Products from an ITS Strategic Assessment

Organize the Study Effort and Expand Stakeholder Involvement
- Listing of stakeholders/users
- Work plan and schedule
- Outreach and consensus-building plan

Develop ITS Vision
- Listing of ITS-related themes or vision statements
- Initial assessment of funding situation and implementation barriers

Define Problems, Existing Goals, and Existing Systems
- Documentation of existing conditions
- Study area map
- Listing or graphic representation of problems and opportunities
- Listing of overall and ITS-related goals and objectives
- Documentation of existing ITS elements in study area

Identify/Screen Market Packages
- Mapping of market packages against problems and goals
- (Alternate) Environmental scan of ITS elements
- (Alternate) SWOT analysis of ITS elements
- Listing of market packages to be further evaluated

Develop ITS Concept Plan
- List of performance criteria
- Results of market package evaluations
- Documentation of recommended market packages by geographic area

Identify Desired Functional Capabilities and Potential Projects
- List of potential system requirements by market package
- Functional requirements definition by subsystem and technology area
- Initial listing of ITS projects that address problems and needs

Define Regional Framework, Including Architecture
- Charts and description of logical, organizational, and physical architectures
- Identification of institutional actions needed to support ITS implementation
- List of recommended technologies for near-term ITS program

Define Operational and Implementation Strategies
- Project definitions, integrated with other transportation projects, where appropriate
- Operations and management plans
- Potential sources of funds (implementation and operating), schedule, and agency responsibility by project
- Potential public private partnerships

Develop the ITS Implementation Plan
- Documentation of ITS regional framework, including an implementation plan
- TIP project summaries for near-term projects
- Potential material for integration into long range plan

EXPAND STAKEHOLDER INVOLVEMENT

Key Activities:

- Identifying stakeholders/users
- Establishing leadership structure
- Acquiring technical support, where needed
- Establishing a work plan and schedule
- Defining outreach activities and the consensus-building process

Key products:

- List of stakeholders/users
- Work plan and schedule
- Outreach and consensus-building plan

Laying the Foundation for Consensus: Defining the Stakeholders

A strategic assessment for an area or region will define the ITS elements to be deployed to meet the needs of the state, area or region. It is designed for all transportation system stakeholders/users, cutting across travel modes, jurisdictions, and the public and private sectors. The identification of all stakeholders/users in the area or region will be vital to addressing the issues and needs of all interested parties. A sample list of potential stakeholders/users is provided in Exhibit 5-4.

Exhibit 5-4. Potential ITS Stakeholders /Users

Motorists - Commuters - Tourists/visitors - Other travelers Transit Riders Bicyclists/Pedestrians Employers Private Industry - Communications industry - Vehicle industry - Electronics industry Private Towing/Recovery Business Fleet Operators (trucking companies, taxi companies, courier fleets, etc.) Traffic reporting services	Law Enforcement - State Police - Local Police State/local transportation departments. Transit Operators Metropolitan planning organizations Emergency Services - Fire/EMS - HAZMAT Activity center operators - Event centers - Major employers - Airport operators

The structure of the consensus-building process can help to create an environment in which consensus can be more easily and efficiently reached. Exhibit 5-5 is an example of one approach. It indicates project oversight by a steering committee, chaired by a knowledgeable individual from the agency with the lead responsibility for the ITS strategic assessment.

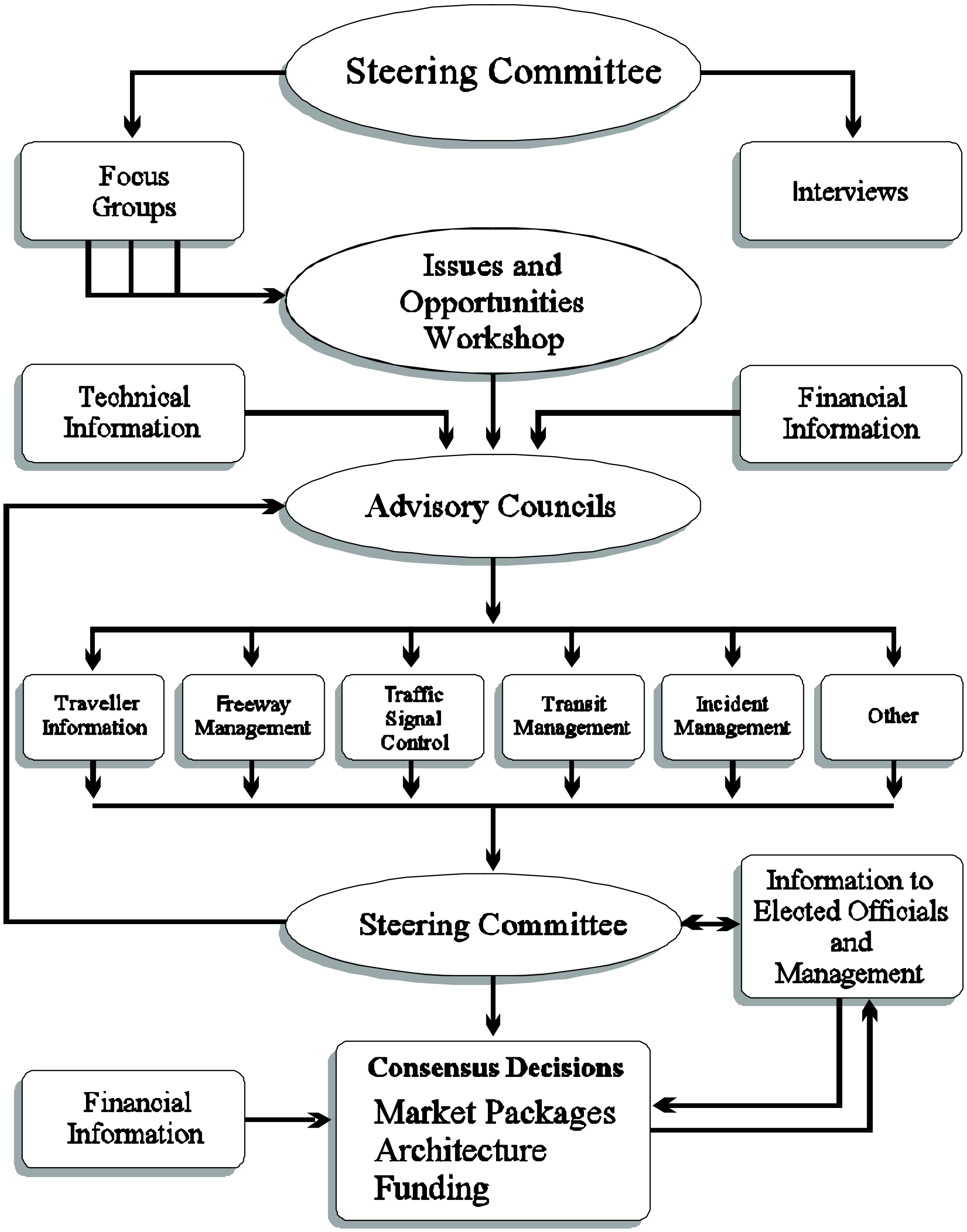


Exhibit 5-5. Example Flow of a Consensus-Building Process

Structuring Initial Outreach: Initial outreach would be conducted through a series of focus groups and individual interviews. The purpose of this initial fact-finding is to:

- Gauge interest of potential participants, including the private sector.
- Identify specific transportation problems and needs.
- Identify additional stakeholders who should be involved in helping develop the strategic assessment.

One useful mechanism for obtaining input is a set of focus group sessions. A focus group is a small group of individuals (typically between 10 and 20) representing various interests and viewpoints that can help identify issues, concerns and ideas associated with a particular topic, in this case ITS. A focus group is not the only way to gather this cross-section of feedback, but it is a relatively efficient and cost-effective method. The list of potential attendees is represented by the stakeholder/users list presented earlier.

Exhibit 5-6 shows a list of questions provided to individuals invited to an ITS focus group for the ITS Strategic Plan project in Riverside and San Bernardino Counties, California. Four meetings were held, spread geographically through the study area. The agenda items included a description of the study, purpose of the meeting, a video providing an overview of ITS, and a structured dialogue with participants regarding their thoughts on a number of questions that were posed. Responses were recorded on flip charts. Some of the principles involved in running a good focus group session include:

- Send out meaningful materials in advance. This should include a description of the study, information about ITS, and topics of discussion for the meeting. Individuals must have a general frame of reference to be able think about the subject in advance or even know whether they are the right ones to attend. In the Riverside/San Bernardino project, a brochure about the ITS project was mailed with the invitation.
- Provide a set of questions to stimulate their thought prior to the meeting.
- Provide a facilitator who can help the participants stay focused on the primary issues of concern. This individual needs to be able to keep things moving, while not discouraging participation and creativity.
- Provide a forum for everyone to express their views, not domination by a small number of individuals. This can be done by systematically rotating around the table in answering questions.

STRATEGIC PLAN FOR
INTELLIGENT TRANSPORTATION SYSTEMS (ITS)
FOR THE INLAND EMPIRE

Focus Group Workshop

June 18, 1996 10 A.M. to 1 P.M.
Kay Ceniceros Center
29995 Evans Road, Sun City, CA 92381

QUESTIONS

- What do you think are the most pressing transportation problems in the Inland Empire?
- What areas are you aware of already in the Inland Empire where technology has been used to improve transportation service?
- In what ways do you think new technology can be applied to commercial vehicle management and operations?
- In what ways do you think new technology can be applied to enhance local or regional traffic services, traffic systems management, and traffic systems operation?
- Which of these areas would seem most practical for the Inland Empire?
- What do you think are the most significant barriers to implementing advanced transportation technology in the Inland Empire?
- We will be forming advisory councils to address several key functional areas, including transit, traffic management/information, and freight movement, at a minimum. The advisory councils will meet approximately once every two months, as needed, to develop recommendations or suggestions for consideration by the project oversight committee. Would you like to be involved in an advisory council? If so, which one?
- Who else should be involved in this process?

Exhibit 5-6. Example List of Questions for ITS Focus Group Meeting

- Take good notes. Writing ideas on a flipchart and having them confirmed by the contributors is a good approach.

The focus groups could be followed by an "Issues and Opportunities Workshop," which would assemble the concerns, ideas, and possible approaches into a session that would begin to focus the direction of possible ITS applications in specific ways. The workshop would be oriented toward agency staff, elected officials, and potential participants from private industry. It would not be intended as a public meeting, although interested citizens could attend. An example agenda for the workshop is shown in Exhibit 5-7.

Exhibit 5-7. Sample Agenda for an ITS Issues and Opportunities Workshop

AGENDA
ISSUES AND OPPORTUNITIES WORKSHOP
ON INTELLIGENT TRANSPORTATION SYSTEMS

Welcome (elected official or high ranking transportation agency representative)

Objectives of the workshop

Description of the strategic assessment process

Overview of Intelligent Transportation Systems

- Status of ITS nationally (should include slides or video of actual applications)
- Status of ITS locally

Overview of ITS opportunities and technologies

- Highway
- Transit
- Travel demand management
- Other

Local issues and opportunities

- Issues identified in the focus groups and interviews
- Problems and concerns identified to date
- Open discussion or breakout groups

Where we go from here

Use of "Advisory Councils." Based on the outcome of the above activities, Advisory Councils (typically 3 to 8 participants each) could be established to tackle specific functional areas that emerge from the initial issues and opportunities list. Typical advisory councils could include: a Commercial Vehicle Council, a Transit/TDM Council, and a Traffic Engineering Council. The Advisory Councils would take on an issues-resolution focus, rather than meeting on a typical monthly basis. This has been shown to be a good mechanism for maintaining the interest of participants, particularly those representing the private sector, while making the process efficient. If the steering committee has adequate representation of these areas, an advisory council structure may not be needed, but the steering committee size should be limited. Existing committee structures can also be used. However, an effort should be made to obtain fresh ideas from the outside, particularly from groups such as private industry, who are important players but often not included in ongoing committee structures.

Interacting with Elected Officials. Exhibit 5-5 shows an iterative exchange (meetings and presentations) between the Advisory Councils and the Steering Committee. It also shows a two-way exchange between the Steering Committee and the elected officials (through meetings and presentations). Elected officials need both to be informed and to inject policy into the project to make it consistent with overall community goals. Financial information must be provided to the project both at an early stage and during the development of recommendations. This provides the project with a level of realism that will be needed to move it forward.

> *"Financial information must be provided to the project both at an early stage and during the development of recommendations."*

There are a number of actions staff can take to work with elected officials on ITS-related programs:

- Help them to identify ways ITS can be useful in addressing the problems presented to them by their constituents.

- Provide them with material showing them some of the proven benefits of ITS. Sample documents include:
  - *Traveling With Success*, Public Technology, Inc., for FHWA, October, 1995
  - *Intelligent Transportation Systems Action Guide*, by ITS America
  - Extractions from the exhibit in Chapter 2 of this Handbook on ITS benefits

- Videos of ITS implementations from around the country. Examples include:
  - *Smart Moves* by Public Technology, Inc. For U.S. DOT
  - U.S.DOT Operation Timesaver Video
  - Moving Transportation Into the Information Age, by ITS America
  - Videos from other comparable areas with successful systems

- Provide for visits to other operational ITS sites, where convenient

- Bring them to the ITS America annual meeting or other local or regional conferences

- Provide them with briefing papers prepared through the ITS strategic assessment or through other ITS planning activities

Elected officials have many issues to deal with other than transportation, many of which are more visible or sensitive. Providing visibility for ITS and encouraging substantive thought about ITS can be difficult in the midst of busy agendas. Separate half-day or full-day workshops have been used in some cases, but again, there is substantial competition for elected officials' time, and this opportunity may not occur. Some of the techniques for overcoming these problems include:

- ! Provide for occasional brief presentations at regularly scheduled council meetings, board meetings, etc. to educate elected officials.

- ! Provide separate material to newly-elected leaders who may have missed prior presentations. Individual meetings may be needed for education through the continuing turnover that occurs in the political arena. Elected officials should not have to ask "What is this project?" when they get to a council or board meeting. They should have already been briefed prior to that time.

- ! Give elected officials credit for successes. Press releases can be provided at project milestones, or press conferences can be arranged for the most significant events, such as initiation of operation of major ITS elements. Ask elected officials for their input and participation.

- ! Provide videos or reading material that elected officials can view or read at home.

- ! Stress the importance of coordinating ITS elements with other parts of the overall transportation program.

Remember that most elected officials have only a certain amount of time for absorbing information. The information given to them should be concise but informative.

Interacting with the Public and with Interest Groups. Certain groups may have an interest in following the progress of and providing input to the strategic assessment. This interest will vary widely from region to region. Some of the logical groups with which to interact could include: chambers of commerce, police/fire/EMS associations, trucking associations, real estate associations, environmental groups, or neighborhood associations. Typically, the venue for communicating project activity would need to be at regular meetings of these groups. Experience of some regions who have used special public meetings just for ITS has been that public turnout is usually limited. Brochures in public places or information accessible on a Web site are relatively cost-effective and allow for exchange of ideas with those who are interested.

DEVELOP ITS VISION/THEMES

Key Activities:

- C Identify key themes or ITS-related vision
- C Relate themes and vision to state/metro area goals

Key Products:

- C Listing of ITS themes or vision statements
- C Initial assessment of funding situation and implementation barriers

The development of a "vision" of ITS for the state or region can be viewed as an element of "top down" planning. Most of the other steps in the ITS strategic planning process reflect a “bottom up” approach, addressing specific problems and user needs. The top down and bottom up approaches are brought together in the development of an ITS concept plan at the conclusion of phase 1. The statement of a vision allows agencies to define the areas of ITS they would like to emphasize as they relate to broader community concerns. The development of a vision is closely associated with setting objectives. An example of an overall ITS vision statement is taken from the ITS Strategic Plan for the San Diego region:

“TO MAXIMIZE TRANSPORTATION PRODUCTIVITY,
MOBILITY, EFFICIENCY, AND SAFETY
WITH A REDUCTION IN ENERGY USE AND
NEGATIVE ENVIRONMENTAL IMPACTS
THROUGH THE USE OF COST-EFFECTIVE
ITS TECHNOLOGIES AND SYSTEMS”

This is supported through a number of vision statement elements (only an excerpt from each statement is included here):

- Technology test bed - The San Diego region will become a national test bed for the testing, integration, and introduction of ITS technologies.

- Travel information - Information regarding the transportation system within the San Diego region will be immediately available to users and operators through a variety of devices . . .

- Traffic management - The traffic on regionally significant routes will be monitored and controlled through an integrated system.

- Commercial operations - In coordination with national and regional initiatives, commercial carriers will be able to drive from one end of the San Diego-to-Los Angeles corridor to the other with minimal delays at toll booths or weigh and inspection stations.

- Toll collection - Where deployed, devices will allow users to electronically pay tolls, fares and fees with a minimum amount of delay.

- Travel demand - Users who wish to rideshare can immediately determine potential candidates and dynamically create carpools.

- Transit systems - Public transportation will be more attractive by faster service resulting from traffic signal priority and control of special ramps or lanes.

- Vehicle tracking - Systems will track commercial carriers, transit vehicles, emergency service vehicles, and hazardous material carriers to monitor the status of these vehicles.

- Emergency management - Devices will notify authorities of the need for dispatching emergency vehicles to the site of a collision or incident. Systems will coordinate the response . . .

- Navigation - Systems and on-board devices will assist drivers to plan and follow safe and efficient driving routes throughout the corridor.

- Air quality - Air quality will be improved through the increased efficiency and use of transportation systems including demand management strategies.

- Intermodal and multi-modal cooperation - All agencies and transportation providers will work together to promote and encourage safe and efficient operation of the transportation network.

As part of their ITS early deployment plan, the Nashville region determined that a major theme for their program would revolve around the tourism industry. This set the stage early in the project for bringing in the tourism industry to create a partnership for jointly supporting the industry and ITS initiatives that would benefit the community at large. Other areas with significant distribution industries have placed an emphasis on commercial vehicle operation initiatives. Areas with dense street networks and varied traffic patterns, event centers, etc. have focused on signal system upgrades.

The vision concept(s) or themes may be defined at an early meeting of the key transportation stakeholders, could be fed by interviews and focus group sessions, or could even serve as a "kickoff" to development of the ITS strategic assessment. In an open setting, the stakeholders may be asked their ideas of the future transportation system for the region. Possible questions for stimulating thinking on ITS-related visions or themes include:

- What functional areas do you think the ITS strategic assessment should emphasize (e.g. information, commercial vehicle operation, etc.)?

- How should those emphasis areas be focused geographically (e.g. which corridors or subareas)?

- What constituencies exist to support initiatives in these emphasis areas?

- Do these constituencies have the commitment and/or financial capacity to carry out the program and back its operation?

- What would you like to see the ITS program accomplish over the next 5 years? 10 years? 20 years?

Answering these questions serves both to provide direction to the program and as a reality check on the customer base (drivers, private sector, and public agencies, etc.) that will be needed to sustain an ITS program in certain areas over the long term. The lack of a clear customer base or support base will bring into question whether a particular element of the vision can be achieved. Elected officials can be brought into this discussion to render their sense of community priorities and how ITS may fit into those priorities. **The vision may be refined throughout the strategic assessment process** but will initially define focal points for the project. Sample themes or vision statements are listed in Exhibit 5-8, related to a sample set of state or regional goals.

DEFINE PROBLEMS AND EXISTING SYSTEM

Key Activities:

- Define transportation system to be examined
- Identify problems and opportunities
- Develop inventory of existing ITS infrastructure

Key Products:

- Documentation of existing conditions
- Study area map
- Listing or graphic representation of problems and opportunities
- Listing of ITS-related goals and objectives
- Documentation of existing ITS elements in the study area

Identification of Problems and Opportunities in the System

An ITS strategic assessment will be targeted to address a specific set of transportation problems and opportunities, defined as follows:

- **Problem**: Failure of the transportation system to perform up to its expected level. An example problem statement would be "congestion in the AM peak period on Facility X southbound", "accident rate exceeding Y on facility Z," or "lack of schedule adherence of transit service along route A". Problems could include both current and anticipated problems. Problems could also relate to agency functions, such as ineffective emergency communications equipment.

- **Opportunity**: These include actions that could make the transportation system or agency operations more efficient, but cannot necessarily be associated with a problem.

Exhibit 5-8. Sample ITS-Related Themes Correlated to Sample

State/Regional Goals

GOAL: PROMOTE ECONOMIC DEVELOPMENT
Themes C Strive for successful private sector business opportunities in the ITS program development C Strongly support economic development through ITS-related accessibility improvements C Support bi-national trade through border access improvements using ITS C Work with freight industry on ITS applications to improve their efficiency and competitiveness with other regions
PROMOTE TRANSPORTATION SYSTEM EFFICIENCY C Support single payment smart card systems for transportation and non-transportation applications C Encourage greater use of HOV facilities and transit systems C Work with telecommunications industry on multi-purpose projects that benefit transportation and local communications
SUPPORT LOCAL ENTERPRISES AND ASSETS C Develop world class airport access system C Support the tourism industry through automated traveler information systems
IMPROVE THE ENVIRONMENT C Support alternative fuel vehicles with ITS applications to improve air quality C Provide and operate transportation systems to minimize energy consumption and emissions
IMPROVE INFORMATION PROVIDED TO THE PUBLIC C Make traveler information readily available to all citizens C Distribute traveler information widely to home and work locations to assist in trip planning.
PROMOTE ALTERNATIVE MODES OF TRAVEL C Provide capability for real-time monitoring and dispatching of bus fleet
REDUCE CONGESTION C Limit recurring congestion on freeways to no more than one hour in the a.m. peak period and one hour in the p.m. period

To improve a transportation system, it is necessary to identify the problems associated with its current operation. Identification of problems and deficiencies may be obtained from numerous sources including: citizen complaints, past studies identifying major transportation issues, current or planned traffic studies and analyses, transit studies and analyses, specially-conducted focus group meetings, surveys of existing and potential transportation users, and field observations or reviews of the transportation facilities. A congestion management system, if one exists, should provide a regular tracking of system deficiencies. Examples of typical problems or deficiencies may include:

C Congested highway sections
C High accident locations
C Lack or absence of transit service

- Slow response to highway incidents
- Undependable transit service (headways, etc.)
- Air quality non-attainment
- Institutional barriers
- Inaccurate information or information that is not timely
- Commercial vehicle management problems
- Intermodal transfer inefficiencies

These problems should be identified on a location-specific basis, where applicable. An example graphic of traffic-related deficiencies or problems from the ITS strategic assessment in Portland, Oregon is displayed in Exhibit 5-9.

An assessment of potential or future deficiencies may also need to be conducted. Travel demand forecasting model results and projected traffic volumes (highway, transit, or pedestrian volumes) may be obtained and used to identify potential deficiencies under projected future programs and transportation scenarios. The study of future projected conditions will provide valuable input into defining the future needs of ITS programs and can be used to supplement the vision statement identified earlier

Inventory of Transportation Facilities and Features

In addition, a basic inventory of current and planned ITS facilities and features is needed. This inventory identifies the current conditions, available resources, and ITS elements already operational. It will define the "point of departure" for the ITS program developed through the strategic assessment.

The inventory may be comprised of sample items as shown in Exhibit 5-10. As indicated in the "lessons learned" section, however, most system elements and traffic-related problems are already known or documented in some fashion. Existing data should be used, to the extent possible.

Amplify Goals and Objectives

Goals and objectives establish the foundation that will be used as the basis for performance criteria. Performance criteria, in turn, are the basis for selecting user services and market packages. The broader transportation planning process will provide the policy underpinnings of all transportation initiatives in a state or region, including ITS. However, there may be reasons why this set would be incomplete. In addition, there are goals and objectives (which imply performance criteria) specific to ITS that should be included so that a complete evaluation of options can be conducted.

> “The broader transportation planning process will provide the policy underpinnings of all transportation initiatives in a state or region, including ITS”

Exhibit 5-9. Sample Maps of Existing and Future Congestion
(Source: Portland ITS Early Deployment Plan)

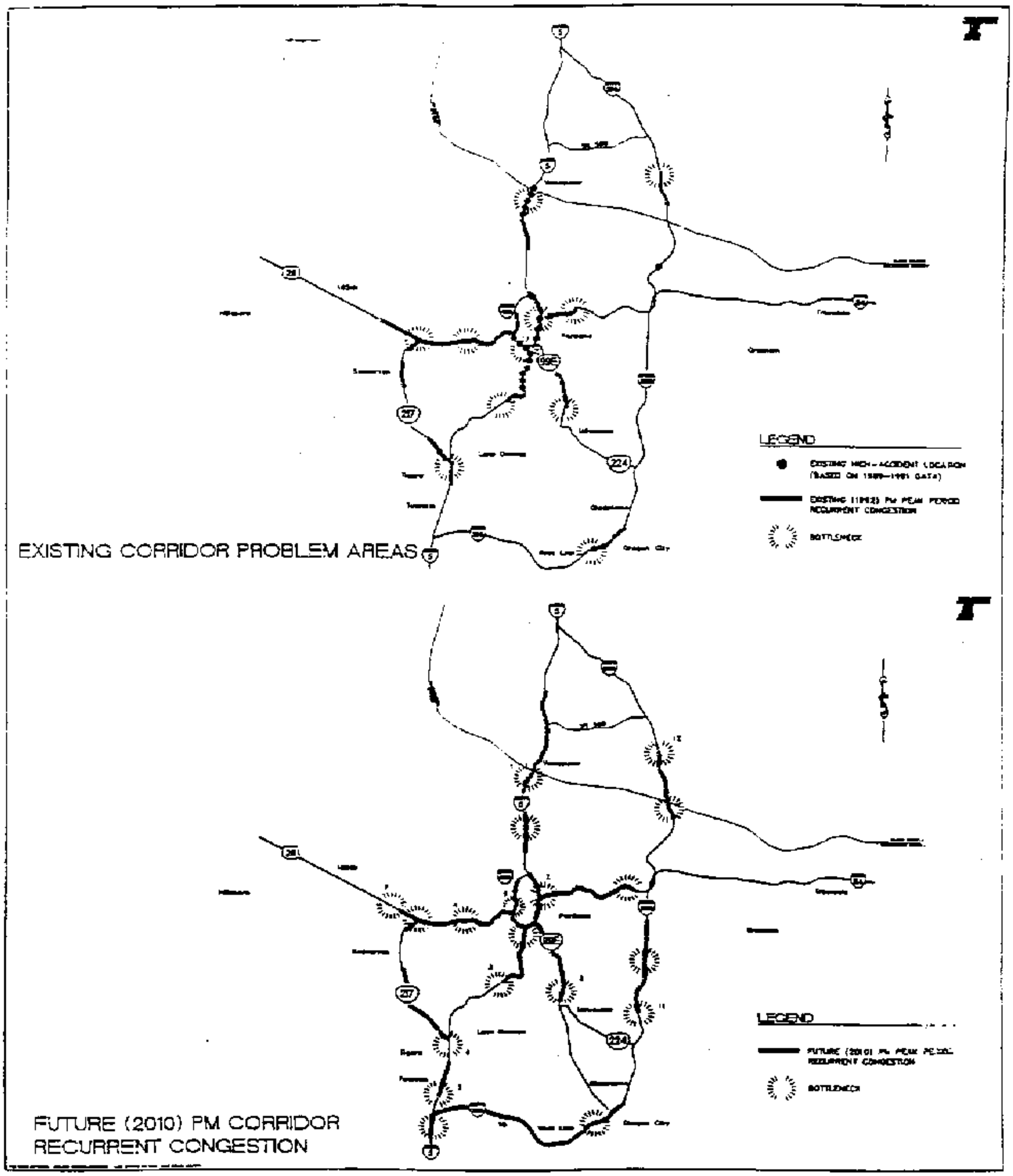


Exhibit 5-10. Sample List of Transportation System Inventory Items

Physical Components	o Miles of highway by facility type o Number of traffic signals by jurisdiction o Transit routes/stops o Number of buses and how equipped o Transportation Management Centers o Transit Transfer Centers o Variable Message Sign Locations and Features o Ramp Meters o Traffic Monitoring Stations o CCTV Locations and Features o Highway Advisory Radio Locations and Coverage o HOV Lanes o GIS capabilities o Signal Systems o Transit Priority System o AVI/AVL Systems o Weigh-in-Motion System o Emergency Vehicle Pre-emption System o Incident Management Programs o Electronic Toll Stations o Commercial Vehicle Dispatch System o Emergency Call Boxes
Organizational Components	o Transportation Operating Agencies - Jurisdiction and Function o Political Jurisdictions o Major Traffic Generators o Operational policies o Funding Sources

It is not intended that the amplification of goals and objectives be an extended or elaborate process. The goals and objectives should consist of statements that address the deficiencies or problems identified earlier, as well as characteristics that agencies expect the implemented market packages to possess (minimize cost, etc.). Some of these goals and objectives may be related to an opportunity or a theme, as described earlier. A sample set of goals is displayed in Exhibit 5-11.

Exhibit 5-11. Sample ITS-Related Goals and Objectives

Goal 1. Increase efficiency (person-carrying capacity) of the transportation system Objectives: C Minimize travel demand for commute trips. C Encourage mode shifts to higher occupancy vehicles. C Minimize travel time for all vehicles. C Maximize trip time reliability. C Increase person capacity.
Goal 2. Reduce emissions and energy consumption

C	Minimize travel demand for commute trips.
C	Provide transit priority at key intersections.
C	Encourage fuel-efficient vehicles.
C	Encourage mode shifts to higher occupancy vehicles.
C	Maintain steady speeds.
C	Minimize stops.
Goal 3.	**Enhance safety**
C	Reduce the number of accidents.
C	Reduce the severity of accidents.
C	Avoid secondary accidents.
C	Speed delivery of emergency services.
C	Enhance general safety through the use of the transportation system.
C	Minimize the impact of construction, maintenance, special events, and incidents.
Goal 4.	**Support transportation operations and planning**
C	Collect data on system performance and usage.
C	Facilitate interagency coordination.
C	Increase productivity of the agency staffs.
Goal 5.	**Improve the quality of life**
C	Address identified problems and deficiencies
C	Increase traveler/shipper convenience (commuters, freight haulers, tourists, etc.).
C	Promote social and geographic equity in delivery of transportation services.
C	Provide equitable distribution of costs and benefits.
C	Distribute benefits across a broad cross-section of users
C	Enhance economic vitality.
C	Improve transportation system reliability.
Goal 6.	**Minimize cost**
C	Minimize non-recurring costs.
C	Minimize recurring costs.
C	Promote public/private partnerships
Goal 7.	**Provide framework for system evolution over time**
C	Allow for expansion to meet future demand
C	Allow for expansion to add capabilities as technologies, solutions, and funding become available
C	Allow for modifications to meet future political and social environments.
Goal 8.	**Maximize implementation potential**
C	Pursue approaches that are within the purview of state/regional/local government involvement.
C	Maximize funding potential
C	Minimize potential for fatal institutional flaws
C	Build on existing successful systems
C	Minimize technological risk
Goal 9.	**Provide for system responsiveness and flexibility**
C	Improve for operational flexibility.
C	Provide maintainable system.
C	Provide for adaptability to changing travel patterns.

IDENTIFY/SCREEN MARKET PACKAGES (ITS STRATEGIES)

Key Activities:

C Evaluation of potential market packages against problems and deficiencies

C Evaluation of potential market packages against goals and objectives

C (Alternate) Environmental scan of potential market packages

- C (Alternate) SWOT analysis of potential market packages
- C Determination of market packages that support statewide or metropolitan goals and objectives

Key Products:

- C Mapping of market packages against problems and goals
- C (Alternate) Environmental scan of ITS elements
- C (Alternate) SWOT analysis of ITS elements
- C Listing of market packages to be further evaluated

The delivery of transportation services, including ITS, should be customer-oriented. The strategy screening activity defines the ITS strategies/market packages that best address the defined goals and objectives. It is the first step in the process of eliminating those market packages that may not be feasible or practical for implementation within the study area.

A note on terminology: It is important to note that the screening analysis could be conducted using the structure of either user services or market packages. As indicated earlier, user services are viewed to be ITS strategies with a customer-orientation, while market packages are viewed to be strategies with an equipment orientation. Whichever terminology is used, it is important that the strategies be defined in sufficient detail to identify benefits, costs, and impacts. In some cases, neither user services nor market packages are defined at a sufficient level of detail for this to occur. Several ITS strategies are sometimes included under a single user service or market package definition (e.g. the market package "freeway management" includes both ramp metering and lane control, two different ITS strategies). Thus, **additional definition below the user service/market package level may be needed.** In this discussion, we will most often make reference to market packages, but the reader should understand that either set of definitions may be used.

There are a number of reasons why an ITS strategy/market package may not be appropriate for a particular area.

- C It does not relate to the identified problems.
- C It does not address the goals and objectives as well as others.
- C Significant barriers (e.g. legal or legislative) stand in the way of its implementation.
- C The area does not have the resources to support it (i.e. it is too costly).

All of the above issues are reflected in the goals and objectives listed earlier. If properly defined, the goals and objectives should provide a reasonable basis for the screening of market packages.

A set of definitions of market packages is provided in Appendix A. It is important to note that **the listing of market packages is neither comprehensive nor prescriptive.** It should be used as a starting point. There are other ideas for ITS market packages that may be developed in response to specific problems identified in the ITS strategic assessment process, or the development of the ITS industry over the coming years may generate new packages. Do not let the current listing of market packages be a limitation in addressing local issues.

There may also be questions about ITS strategic assessments (or Early Deployment Plans) that were developed on the basis of ITS user services. In most cases, these plans have moved beyond user services to recommendations for actual projects and programs. In doing so, these plans likely dealt with market package concepts, even though the term "market package" was not in existence at the time of that study. Thus, there is no reason to re-analyze these plans, in most cases, just because of the terminology. However, there may be a need to re-evaluate the concepts and projects due to changes in technology, in the regional transportation vision, in funding, or for other reasons.

Screening ITS Strategies Against Problems and Goals

The screening of ITS strategies/market packages down to those applicable for the area of interest can involve one or both of the following:

- Mapping of market packages against identified problems and deficiencies. The purpose is to determine the extent to which each market package addresses problems and needs specifically identified in the study area.
- Mapping of market packages against goals and objectives. This is a broader evaluation than just of the relevance to a problem. It incorporates the full range of objectives that are believed to be important in shaping the system. It includes a consideration of cost and institutional elements in addition to effectiveness.

Using the market package definitions provided in Appendix A assists in matching the specific problem/deficiency to feasible market packages. A sample of selected deficiencies (representative of list that might come from a metropolitan area) and respective market packages is shown in Exhibit 5-12. The association of market packages with problems and deficiencies is a relatively simple, qualitative process.

Exhibit 5-12. Example of Potential ITS Market Packages Related to Identified Problems

Identified Problems	Market Packages
• High number of incidents along highway X	• Network surveillance • Broadcast-based ATIS • Interactive traveler information • Incident management system • Traffic information dissemination
• Slow speeds along arterials X, Y and Z	• Surface street control

Identified Problems	Market Packages
C Limited transit usage	C Transit vehicle tracking C Fixed-route operations C Transit security C Multi-modal coordination
C Delays at Weigh Stations	C Electronic Clearance C Weigh-in-motion
C Traffic congestion on freeways A and B	C Freeway control C Broadcast-based ATIS C Traffic information dissemination C Network surveillance
C Heavy tourist traffic-weekends	C Interactive traveler information C Yellow pages and reservation C Broadcast-based ATIS C Traffic information dissemination
C Special event traffic handling at stadium and coliseum	C En-route Driver Information C Incident Management C Traffic control
C Long delays at toll booths	C Dynamic toll management

The market packages can also be matched to the system goals and objectives. This process can be designed to result in a sense of priority among market packages. For example, a numerical ranking can be assigned that provides a total score of each market package against the goals or objectives. Weightings can also be applied to differentiate the relative importance of goals or objectives. The evaluation can also be conducted qualitatively with a high-medium-low system. There is no single technique. However, the process should be systematic, involve multiple stakeholders (probably an exercise conducted by the strategic plan steering committee), and be well documented so that the decision-making process is clear. Exhibit 5-13 provides a sample evaluation for one market package.

Additional Screening Techniques

Although the screening of market packages against identified problems and stated goals and objectives is the preferred screening approach, there are other approaches as well. Two of these are the environmental scan (or e-scan), and the SWOT analysis.

Environmental Scan: The basic concept behind an environmental scan is to learn from the experiences of other, similar regions. In the environmental scan, the analyst identifies other regions with similar socioeconomic and transportation characteristics to the region in question. Then, the analyst looks at the region's use of ITS to find both positive and negative experiences. These experiences can then be used to screen market packages for the strategic assessment.

For example, consider developing an ITS strategic assessment for a moderately sized region characterized by its port and major interstate tunnel facilities. Other regions with similar characteristics are identified. Through field visits, interviews, and data analysis, it is found that within these areas, the market package "broadcast-based ATIS" has been very effective, while efforts to introduce the commercial vehicle electronic clearance market package has met with significant resistance. In this case, the analyst may use this information to prioritize broadcast-based ATIS while eliminating electronic clearance from consideration for the region being studied.

The caution to be exercised in using this technique is that situations are not always easy to compare. For instance, there may be similar physical features, but the main factors behind what was done in another region may have been purely institutional.

SWOT Analysis: SWOT stands for strengths-weaknesses-opportunities-threats. It is a classic analytical approach to certain problems or situations, and could be applied to the screening of ITS market packages. In this screening step, the analyst considers the region's strengths and weaknesses as they relate to deploying ITS. Opportunities and threats to deployment are considered as well. This step requires that the analyst go beyond the conceptual idea of a market package to considering its political and institutional viability. The analyst must effectively use the steering committee to conduct this screening step. Often, these concerns are implicitly considered in the screening of market packages against goals and objectives. The SWOT analysis can bring out these issues explicitly.

Exhibit 5-13. Sample Evaluation of Fixed Route Operations for Transit Against Goals and Objectives

Goals and Objectives	Responsiveness to Objective
Goal 1. Increase efficiency (person-carrying capacity) of the transportation system	
Objectives:	
C Minimize travel demand for commute trips.	**High**
C Minimize travel time for all vehicles.	**Low**
C Maximize trip time reliability.	**Medium**
C Increase person capacity.	**Low**
Goal 2. Reduce emissions and energy consumption	
C Minimize travel demand for commute trips.	**High**
C Encourage fuel-efficient vehicles.	**Low**
C Maintain steady speeds.	**Low**
C Minimize stops.	**Low**
Goal 3. Enhance safety	
C Reduce the number of accidents.	**Low**
C Reduce the severity of accidents.	**Low**
C Avoid secondary accidents.	**Low**
C Speed delivery of emergency services.	**Low**
C Enhance general safety through the use of the transportation system.	**Low**
C Minimize the impact of construction, maintenance, special events, and incidents.	**Low**

Goal 4. Support transportation operations and planning C Collect data on system performance and usage. C Facilitate interagency coordination. C Increase productivity of the agency staffs.	 **High** **Low** **Medium**
Goal 5. Improve the quality of life C Address identified problems and deficiencies C Increase traveler/shipper convenience (commuters, freight haulers, tourists, etc.). C Promote social and geographic equity in delivery of transportation services. C Provide equitable distribution of costs and benefits. C Distribute benefits across a broad cross-section of users C Enhance economic vitality. C Improve transportation system reliability.	 **Medium** **Low** **Medium** **High** **Medium** **Low** **High**
Goal 6. Minimize cost C Minimize non-recurring costs. C Minimize recurring costs. C Promote public/private partnerships	 **Medium** **Medium** **Low**
Goal 7. Provide framework for system evolution over time C Allow for expansion to meet future demand C Allow for expansion to add capabilities as technologies, solutions, and funding become available C Allow for modifications to meet future political and social environments.	 **High** **High** **High**
Goal 8. Maximize implementation potential C Pursue approaches that are within the purview of state/ regional/local government involvement. C Maximize funding potential C Minimize potential for fatal institutional flaws C Build on existing successful systems C Minimize technological risk	 **High** **?** **High** **Medium** **?**
Goal 9. Provide for system responsiveness and flexibility C Improve for operational flexibility. C Provide maintainable system. C Provide for adaptability to changing travel patterns.	 **High** **Medium** **High**

Consider the following examples for guidance in completing the SWOT analysis screening:

Strengths. A region has been found to have an active, long-standing incident management team. This strength provides a strong foundation for a number of traffic management market packages, such as the incident dispatch coordination/communication system.

Weaknesses. Public transit has been receiving less funding in the region over the last several years, resulting in a loss of staff, and poor maintenance of existing equipment. This weakness may not provide the support necessary for some of the public transportation market packages such as transit vehicle tracking. This factor would not necessarily rule out moving forward with this market package, but would be a consideration in that decision. On the other hand, this weakness could also be seen as an entre to developing more efficient management of the existing system, countering or adjusting to existing trends.

Opportunities. The largest local police department in the region is planning to procure a new computer-aided dispatch system in two years. This represents an opportunity to more easily and effectively integrate market packages such as Mayday Support and Incident Dispatch Coordination/Communication System.

Threats. The political climate in the region has shifted to a small-government, low taxes philosophy. This philosophy threatens certain market packages that would be operationally intensive.

The output of this activity will be the set of market packages designed to address the identified problems, deficiencies, and goals for the study area. At this time, a review meeting should be held with the steering committee to present the key findings, the list of market packages to address the region's priority needs, and to maintain the consensus-building efforts in the strategic assessment development process.

ITS CONCEPTS DEVELOPMENT AND DOCUMENTATION

Key Activities:

- Identification of evaluation criteria that relate to the types of benefits expected from the market packages.
- Evaluation of potential market packages against goals, objectives, and/or evaluation criteria.
- Selection and prioritization of market packages.
- Documentation of market package priorities and overall ITS concepts.

Key Products:

- List of performance criteria.
- Results of market package evaluations.
- Documentation of recommended market packages by geographic area

Evaluation Criteria

Phase 1 of the ITS strategic assessment should culminate with the prioritization of market packages and documentation of the results. This sets the stage for the identification of projects, establishment of the regional ITS framework, and development of an implementation plan in Phase 2.

The evaluation criteria used to prioritize market packages should take advantage of the information developed up to this point, but add evaluation elements that will help to distinguish the feasibility of moving forward with various market packages, in addition to identifying their potential effectiveness. In most cases, the criteria used to prioritize market packages can also be used in evaluating potential ITS projects.

There are two basic categories for development of evaluation criteria: evaluation of **performance**, and evaluation of **implementation potential**. The performance criteria mainly address the benefits of the market package. The implementation potential addresses factors that influence whether or not the market package is likely to be a reasonable investment for the area in question. To the extent practical, the performance criteria should be quantitative, even though there may be limited data to support their analysis.

It is useful to think of performance criteria in terms of how projects will ultimately be selected in the TIP or in various "calls for projects." A strategic assessment should be designed to provide any information that an MPO (and other agencies that make project-level decisions) might need to evaluate potential ITS projects against other projects. A strong argument can be made for a "core" set of performance criteria that can be used to compare ITS projects not only against one another but against or along with other types of projects. Some of the key performance criteria often used for making these project comparisons include:

- vehicle miles of travel (VMT).
- vehicle hours of travel (VHT).
- average speed.
- number of accidents.
- percentage of trips by mode (transit, carpool, single occupant vehicle).
- vehicle emissions.
- energy consumption.
- transit on-time performance.
- cost (capital, maintenance, and operating).
- benefit/cost ratio or net present value.

Typically, quantitative assessments cannot be achieved at the market package stage, because the market packages are not defined well enough to enable such an evaluation. Quantitative assessments may be possible at the project definition stage, but even then, quantitative analysis is often limited. Appendix E provides additional information for how to evaluate selected ITS strategies and generate some of the above performance measures.

Individual market packages have features that may require "secondary" performance criteria. For example, timeliness of information might be used to distinguish among various ways to provide information to vehicles or to transit passengers. Several examples of these secondary criteria are provided in Exhibit 5-14.

Exhibit 5-14. Example Secondary Performance Criteria

Market Package	Secondary Performance Criteria
Incident Management System	Total incident duration Detection/verification time Response time Clearance time Incident-related delay False/wrong calls eliminated

Transit Vehicle Tracking	Response-to-breakdown time Reduction in field supervision costs

For the prioritization of market packages, the performance of the market package would be only one of a number of considerations. The following list represents a sample of the types of criteria that could be considered, including criteria that address implementation potential. In this case, the assessment against performance criteria might be grouped into a single "performance" category.

- Performance (benefits to mobility, safety, etc.).
- Consistency with regional goals and objectives.
- Degree to which identified problems are addressed.
- Implementation costs.
- Operating and maintenance costs.
- Cost-effectiveness.
- Public acceptance.
- Operational feasibility (including the potential for working out institutionally acceptable arrangements).
- Extent to which technology is proven (level of risk or reliability).
- Extent to which market package enables other functions.

In most cases, a simple high-medium-low evaluation of each of the above factors displayed in a simple matrix format would provide ample information for making recommendations of high priority market packages at this point in the strategic assessment. Although some regions may prefer to go through a numerical rating, this is not particularly recommended, as the criteria can be viewed as having different levels of importance. The list is merely a way of exposing the strengths and weaknesses of the various market packages. It is a mental "checklist" of considerations. As indicated earlier, however, the best way to proceed with these criteria is to take those already used by the state or region in examining all projects. In some cases, additional criteria may need to be added to address the unique capabilities of ITS.

Locations for Potential Market Package Application

Some of the market packages may be location-specific, while others may apply on a regional or wide-area basis. Potential locations for market package application should be identified either through mapping or in a table. The mapping would show the facilities or routes (including transit routes) along which the market package is to be considered or the potential area to be covered. Some areas may be clearly inappropriate for application. Specific equipment locations are not specified at this point (e.g. surveillance detector spacing or vehicle probe surveillance frequency).

Evaluation of Market Packages Against Performance Criteria

The evaluation of market packages can range widely in scope. With the physical identification of potential locations for the packages, a quantitative evaluation may be possible for some market packages for selected performance criteria. For example, it may be possible to estimate the reduction in vehicle hours of travel that would accrue to applications of the freeway control market package or reduction in passenger hours of travel for transit passenger and fare management.

Chapter 6 introduces procedures for the evaluation of ITS strategies. Appendix E provides specific procedures for selected market packages. Three approaches are discussed: sketch planning, travel demand modeling, and traffic simulation. Although any of the three approaches could be applied to ITS analytical evaluations in a strategic assessment, the sketch planning level is the most likely and most cost-effective method. Simulation may be preferred in corridors where these tools have been developed already, but generally this is not the case. The following principles can be applied to evaluation at the strategic assessment level:

- Keep the evaluation as simple and understandable as possible. The participants will provide good input when they understand the information and their objectives. Creating an evaluation process which is overly complex will be counterproductive.

- Generally, the most straightforward way to conduct an evaluation of market packages is to array the market packages against the criteriain a matrix format. This is illustrated in Exhibit 5-15, using the sample list of criteria presented earlier. A numerical scale could also be used, with the point total representing the level of priority that should be assigned in moving forward with certain market packages. The point score could be weighted by the perceived relative value of the criteria.

Exhibit 5-15. Example Market Package Evaluation Matrix

	Evaluation Criteria			
	Performance	**Consistency With Goals**	**Addresses Problems**	**Etc.**
Market Package 1	High	Medium	Medium	
Market Package 2	Medium	Low	Medium	
Etc.				

- There are several mechanisms for going through the evaluation of market packages. An individual or subgroup could conduct an initial ranking, followed with review by the project steering committee. The steering committee could also conduct the evaluation directly.

- If an update is being conducted, rather than an evaluation from scratch, only deal with those market packages for which there are questions. In an update, it may not be necessary to go through this step, but candidate projects could be identified and evaluated directly. But if the original strategic assessment is believed not to have been comprehensive, a new evaluation may be advisable.

- Recognize that there are limitations in the analytical techniques and base data available. Do not give the users of the results the impression of greater accuracy than actually exists. It may be appropriate to specify the results as a range.

Identification of Key

The *ITS Architecture Implementation Strategy* (from which much of this section is extracted) describes the concept of key market packages. Many of the market packages are inter-related and are also dependent on external factors such as technology advancement, policy change, and development of common interface standards. Moreover, each market package provides different benefits, lends itself to different cost recovery mechanisms, and is subject to different levels of market influence. It is through the interplay of these influences that ITS deployments will occur over time.

As ITS deployment is initiated and basic market packages are deployed, the deployment of more advanced market packages which build on the existing capabilities will be enabled. As technology advances, technical constraints for a market package should be reduced. As the required standards are developed and approved, interoperability issues are resolved. Thus, as a natural progression, market demand may overcome the challenges associated with an increasing number of market packages over time as the impediments are reduced.

By considering each of these factors, a subset of the market packages can be highlighted as important early deployments. Such market packages are identified as *key market packages*. The key market packages are those packages that tend to address three general criteria:

- *Care function*. A key market package that satisfies fundamental requirements that enable implementation of a range of more advanced packages which can be selectively implemented over time to meet local needs.

- *Feasible*. A key market package which can be implemented with existing technologies, is not dependent on forthcoming national standards for basic implementations, and is also subject to limited non-technical risk.

- *Established benefit*. A key market package that has already been implemented in several locations around the nation is an indicator of potential demand for the package. Moreover, these preliminary deployments have demonstrated tangible benefits in an operational setting. As such, a key market package will have fewer unknowns and is likely to subject the local implementor to limited risk.

In short, the key market packages appear to be early winners due to promising combination of low risk implementation characteristics, developing public or private markets for the packages, and tangible system or user benefits. Exhibit 5-16 taken from the *ITS Architecture Implementation Strategy*, evaluates the market packages against these attributes and identifies the key market packages. Several of the criteria for identifying key market packages are similar to the example criteria used earlier. An explanation of the column headings is provided following the exhibit. It should be noted that each region may wish to make its own assessment of key market packages, based on the criteria in Exhibit 5-16 or on other criteria believed to be more appropriate.

Core Function: Market packages that are checked (**T**) are highlighted as providing critical early capabilities that will enable future deployments of more advanced services.

Technology Available: The majority of the market packages require only relatively mature, commercially available technologies for implementation. Market packages that are checked (**T**) are identified as not reliant on an identified critical technology area. For instance, the HOV and Reversible Lane Management market package is identified as reliant on a critical vehicle passenger occupancy verification technology. Since useful implementation of this market package can be achieved, even without this technology, this market package is still identified as technically feasible.

Standards Not Required: Market packages that are checked (**T**) are not dependent on forthcoming national standards for basic implementation. In reviewing the standard interface requirements associated with each of the market packages, interfaces that are fundamental to provision of a service were distinguished from optional interfaces. Also, it was recognized that even fundamental "national interoperability" requirements will often be met through multiple, competing product-specific "standards". All market packages which can be viably implemented without the associated standards are identified in the column.

Institutionally Feasible: Market packages that are subject to limited non-technical risk are checked (**T**). Market packages that were identified as having associated interjurisdictional issues, liability implications, antitrust issues, privacy issues, or regulatory constraints are not checked in the column.

Established Benefit: Results from the separate "Performance and Benefits Study" (performed as part of the National Architecture Study) were used as a basis for this column. Only market packages that were highlighted in the Performance and Benefits study as particularly beneficial that were checked in this column. To further reduce the set of candidate market packages, only those market packages which have existing or currently emerging implementations were considered since the benefits associated with these market packages can be more reliably estimated.

Exhibit 5-16. Identifying Key Market Packages

Market Package	Core Function	Technology Available	Standards not Reqd	Institutionally Feasible	Established Benefit	Key Package
TRAFFIC MANAGEMENT						
Network Surveillance	T	T	T	T	T	T
Probe Surveillance	T	T				
Surface Street Control	T	T	T		T	T
Freeway Control	T	T	T		T	T
HOV and Reversible Lane Management		T	T			
Traffic Information Dissemination		T	T	T		T

Exhibit 5-16. Identifying Key Market Packages

Market Package	Core Function	Technology Available	Standards not Reqd	Institutionally Feasible	Established Benefit	Key Package
Regional Traffic Control	T	T			T	T
Incident Management System		T	T		T	T
Traffic Network Performance Evaluation		T	T			
Dynamic Toll/Parking Fee Management	T	T			T	T
Emissions and Environmental Hazards Sensing					T	
Virtual TMC and Smart Probe Data		T				
TRANSIT MANAGEMENT						
Transit Vehicle Tracking	T	T	T	T	T	T
Transit Fixed-Route Operations	T	T	T	T	T	T
Demand Response Transit Operations	T	T	T	T	T	T
Transit Passenger and Fare Management	T	T		T	T	T
Transit Security		T			T	T
Transit Maintenance		T	T	T		T
Multi-modal Coordination		T				
TRAVELER INFORMATION						
Broadcast Traveler Information	T	T		T	T	T
Interactive Traveler Information	T	T	T	T	T	T
Autonomous Route Guidance	T	T	T	T	T	T
Dynamic Route Guidance		T		T	T	
ISP Based Route Guidance		T				
Integrated Transportation Management/Route Guidance						
Yellow Pages and Reservation		T		T		
Dynamic Ridesharing		T				
In Vehicle Signing		T				
ADVANCED VEHICLE SYSTEMS						
Vehicle Safety Monitoring	T	T	T	T	T	T
Driver Safety Monitoring			T			
Longitudinal Safety Warning			T	T		
Lateral Safety Warning			T	T		
Intersection Safety Warning			T			
Pre-Crash Restraint Deployment			T	T		
Driver Visibility Improvement			T			
Advanced Vehicle Longitudinal Control			T			
Advanced Vehicle Lateral Control			T			
Intersection Collision Avoidance						
Automated Highway System						
COMMERCIAL VEHICLE OPERATIONS						
Fleet Administration	T	T	T	T	T	T
Freight Administration		T	T	T	T	

Exhibit 5-16. Identifying Key Market Packages

Market Package	Core Function	Technolog y Available	Standards not Reqd	Institutionally Feasible	Established Benefit	Key Package
Electronic Clearance	T	T		T	T	T
Electronic Clearance Enrollment	T	T		T	T	T
International Boarder Electronic Clearance		T			T	
Weigh-In-Motion		T	T	T	T	
Roadside CVO Safety	T	T		T	T	T
On-Board CVO Safety		T				
CVO Fleet Maintenance		T	T	T		
HAZMAT Management		T			T	T
EMERGENCY MANAGEMENT						
Emergency Response	T	T			T	T
Emergency Routing		T	T	T	T	T
Mayday Support	T	T			T	T
ITS Planning	T	T			T	T
NOTE: Check marks (T) indicate the market package meets the criteria identified in the column heading. See supporting text for additional information.						

The key market packages are those that best satisfy the combination of these criteria as identified in the last column of Exhibit 5-16. In some cases, a compelling benefit or significant market activity for a market package caused it to be identified as key even though there may be remaining standards or institutional issues associated with the package.

Market Package Prioritization

The end result of ITS concept development in Approach 1 is a set of recommended location-specific market packages. In addition, priorities will be established by corridors or subareas, where appropriate. These priorities may be revised as the process continues through additional steps to incorporate cost tradeoffs and system architecture decisions. The recommendation of market package locations and priorities under Approach 2 is not conducted until the second phase of that approach. However, the process is essentially the same. Each state or metropolitan area has flexibility in how rigorous their approach should be.

Possible activities in market package prioritization could include:

- Assemble the evaluation data along with the previously conducted mapping of market packages against goals and objectives and against identified problems.

- Prioritize the market packages into high/medium/low priority.

- Classify the market packages by short-term (1-5 years), mid-term (5-10 years), and long-term(10-20 years). Distinguish by geographic areas, where appropriate. For example, the most congested freeways or more densely traveled transit routes might be given higher priority and be implemented first.

Documentation

Documentation of ITS concepts should be prepared summarizing the decisions made in this activity. For the sake of discussion, the documentation will be referred to as the "ITS Concept Plan." However, agencies may title the report according to their own local preferences. Sections to consider for inclusion are:

- Purpose of the ITS Concept Plan.
- Description of candidate market packages.
- Statewide or metropolitan goals to be addressed by the market packages.
- Evaluation process.
- Evaluation results and recommended market packages.
- Initial prioritization of market packages.

A listing of benefits is instrumental in displaying to the target audiences the value of ITS programs and the ITS strategic assessment. Some of the benefits can be quantified, while others must be specified qualitatively. The benefits should be associated with specific stakeholder groups. Some examples of such benefits are highlighted in the descriptions in Exhibit 5-17, adapted from a completed ITS early deployment planning study in Sacramento, California.

It should also be noted that many benefits will accrue in the form of increased efficiency in administrative processes and reduced paperwork. It is unlikely that these areas of benefit can easily be identified in quantitative terms. In assessing the potential areas of benefit that may result from ITS deployment, it is necessary to make assumptions on the areas of application and the stakeholders who may benefit from each market package.

Exhibit 5-17. Sample Benefit by Market Package
(Source: Adapted from Sacramento ITS Early Deployment Planning Study)

Stakeholder	How They Benefit
MARKET PACKAGE: SURFACE STREET CONTROL	
All Motorists	Reduced delay, lower accident rates
Business Owners	Improved mobility of customers and employees
General Public	Control over neighborhood traffic, improved air quality
Bus Transit Riders	Improve travel times
Private ITS Industry	Market for products
Insurance Industry	Reduced accident claims
Fleet Operators	Reduced delays
System Operators	Operational flexibility, improved data gathering capability
Transit Operators	Improved on-time performance
Federal Government	Reduced funding needs for road construction
Regulatory Agencies	Aid in meeting air quality goals
Emergency Services	Improved response times
MARKET PACKAGE: INCIDENT DISPATCH COORDINATION/COMMUNICATIONS	
All Motorists	Reduced delay, less secondary accidents
Accident Victims	Lower response times
Business Owners	Improved mobility of customers and employees
General Public	Improve air quality
Bus Transit Riders	Improve travel times
Private ITS Industry	Market for products
Private Tow/Recovery Business	Public market for business
Insurance Industry	Reduction in number of accidents and severity of injuries
Fleet Operators	Reduced delays
Local System Operators	Fewer unknowns, pre-determined strategies
State System Operators	Fewer unknowns, pre-determined strategies
Transit Operators	Improve on time performance
Regulatory Agencies	Aid in meeting air quality goals
Emergency Services	Improved response and deployment of correct resource
Law Enforcement	Reduced response and restoration times
MARKET PACKAGE: TRANSIT FIXED-ROUTE OPERATIONS	
Business Owners	Improved mobility of customers and employees
General Public	Improved transportation service, improved air quality
Transit Riders	Improved travel times, reduced wait times
Private ITS Industry	Market for products
Transit Operators	Improved administration and productivity, improved ridership
MARKET PACKAGE: INTERACTIVE ATIS WITH DYNAMIC RIDESHARING	
Single Occupancy Vehicle Motorists	Reduced delay resulting from mode shift to HOVs
High Occupancy Vehicle Motorists	Reduced travel time resulting from HOV incentives
Business Owners	Improved mobility of customers and employees
General Public	Improved mobility, improved air quality
Transit Riders	Reduced travel time resulting from HOV incentives
Local System Operators	Inter-agency coordination for operations, input to private employers, reduced SOV demand
Transit Operators	Increased ridership from HOV incentives
Air Quality Agencies	Aid in meeting air quality goals
MARKET PACKAGE: EMISSIONS AND ENVIRONMENTAL SENSING	
Local Motorists	Reduced bureaucracy for "clean" vehicles
General Public	Improved air quality
Private ITS Industry	Market for products
Regulatory Agencies	Aid in meeting air quality goals
MARKET PACKAGE: ROUTE GUIDANCE	

Local Motorists	Reduced trip length, reduced travel time
Inter-Regional Travelers	Reduced trip length, reduced travel time
Business Owners	Increased patronage when coupled with travel services information
General Public	Reduced through trips in neighborhoods
Private ITS Industry	Market for products
Fleet Operators	Reduced trip length, reduced travel time
Regulatory Agencies	Reduced VMT
Emergency Services	Improved response time
Law Enforcement	Improved response time
MARKET PACKAGE: INTERACTIVE ATIS WITH DRIVER AND TRAVELER INFORMATION	
Local Motorists	Predictable travel time
Inter-Regional Travelers	Decision support for mode choice
General Public	Improved air quality through fewer peak period trips
Transit Riders	Decision support for mode choice and trip scheduling
Private ITS Industry	Market for products
Fleet Operators	Reduced en-route weather and congestion-related delay
Local and State System Operators	Reduced delay in peak periods and during incidents
Transit Operators	Potential increased ridership
Regulatory Agencies	Reduced VMT

IDENTIFY DESIRED FUNCTIONAL CAPABILITIES AND POTENTIAL PROJECTS

Key Activities:

- Develop list of potential system requirements.
- Correlate recommended market packages to equipment packages, organized by subsystem.
- Determinefunctional requirements of market packages by subsystem and technology area.
- Develop an initial listing of projects, based on problems and needs

Key products:

- List of potential system requirements by market package.
- Functional requirementsdefinition by subsystem and technology area.
- Initial listing of ITS projects that address problems and needs.

Basic Concepts

As indicated in the "lessons learned" section of this chapter, an ITS strategic assessment should identify implementable projects, not just concepts. There is some debate concerning how early in the process potential projects should be identified. Experience from many ITS strategic planning and early deployment planningefforts suggests that **early identification of potential projects can be advantageous for several reasons**:

- **Defining projects helps to keep the stakeholders engaged in the planning effort.** When agencies recognize that there will be actual projects coming from the planning effort, they are more likely to actively participate and provide meaningful input.

- **Defining projects provides a basis for more explicitly structuring the regional ITS framework, which will tie the various ITS projects together.**

C **Defining projects provides a basis for specifying ow ITS can be integrated with other transportation strategies.**

C **Projects provide the basis for more realistically estimating potential benefits and costs.** This allows for a more realistic assessment of priorities. Estimates of benefits and costs usually require the definition of a geographic coverage area.

C **Projects represent a bridge from the market packages identified in Phase 1 to an implementable plan in Phase 2.**

One way to think of projects is that **projects provide geographic and institutional definition to the priority market packages.** A market package by itself does not define a geographic coverage area or the institutions that should be involved in its implementation or operation. A project overlays specific geographic and institutional decisions on the market package. One way to think of defining a project is to specify it in sufficient detail to enable an estimate of planning-level costs and benefits. This forces the planning to take on a geographic dimension, and one that is more real to the stakeholders. This does not mean that technologies need to be specified. Planning-level costs and benefits can usually be identified without reference to specific technologies. Specification of technologies is really only pertinent for near-term projects. An example of this will be given later in this chapter.

There are several points at which initial project concepts can be identified. The choice of the most appropriate point for entering this part of the planning process will be a local decision. Several of the options include:

C Immediately following the definition of priority market packages. Projects would be structured around the market package definitions.

C As an integrated step with the development of the regional architecture. In other words, the projects and the architecture could be developed simultaneously.

C Following the initial development of the regional architecture.

In any of the above cases, it is important to understand that **the definition of projects is an iterative process**. The projects and the regional ITS framework (which includes the regional architecture) will both be most effective if they are developed in conjunction with one another. Both individual projects and the regional ITS framework will normally be refined and further developed as the planning process continues through the remainder of Phase 2. These refinements may be based on information such as: developments in other non-ITS projects with which ITS project may be integrated, funding opportunities that may encourage specific project types, institutional constraints, etc. For purposes of discussion in this chapter, it will be assumed that the initial project definitions are developed at the beginning of Phase 2 (i.e. after the development of the ITS Concept Plan) and refined as the planning effort continues.

Some of the key points to remember in defining initial projects include:

- **Relate the projects back to the problems, goals, and objectives identified earlier in the process.** Projects should not come from "out of the blue," but should percolate up from the needs identified at the regional and local level.

- **Think of implementation across agency structures, not just within a single agency**. Many of the benefits of ITS accrue from linking operations and information exchange among agencies. It is easy to limit one's thinking to the traditional role of an individual agency. Although there are greater implementation challenges on multi-agency projects, that is the horizon that much of ITS is intended to address.

- **Keep the projects from becoming too complex and risky for the agencies which must implement them**. Focusing on areas where implementation has already been demonstrated in other areas of the country will help ensure that the definitions of projects are realistic. However, other more risk-prone projects that are key to moving the region's transportation program forward may also be needed. **The experience and abilities of agencies in managing ITS projects will be a major factor in how aggressive or complex a project should be.**

- **Think in terms of projects that will make sense to those who will ultimately need to approve them**. ITS projects can be difficult for many decision-makers to understand, and the projects will need to be explained in ways that demonstrate how they will benefit constituents.

Another activity that is part of developing and fleshing out project concepts is that of **functional requirements**. Several concepts within the National ITS Architecture also come into play here:

- **Equipment Package**: An equipment package (or set of packages) contains the capabilities required for an individual ITS subsystem to implement an individual market package.

- **ITS subsystems**: Components that will make up the physical architecture. Subsystems are classified into four categories:
  - Vehicle subsystems
  - Roadside subsystems
  - Center subsystems
  - Remote access subsystems

- **Technology areas (or functional areas)**: Technological functions allow the market packages to be implemented.

- **Requirements**: Functions that are either required or desired within a market package. The requirements would be specified by technology area and subsystem.

Functional requirements will be discussed first, followed by further discussion on identification of projects.

Functional Requirements or Features

Functional requirements are generally used to help define projects and to link equipment packages to those projects. These options would be evaluated in terms of priority (e.g. high, medium, low), or desirability (e.g. mandatory, desirable, not necessary). For example, the market package "surface street control" might include the list of potential system features in Exhibit 5-18.

Exhibit 5-18. Partial (Sample) List of Potential System Requirements or Features of Market Package "Surface Street Control"

- Algorithms
  - Ability to optimize on total travel time? No. of stops? Emissions?
  - Ability to estimate delays at intersections?
  - Ability to optimize across jurisdictional boundaries?
  - Ability to optimize dynamically for special events?
  - Ability to generate and incorporate off-line timing plans? How many?
- Signals
  - Capability to accommodate __ intersections
  - Include HOV preferential treatment?
  - Include emergency vehicle preferential treatment?
- Sensors, traffic
  - Capability for video at critical intersections? Special event centers? Critical links?
  - Capability to prevent spillback into intersections?
- Information management
  - Capability to store data for __ days on disk.
  - Ability to store non-filtered data for planning purposes?
  - Ability to count turning movements at intersections?
- User interface
  - Make condition reports available to multiple agencies?
  - Make condition reports available to public?
  - Provide interfaces for other systems?
  - Provide manual overrides?

A systematic approach to this activity could include the following:

- Identify the subsystems that are relevant to each market package. Exhibit 5-19 illustrates the subsystems and their relationships, as defined in the National ITS Architecture.

- Identify the technology areas that are relevant to subsystems within each market package. Exhibit 5-20 lists the technology areas related to each market package as defined in the National Architecture. The opaque (black) squares denote a basic relationship between the market package and the technology area. This assignment indicates that the technology area is fundamental to the core services provided by the market package. The transparent (white) squares denote a secondary relationship between the market package and the technology area. Use of this technology area is desirable but not necessarily required for market package implementation.

C Specify system requirements by subsystem and technology area for each market package. These requirements can be specified at three levels: "Mandatory," "desired," and "not important." Alternatively, the requirements could be rated on a numerical scale from "very important" to "not important." The specification of requirements in this step represents an opportunity to "localize" the functions anticipated for the recommended market packages. It is important that this exercise not become merely a "wish list." It needs to include a realistic assessment of what will constitute useful, effective system capabilities. Exhibit 5-18 previously listed a sample of system requirement issues or questions. The issues were organized by technology area.

Exhibit 5-19. National ITS Architecture Subsystems and Communications (Source: National ITS Architecture Implementation Strategy)

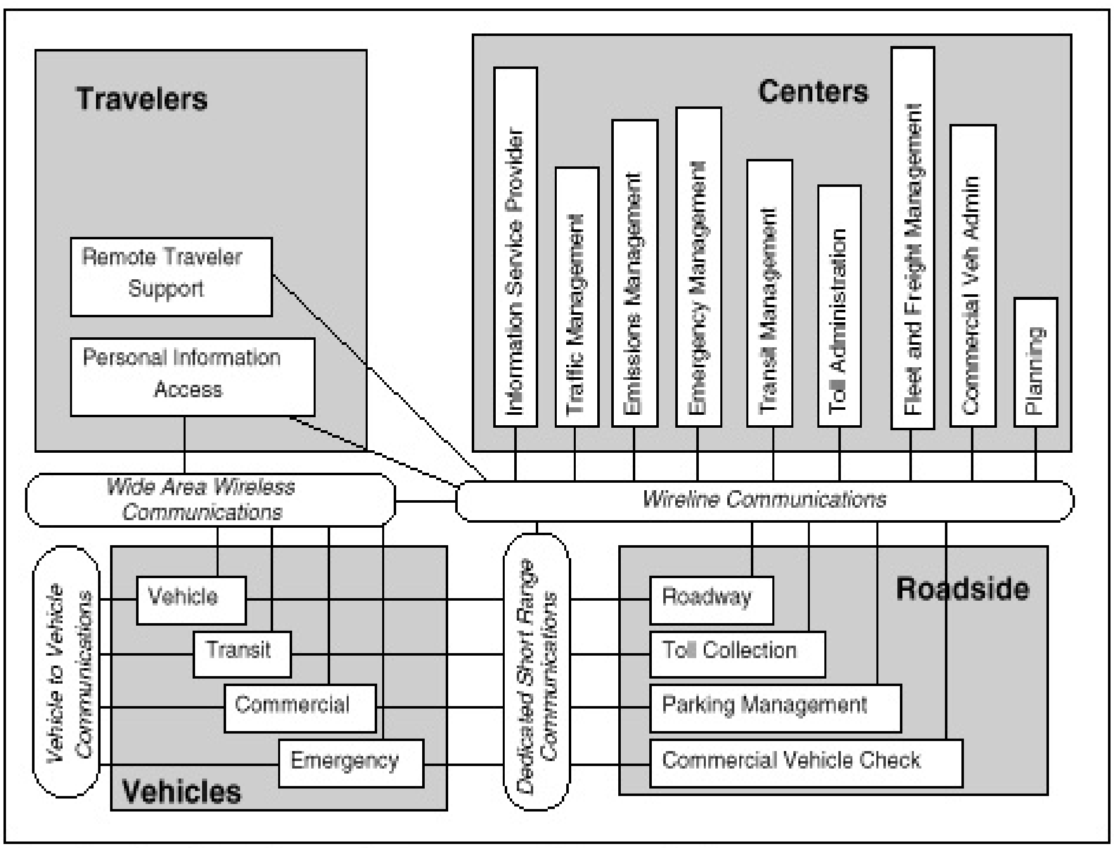


Exhibit 5-20. Market Package Requirements by Technology Area (Source: National ITS Architecture Implementation Strategy)

	Market Packages	Technology Area																							
		Sensor										Comm									User I/F			Control		
		Traffic	Vehicle Status	Environment	Vehicle Monitoring	Driver Monitoring	Cargo Monitoring	Obstacle Ranging	Lane Tracking	Security	Location Determination	Call-Based (U1t)	Vehicle-Roadside (U2)	Vehicle-Vehicle (U3)	Broadcast (U1b)	Fixed (W)	Algorithms	Information Mgmt	Payment	Driver	Traveler	Operator	Signals	Signs	Vehicle
ATMS	Network Surveillance	■		❑												■	❑	■				■			
	Probe Surveillance				■						■	■	❑			❑	■	■				■			
	Surface Street Control	■														■						■	■		
	Freeway Control	■														■						■	■	❑	
	HOV and Reversible Lane Mgmt	■	■								■	■				■	❑					■	❑	■	
	Traffic Information Dissemination														■	■	❑	■				■		❑	
	Regional Traffic Control	■			■											■	■	■				■	■	■	
	Incident Management System	■			■						■	■				■	■	■				■	❑	❑	
	Traffic Network Performance Eval	■			■											❑	■	■				■			
	Dynamic Toll/Parking Fee Mgmt	■	■									❑	■		❑	■	■	■	■	■		■	❑	❑	
	Emissions and Environmental Haz.		■	■	❑											■	■	■		❑		■		❑	
	Virtual TMC and Smart Probes				■						■	■	❑			❑	■	■				■			
	Standard Railroad Grade Crossing	■														■		❑					■		
	Advanced Railroad Grade Crossing	■	❑			❑		❑								■	■	❑					■		
	Railroad Operations Coordination				■						■	■	❑			■	■	■				■			
APTS	Transit Vehicle Tracking				❑	❑					■	■	❑			❑		■			❑	■			
	Transit Fixed-Route Operations											❑	❑			❑		■		❑	❑	■			
	Demand Response Operations											■				❑	❑	■		■	❑	■			
	Transit Passenger and Fare Mgmt									❑	❑	❑				❑		■	■		■	■			
	Transit Security									■	❑	❑				❑		❑		■	■	■			
	Transit Maintenance				■	❑					❑	❑				❑		■		■		■			
	Multi-modal Coordination										■	■	■			■	❑	■		■		■			
ATIS	Broadcast Traveler Information	■		❑											■	■	■	❑		■	■	■			
	Interactive Traveler Information	■		❑							❑	■				■	■	❑		■	■	■			
	Autonomous Route Guidance										■						■	❑		■	■				
	Dynamic Route Guidance	■		❑							■	❑			■	■	■	❑		■	■				
	ISP-Based Route Guidance	■		❑							■	■				■	■	■	❑	■	■	■			
	Integrated Transportation Mgmt/RG	■		❑							■	■				■	■	■	❑	■	■	■			
	Yellow Pages & Reservation										❑	■				■	■	❑		■	■	■			
	Dynamic Ridesharing									❑		■				■				■	■	■			
	In Vehicle Signing		❑	❑	❑	❑	❑				■	❑	■			❑	❑	❑		■		❑			
AVSS	Vehicle Safety Monitoring				■							❑					❑			■					
	Driver Safety Monitoring				■	■						❑					■			■					
	Longitudinal Safety Warning				■	❑		■									■			■					
	Lateral Safety Warning				■	❑		■	■								■			■					
	Intersection Safety Warning		■	❑	■	❑		■	■			❑	■	❑		■	■	❑		■			❑	❑	
	Pre-Crash Restraint Deployment				■	❑		■									■								❑
	Driver Visibility Improvement					❑		■												■					
	Advanced Vehicle Longitudinal Ctrl				■	❑		■									■			■					■
	Advanced Vehicle Lateral Control				■	❑		■	■								■			■					■
	Intersection Collision Avoidance		■	❑	■	■		■	■			❑	■	❑		■	■	❑		■			❑	❑	■
	Automated Highway System	❑	■	❑	■	■		■	■	❑	■	■	■	■		■	■	■	❑	■		■	❑	❑	■
CVO	Fleet Administration				■						■	■	❑			❑	❑	■		■		■			
	Freight Administration						■				■	■	❑			■	❑	■		■		■			
	Electronic Clearance												■			■		■		■		■	❑	❑	
	CV Administrative Processes											❑				■		■							
	International Border Clearance												■			■		■		■		■	❑	❑	
	Weigh-In-Motion		■										❑				❑					■	❑	❑	
	Roadside CVO Safety		■		❑		❑						■			■	❑					■	❑	❑	
	On-board CVO Safety				■	■	■					❑	❑				❑			■					
	CVO Fleet Maintenance				■						■	■				❑	❑	■		■		■			
	Hazmat Management						■				■	■	❑			■	❑	■		■		■			
EM	Emergency Response									■	❑	❑				■	❑	■				■			
	Emergency Routing				❑	❑					■	■	❑			❑	❑	■		■		■			
	Mayday Support		❑								■	■				■		❑		■	■	■			
	ITS Planning													■		■		■				■			

The market packages often include capabilities that are allocated to several different subsystems. For instance, the Transit Vehicle Tracking market package includes vehicle location equipment in the Transit Vehicle Subsystem, a base station element in the Transit Management Subsystem, and a basic traveler information capability from the Information Service Provider Subsystem. A particular end-user may require only a portion of the capabilities included in an equipment package and should be afforded the option of purchasing only the desired subset equipment without incurring additional risk through forced procurement of additional undesired "rider" capabilities. This is the reason that a detailed analysis of functional requirements is needed at this stage. Fortunately there will be a limited number of subsystems that correlate to technology areas for a given market package, simplifying the evaluation of requirements.

The requirements analysis activity could be undertaken in at least two ways:

- An individual or agency (public agency or consultant) provides an initial evaluation, which is reviewed by the advisory councils and/or strategic assessment steering committee.

- The activity is conducted as a group exercise, with composite scores developed from the individual evaluation.

At this stage, the requirements are independent of technology and architecture. Rather, they express the desired functions to address the region's unique goals, objectives and desires regarding ITS. However, the requirements analysis should not be independent of other transportation initiatives in the region.

Market Package Synergy

An important precursor to architecture development is the identification of ITS market packages that may have a synergistic effect (i.e. the benefits of combining the strategies may be greater than the sum of the individual benefits). This is part of taking advantage of the potential benefits of ITS integration. Consideration for these market package synergies can result in more efficient deployment of ITS services over time. It is up to the local implementor to develop a deployment strategy that capitalizes on these efficiencies. The *ITS Architecture Implementation Strategy* provides a description of how to go about identifying these synergies or inter-dependencies.

Initial Definition of Projects

As indicated earlier, the definition of projects will likely be developed and refined throughout the strategic assessment effort. There can be a number of sources for the identification of ITS projects. These could range from projects identified through other studies (such as corridor/subarea studies), to projects identified specifically through the ITS strategic assessment. Some of the sources include:

- Idea-generating discussions held as part of the strategic assessment. Some agencies have held workshops or formal discussions to generate ITS project ideas that relate to the goals and objectives for transportation system improvement in the region.

- Submission of projects for consideration by agencies within the region. The ITS strategic planning effort for Los Angeles/Ventura Counties in California recently went through a process of calling for ITS project submissions. These will be evaluated for potential inclusion into the plan.

- Projects identified through other planning efforts, including corridor/subarea plans, individual agency plans (such as an operating plan coming from a transit agency), or other regional-level planning activities.

- Projects identified through the private sector. This could include possible public/private ventures or public projects that may support later private ventures.

- Projects identified through the contributions of other individuals or groups (including elected officials, citizen advisory committees, etc.).

One of the tasks of the strategic assessment is to associate projects with real problems and needs, to help identify the means for integrating the projects across geographic and institutional boundaries, and determine which may be appropriate for inclusion in the resulting documentation. Projects should be related to the problems and needs originally defined. One example format for this is shown in Exhibit 5-21. An "X" means that a project addresses the identified problem. A numerical scale could also be used to identify the degree to which a project addresses each problem or need (e.g., 1 for "not at all," up to 5 for "directly addresses problem." Another mechanism for doing this is to use the performance criteria or project evaluation criteria discussed in the previous sections. This would be similar to Exhibit 5-15, but with projects listed instead of market packages. It should be noted that **not every candidate project would be accepted into the plan. Rather, candidate projects would be evaluated, and those that were best for the region or for individual geographic areas would be included**. The evaluation process could also be conducted in a framework of evaluating **alternatives**, similar to other transportation studies. Alternatives or groups of projects could be constructed reflecting different approaches, levels of investment in ITS, etc.

Exhibit 5-21. Example Table Showing How Potential Projects Relate to Identified Problems and Needs (X Indicates Problems Addressed)

Candidate Projects	Identified Problems			
	Accidents on Facilities X/Y/Z	Congestion on Freeways X/Y/Z	Bus Schedule Adherence	Etc.
Project A	X	X		
Project B			X	
Etc.				

At this stage, the candidate projects could also be grouped into initial **program areas**. These would represent categories of projects that tend to focus on specific objectives or elements of the ITS vision. **Example program areas could include Transit/Travel Demand Management, Freeway Operations, Arterial Operations, Commercial Vehicle Operations, etc.** The projects could also be organized geographically.

DEFINE REGIONAL FRAMEWORK, INCLUDING THE REGIONAL ARCHITECTURE

Key Activities:

- Identify the linkages among subsystems and technology areas, using the National Architecture as the base.
- Develop the logical, physical, and organizational architectures
- Identify potential short-term or early start projects (and possibly technologies to support those projects).

Key Products:

- Charts and description of logical, organizational, and physical architectures.
- List of potential projects and technologies for near-term ITS program.

It is important to be clear on the difference between the terms "regional ITS framework" and "regional ITS architecture." The regional ITS framework is all-encompassing, and includes the architecture as well as all the institutional, operations, and management activities necessary to implement the architecture. The regional ITS architecture is used mainly to describe how individual ITS elements are linked together, both physically and logically. The regional architecture should be consistent with the National Architecture and may be based on or developed from the National Architecture. However, there could be ITS applications not addressed in the National ITS Architecture that agencies plan for and implement within their own regional architecture.

The development of the regional architecture is termed "Layered Framework" in Approach 2 to the ITS strategic assessment process. This term is used because architecture development takes place at three levels: transportation, communications, and institutional, as described earlier. In both Approach 1 and Approach 2, the architecture development is viewed to be an iterative process, identifying initial concepts and narrowing down to a preferred concept through a series of discussions among multiple agencies. It is perhaps the most creative process in an ITS strategic assessment.

> *"Without an architecture to guide the development of a new system, the system may be unable to share data, cooperate in carrying out a process or strategy, evolve with changing practices and technology, and optimize program development with funding opportunities."*

Without an architecture to guide the development of a new system, the system may be unable to share data, cooperate in carrying out a process or strategy, evolve with changing practices and technology, and optimize program development with funding opportunities. An ineffective architecture definition could also result in overlapping functions and redundant development of components in the system. The goal is to define an architecture which meets the functional requirements of the proposed system and can provide for inevitable change, evolution, and growth.

In the context of ITS, **an "architecture" is a framework that describes what a system does and how it does it** , providing the general structure within which the various system components are deployed. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components.

Three forms of architecture are normally defined. These are "logical" architecture, “organizational” architecture, and "physical" architecture. The **logical architecture** is a description of the functions required to carry out an ITS system in a defined area. The logical architecture is typically shown in data flow diagrams (DFDs) and process specifications (P-specs). It is most related to the communications layer as described in the National Architecture The **organizational architecture** focuses on agency responsibilities needed to implement the architecture. It represents the institutional layer as described in the National Architecture. The **physical architecture** groups functions into subsystems, identifies technological areas required, and identifies how the functions are related to one another. It is most similar to the transportation layer of the National Architecture. All the architecture elements are highly inter-related and should be developed together in an iterative process. Initial architecture concepts should be able to accommodate all candidate projects remaining at that stage.

It should be noted that any evaluation of technologies done at this stage should be limited to short-term opportunities. Technologies are changing rapidly, and both the types of technology available and their cost may change over a short period of time and thereby alter decisions that may be made. More detailed technology evaluations typically take place during system definition, design, and implementation.

Building on the National Architecture

The development of the **National ITS Architecture** has provided a foundation for the development of **regional architectures.** Regional architectures can be defined for entire metropolitan areas, corridors (rural or urban), or other subareas. Two resources from the National Architecture work can be particularly helpful here: the ITS architecture subsystems diagram (previously shown in Exhibit 5-19, a generalized physical architecture diagram) and generalized logical architecture diagrams showing data flows for the various market packages (a sample is shown in Exhibit 5-22). Exhibit 5-23 illustrates a sample organizational architecture from the Boston region ITS Strategic Plan. A possible approach to regional architecture development based on the National Architecture includes the following steps:

C If there are current ITS applications, diagram the regional architecture as it currently exists. The subsystems framework previously shown in Exhibit 5-19 can be used as an initial starting point.

- Construct individual data flow diagrams for the selected market packages, as illustrated in Exhibit 5-22. Most of this work has already been done in the National ITS Architecture.

- Determine the market packages that should have inter-relationships, and develop an amplified physical architecture diagram. (note: all selected market packages do not need to be included in a single architecture diagram. Some may be implemented totally independent of other market packages.) Use the National Architecture subsystems structure as a guide.

- Develop the corresponding logical and organizational architecture diagrams. It is possible that several options will need to be developed that reflect different ways of organizing the market packages. Organizational responsibility can be associated with either the logical or physical architecture diagrams, if desired. Exhibit 5-24 illustrates a generalized physical architecture diagram from Dallas, Texas diagramed in the National Architecture structure.

- Work through variations of the architecture diagrams in a consensus-building process until the right combination of market package inter-relationships and agency responsibilities is derived.

The development of the organizational architecture (i.e. determining agencies responsible for various functions) can be controversial. Decisions need to be made regarding the agencies with which certain functions will reside. **In most cases, ITS will primarily involve enhancement of existing agency functions, not a reconstruction of core functions.** However, substantial losses in efficiency or increases in expense can sometimes be incurred if decisions on consolidation or change of agency functions are not a consideration. It is here that the consensus-building skills of the steering committee leader will be particularly important. Some of the principles that will assist in working through the logical and organizational architecture include:

- **Try to preserve existing agency functions, when doing so does not present a major impediment to system effectiveness.**

- **Do not rush the process. Take time to work with agencies individually to resolve difficult choices.** There should be no surprises.

- **Be customer-oriented**. Failure to serve the traveling public or the business community will ultimately damage the credibility of all the agencies involved. It is better to make the difficult decisions and move on, rather than live with unnecessary costs and inefficiency.

- **Secure written agreements that clearly spell out responsibilities and expectations for the most critical areas of application.** While this may take additional time, it will serve as the foundation for the future and reduce the potential for misunderstandings. This would ordinarily be done following the completion of the ITS strategic assessment, but could be done as part of the process as well.

Reference should be made to the *ITS Architecture Implementation Strategy* for additional guidance on architecture development.

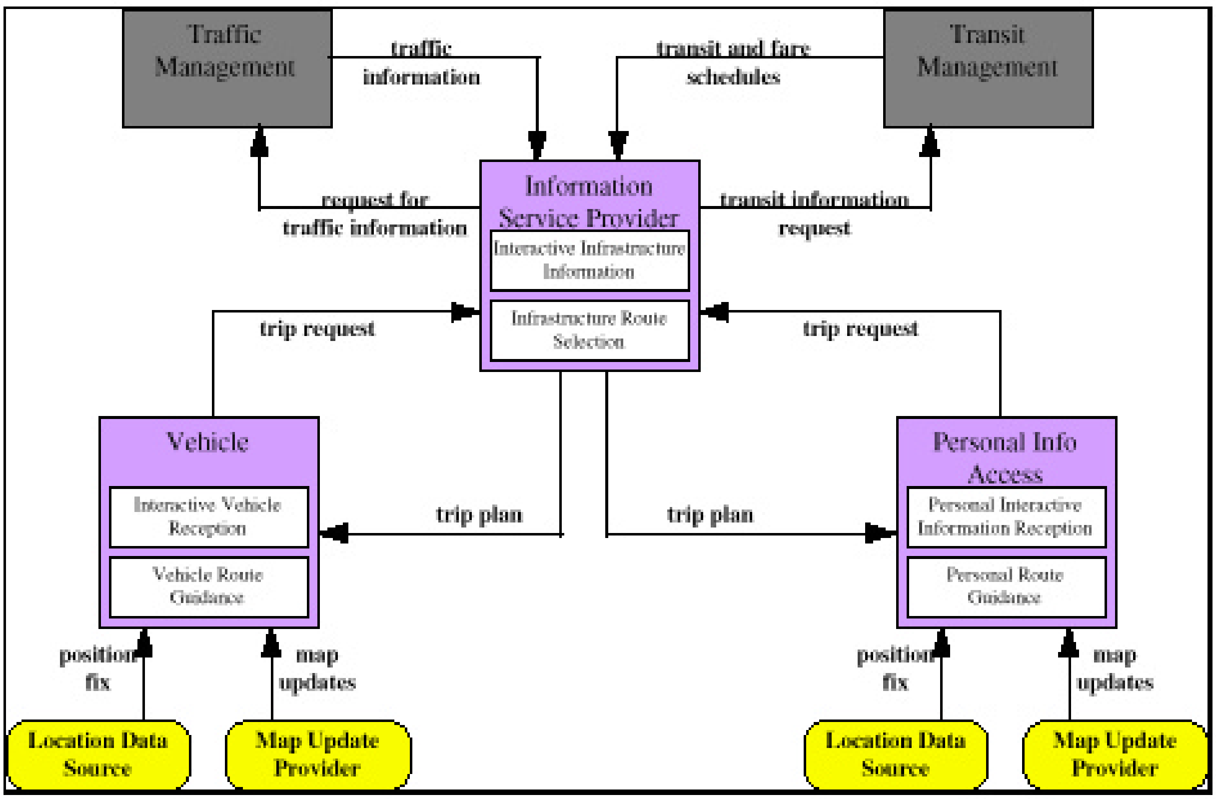


Exhibit 5-22. Example Generalized Data Flows for the ISP-Based Route Guidance Market Package (Source: National ITS Architecture Implementation Strategy)

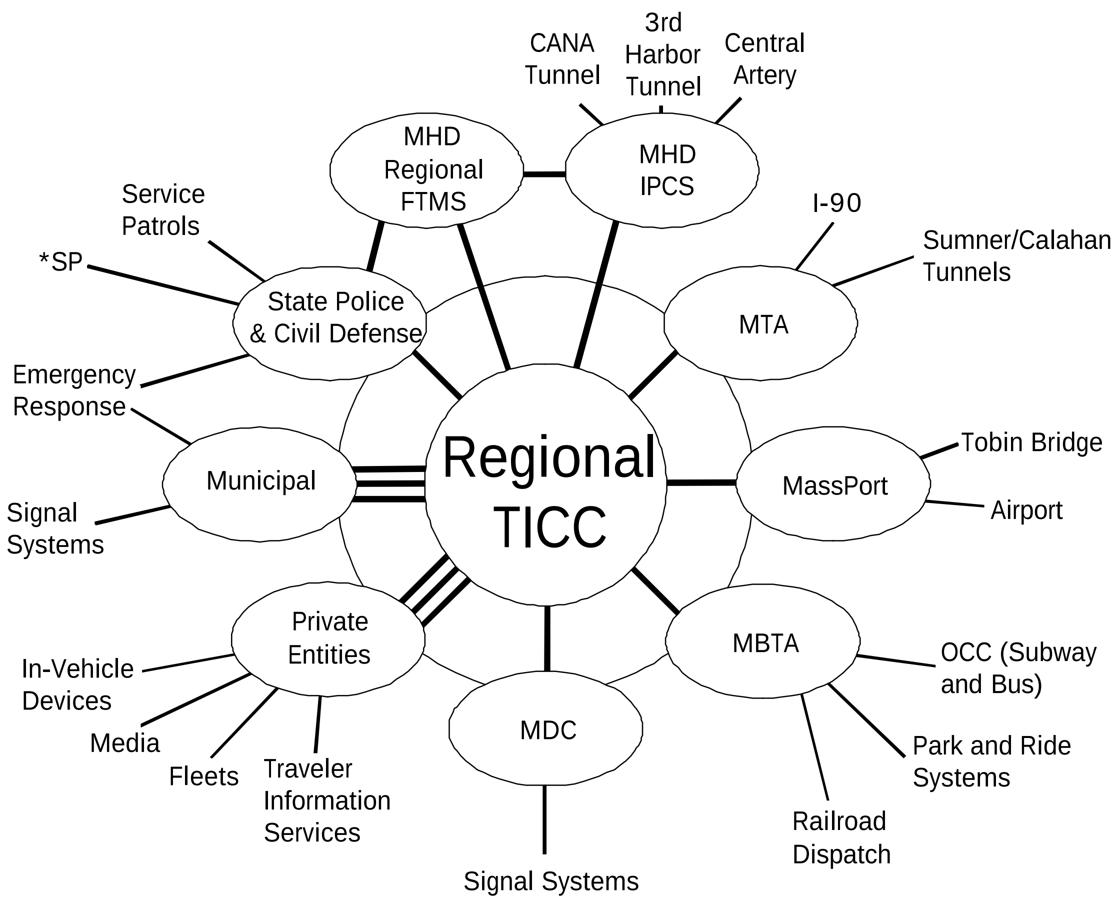


Exhibit 5-23. Sample Organizational Architecture
(Source: Boston ITS Strategic Plan)

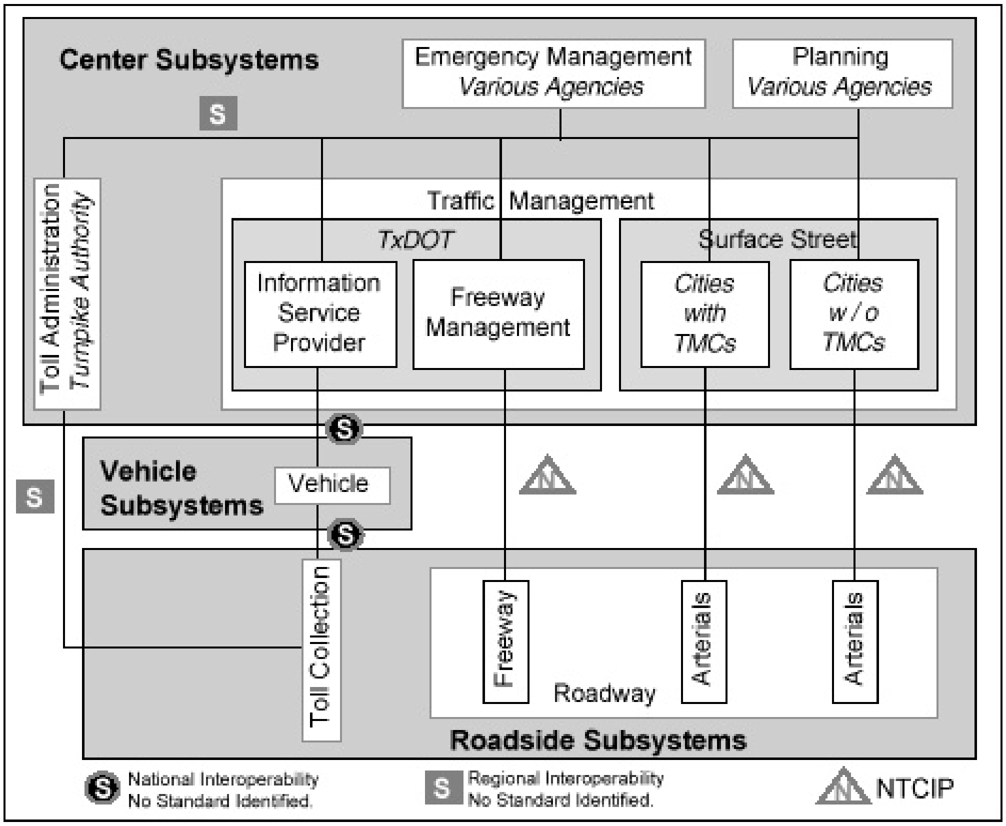


Exhibit 5-24. Generalized Physical Architecture Diagram Using the Subsystem Structure of the National ITS Architecture (Source: National ITS Architecture Implementation Strategy)

Architecture Considerations

Defining an architecture within the regional ITS framework requires a review of a number of key considerations. These considerations are highlighted below.

- **Institutional Framework**: An ITS architecture, particularly on the regional level, must fit within the existing organizational infrastructure. It is unrealistic to demand significant changes or to impose a new institutional framework on the various jurisdictions and entities who are involved or affected by ITS, other than to build logical extensions to the existing framework. In essence, the regional architecture must provide for a seamless transportation network while respecting local autonomy--a win-win solution. Care must be exercised in defining involvement by agencies which permit compatibility to their existing and planned resources and provide advantages or value to the agency being part of the system.

- **Functional Areas**: The development of a regional ITS architecture is primarily based on the market packages it will provide. The identification of functional areas needed to support and tailor the market packages was described in the previous step. This list establishes the functions and activities to be part of the system architecture.

- **Technology Availability and Implementation Phasing**: The availability of key enabling technologies within the functional areas is critical. Certain system strategies and functions (e.g. in-vehicle routing) require hardware and/or software which is not yet fully developed and tested, and prerequisite information (e.g. real-time surveillance) which is not currently available. Accordingly, the system architecture must be flexible such that these (and other) enabling technologies may be readily incorporated into the ITS network in the future.

- **Openness**: An ITS architecture must also be "open" to ensure compatibility with existing/proposed systems and with future technologies. "Open" architectures utilize standards and non-proprietary interface protocols, thereby allowing various (and conceivably dissimilar) systems to interact with one another, and allowing modular replacement and upgrading of system elements and subsystems with minimal impact on other components. Openness allows multiple vendors to supply the same type of element, thereby preventing the operating agency from becoming locked into a single proprietary component. Moreover, standards and protocols typically provide upward compatibility for accommodating new technologies in the future.

- **Public/Private Responsibilities:** A key issue in defining and developing ITS-based transportation networks is the concept of public-private partnerships and the respective roles of each in implementation, operation, and maintenance of these systems. To date, nearly all ITS implementations within North America have been based on the philosophy that most, if not all, surveillance, management, and traveler information functions should be provided by government (i.e. the public side). In essence, ITS has been viewed as an advanced technology/electronic extension of the transportation operations which are currently provided by government. Within this context, "public/private" relationships have traditionally involved the public agency hiring a private entity to perform work that cannot be effectively accomplished with in-house staff or resources. A new role of public-private partnership exists--one in which the private entity still provides ITS services and/or system elements; but, instead of direct reimbursement from the public agency, some or all of the private entity's costs for these functions are recouped by selling ITS-based services to other private entities (collecting a user fee), or by receiving a non-monetary consideration for these services from the public agency. Several examples of this concept being used in the United States include:

  - Marketing and sales of in-vehicle and portable devices to provide real-time traveler information and routing.

- The government agency providing access to the highway agency right-of-way to a private communications firm, in return for which the private entity installs and maintains a communications network for the government agency's ITS network.

- Collection, marketing, and sales of real-time traveler information or of traveler services information.

The regional framework incorporates the architecture and defines the relationships between the public and private sectors, along with their respective responsibilities to most effectively utilize these available resources.

The assessment of alternative architectures may take on many forms, depending on the existing architecture in place, the cooperation level of agencies in the region, and the resources available for the effort. The analysis may range from a general weighing of advantages and disadvantages (in the form of a comparison matrix) of alternative scenarios to a highly detailed cost-benefit analysis of alternatives. In all cases, the study team must compare each feasible alternative's ability to meet the region's goals and objectives, to address the system constraints and sensitivity issues, to properly function given the available resources (time, equipment, and manpower), and to be implementable and open/robust to meet the future and dynamic needs of the region's transportation system.

Technology Requirements

A range of technologies, each with unique performance, cost, and maturity characteristics can be applied to provide ITS services through the market packages. The majority of these technologies are commercially available and expose the agencies to little technical risk. The most problematic technology implications exist where a required ITS function is not supported by any cost-effective, commercially available technology.

In a few cases, required technologies may not exist or may be too costly and/or unreliable for commercial application. Market packages that are dependent on such technologies require further research and development to provide the enabling technology and integrate it into a commercially viable deployment package. Exhibit 5-20 previously identified functional groups of technologies and related them to the market packages.

Feasible Technologies Assessment for Short-Term (or Early Start) Projects

An assessment of technologies may be conducted, but is recommended only for short term or early start projects. Technologies are changing rapidly. As a result, cost-effectiveness relationships for projects to be implemented beyond a 2 or 3-year time frame may change that will, in turn, affect technology decisions. For example, leasing communications lines and wireless communications have become much more competitive to traditional dedicated communications, due to the major changes in the communications industry in recent years. In addition, legal impediments may sometimes be rectified that will make an option that is currently infeasible, highly attractive. For this reason, the ITS technology assessment should be fluid over time, except for short-term or immediate deployment projects. The framework for technology assessment provided in this section can be applied to a wide range of current and future technology, but the process should be applied only for short term projects.

A review of existing and emerging specific technologies or standards will normally be conducted to define the most cost-effective concepts to achieve the defined goals and objectives. For example, to meet vehicle surveillance needs of the ITS system, alternate technologies may include: in-pavement sensors, overhead detectors (several feasible technologies), CCTV, cellular telephones, and others. Advantages and disadvantages exist for each alternative that will result in the selection of a cost-effective alternative.

> *"Technologies are changing rapidly. As a result, cost-effectiveness relationships . . . may change that will, in turn, affect technology decisions."*

A wide range of technologies are identified in the documentation for the National ITS Architecture. Technology options may include hardware components, software components, and control strategies. Sources such as: state-of-the-art reviews, evaluation studies and reports, manufacturer's literature and/or demos, visits to existing systems, and technical inputs or papers from current users of the technologies should be used to identify alternative technologies whose performance and reliability may meet the functional requirements of the planned systems.

Technology evaluation issues should consider: (1) the interaction of alternative technologies and the other elements that will be part of the planned architecture, (2) the impact on the physical configuration of the planned architecture and the performance of other technologies and/or components, (3) the compatibility with the regional goals and objectives, (4) the expansion capability and flexibility of alternative components, and (5) the availability of standards for specific technologies (e.g. IEEE, NEMA, ASTM, etc.). The incorporation of standards will allow the option of using different vendors for the same service, helping to ensure compatibility with new products and services in the future, and providing compatibility between neighboring traffic operating systems. In addition, specific technologies should be selected to assure compatibility with existing, in-place components of the ITS system.

An analysis to determine the desirable technologies for short-term projects may be conducted. Some agencies may wish to conduct this analysis outside the framework of the ITS strategic assessment. Others may view it as a legitimate activity to address short-term project and program decisions within the strategic assessment. Detailed analysis for mid- and long-term services is generally not advisable at this stage due to the dynamic nature of ITS technology and needs. Technology readily adaptable today may be obsolete or inefficient several years down the road. Technology assessments can be conducted as a later project development activity in this case.

For near- or short-term projects, a higher, more detailed level of analysis is sometimes warranted. The evaluation may consist of a detailed life-cycle cost evaluation (accounting for procurement, installation, construction, initial costs, anticipated benefits, and operations and maintenance costs, product reliability, product replacement values, and system expansion features). An alternative approach may be by qualitative evaluation using key criteria in an evaluation matrix. Typical evaluation criteria for a technology assessment include:

- Applicability
- Maintainability
- Reliability
- Initial cost
- Operating cost
- Ease of integration
- Openness
- Feasibility

The criteria may vary depending on the type of technology being evaluated. The *ITS Transguide Design Report* for the San Antonio area provides several good examples of technology assessments. The following exhibits are excerpted from that report: Exhibit 5-25, Detection Method Decision Matrix; Exhibit 5-26, Camera Technology Decision Matrix; Exhibit 5-27 Communications System Decision Matrix; and Exhibit 5-28, Computer System Decision Matrix. The format is attractive, as it provides descriptive information in parallel on each alternative. Note that the evaluation criteria vary depending on the technology area being examined. A numerical rankingsystem could be added, if desired. However, a ranking system alone loses some of the information that can be useful to those who are reviewing the results of decisions.

It should be reiterated that this type of evaluation is probably not appropriate for long term projects in the planning stage. Yet it may be appropriate for short-term projects to provide reasonable cost estimates for projects to be included in the Transportation Improvement Program. Without this type of analysis, an unacceptably wide or uncertain range in cost estimates could occur. The technology choices may also have an impact on operating and maintenance resource needs, which also have an impact on costs. Whether this short-term technology definition occurs within the strategic assessment or in a follow-up activity is a decision agencies will need to make. The decision on how far to take the technology assessment points to how inter-connected many of these decisions on ITS actually are. As stated earlier in this Handbook, ITS requires the planning community to think farther through the process than they may have been required to do previously.

". . . ITS requires the planning community to think farther through the process than they may have been required to do previously."

The technology assessment can be updated periodically. Given the pace of change in technology, continuous feedback may be required. Added to this input should be the feasibility of incorporating ITS technologies as they become proven in field operational tests. As such, the technology assessment should plan for "openness" in allowing for multiple vendor supply as well as flexibility to incorporate enhancements or major breakthroughs in the market.

The output of this step will be: (1) the definition of the architecture; (2) feasible technologies or concepts to support short-term ITS projects, and (3) institutional arrangements that will allow for the effective implementation of the architecture. It is possible that short term ITS projects may be defined prior to or during the architecture. To the extent possible, these projects should be examined for compatibility with what is known about the architecture at that time.

Exhibit 5-25. Detection Method Decision Matrix (Source: San Antonio *Transguide Design Report)*

Characteristic	Priority	Loop Detection	Radar Detection	Video Detection	Audio Detection
Maintainability	Very high	High, stable soil, no salt usage, no ground freezing	High, easily accessible	High, easily accessible	High, easily accessible
Reliability	Very high	High, (in San Antonio stable) soils, no salt usage, no ground freezing	Moderately high, little history, but no foreseeable high failure components	Moderate, could have weather or vehicle specific detection problems	Moderate, little history, but no major expectation of failures
Initial costs	Medium	Medium, some loops already installed, lots of experience	Moderately high, new method, higher risk	High, expensive systems, prices should fall	Moderately high, new system, high risk
Operational costs	High	Low, few failures, low maintenance	Moderate, components could be expensive	Moderate, components could be expensive, system updates may be required	Low, unknown, but no major expected expenses
Accuracy	High	High, lots of experience	Medium, should be good, but not much history	Medium, relatively complex and new	Medium, primarily unknown, could be relatively low
Ease of integration	Medium	High, some loops already available	Medium, requires overhead installation at all locations, could be fairly compatible	Medium, complex, overhead installation required at each location, but could be relatively compatible	Medium, installation new, compatibility unknown
Feasibility	Very High	High, available, known technology	Low, not well proven at design time	Moderate, available, but not well proven at design time	Moderate, not well proven at design time

Exhibit 5-26. Camera Technology Decision Matrix (Source: San Antonio *Transguide Design Report)*

Characteristic	**Priority**	**Black & White**	**Low Resolution Single-Chip Color**	**High Resolution Single-Chip Color**	**Three-Chip Color**	**Digital**
Color	High	No	Yes	Yes	Yes	Yes
Daylight Resolution	High	Moderate, loss of color clues	Low, combined camera and lens	High, requires reasonable lens	Very high, combined with very good lens	Very high, but can be lost quickly due to digital magnification
Night Resolution	High	High, good contrast, but some light artifacts	Very low, divided light & low resolution	Medium, divided light, but high resolution	High divided light, but high gain and high resolution	High, lost quickly when digital magnification is applied
Cost	High	Low, low cost camera, variable cost lens	Low, low cost camera and lens	Medium, medium priced camera relatively low cost lens	Medium high, moderately high priced camera, high priced lens	Medium, moderately high priced camera with fixed lens
Bright Light Effect	Moderately High	High Significant effects	Very high, combination of low resolution and large effects	High, some effects reduced	Medium, most effects reduced and some eliminated	Medium, most effects reduced and some eliminated

Exhibit 5-27. Communications Systems Decision Matrix
(Source: San Antonio *Transguide Design Report)*

Characteristic	**Priority**	**Leased T1**	**Leased T3**	**Dedicated Optical Coax, and Digital**	**Microwave**	**Dedicated SONET Fiber (OC3 Multiplexer)**
Maintainability	Very high	High, single telco connection, external network management	High, single telco connection, external network management	Low, multiple cables, no standard network management	Low, many independent connections required	High, one cable, standard network management
Reliability	Very high	Medium, not under direct control	Medium, not under direct control	Low, multiple failure points	Low, weather and interference among other factors	High, redundant fiber and communications cards
Operational Costs	High	Moderately high, leasing costs add to operational costs	High, leasing costs for T3 connections are very high	High, maintenance will increase overall operational costs	Medium, easy access for all maintenance requirements	Low, redundant fibers make maintenance non-critical operation
Maximum data rate	High	1.5Mbps	45Mbps	Varies, analog, low speed data and fiber for future applications	45Mbps	155 Mbps per fiber
Video clarity	High	Medium, jumpy in dynamic situations	High, near broadcast quality	High, standard cable type signals	Variable	High, near broadcast quality
Installation costs	Medium	Low, telco investment	Low, telco investment	Medium, cables must be pulled	Medium, establish path for each hub	Medium, must pull fiber
Video interface costs	Medium	High, compression required	Low, very little compression required	Very low, standard components	Very high	Low, very little compression required

Exhibit 5-28. Computer System Decision Matrix
(Source: San Antonio *Transguide Design Report*)

Characteristic	**Priority**	**Loop Detection**	**Radar Detection**	**Video Detection**	**Audio Detection**
Maintainability	Very high	Moderate, requires multiple location maintenance	High, can easily replace workstation while system continues to operate	Moderate, back on line fast when there are failures	Very high, most of system can be replaced while the system is still operational
Reliability	Very high	Low on entire system, but high for most of the system	High, overall system should stay up almost all the time	Moderate, quality systems	Very high, almost no failures that affect system performance
Feasibility	Very high	High, can address one section at a time	Moderate, requires complex design, some risk	High, no significant effects on system complexity	High, little risk added by fault tolerance
Operational Costs	High	High, due to multiple sites	Moderate, maintaining several, similar computers	Moderate, primarily off-line repairs	Moderate, infrequent, non-critical repairs
Availability	High	High overall, tolerates faults by losing sections	High for overall system, transitions required when workstations fail	Moderately high, back on line rapidly when the primary fails	Very high, repairs can be made while system is available
Installation Costs	Medium	High, but can be spent in minimum size chunks	Medium, more workstations can be added as needed	Moderately high, must be included in initial purchase	High, must be purchased initially
Ease of Integration	Medium	Low, difficult unless designed as a system from the beginning	Moderate, complex initial system design to maximize use of resources	High, no significant effects on system complexity	High, minimum added design complexity for fault tolerance

DEFINE OPERATIONAL AND IMPLEMENTATION STRATEGIES

Key Activities:

- Define operational strategies.
- Examine funding opportunities.
- Develop implementable projects.
- Develop phasing plan.

Key Products:

- Project definitions, integrated with other transportation projects, where appropriate.
- Operations and management plan.
- Potential sources of funds (implementation and operating), schedule, and agency responsibility by project.
- Potential public private partnerships.

In this step, the implementation and operational strategies for the strategic assessment are defined. This would be included in the "Implementation Strategy" portion of Approach 2. These strategies should be aimed at identifying a near-term program of projects which has a high likelihood of success and directly contributes to the long range vision of an integrated, efficient, and productive transportation system. This may be accomplished by:

- Examining ITS implementation not just in terms of hardware and software installation, but in terms of ongoing operation and maintenance, e.g. costs, responsibility, public acceptance, etc.

- Recognizing that ultimate success will largely rest on the fundamental benefit of the implemented ITS actions to the public and industry and on the coalition that supports those actions.

- Maintaining a healthy balance between "vision" and the "nuts and bolts" issues of implementation and costs. Innovation should lead to more cost-effective applications.

- Recognizing the importance of successful near-term implementation in the long-term success of ITS. Make the near-term implementation visible but manageable.

Implementation/ Operations Plan

A plan for implementation and operations should be developed. It need not be a lengthy document, but should spell out which agencies will be responsible for various elements of ITS implementation. An implementation/operations plan should, as a minimum, address the following issues:

- Operations and maintenance strategy.
- Project definition consistent with requirements for the TIP.
- Planning-level cost estimates.
- Project phasing.
- Procurement approaches.
- Funding levels.
- Legal issues.

C Ongoing consensus-building.

The following sections highlight the key factors in each of these issues.

Operations and Maintenance Planning

The operations and maintenance requirements of the planned systems must be in balance with the availability of proper personnel, equipment, and budget resources to operate and maintain the systems. Providing qualified personnel and staff with available equipment to operate the system is a MUST. New equipment and new technologies will require specific operations and maintenance activities that may be unique to each technology and may be foreign to existing staff capabilities.

Most strategic assessment efforts do not go far enough in thinking through approaches to operating ITS. Examining the strategy for operation of a system in greater detail may reveal either gaps in the plan or overlapping, unnecessary, or unproductive functions. For example, an effective traveler information system needs to examine where travelers should be receiving information, how frequently, and of what type. These parameters will have implications on sign locations, and the use of alternative information outlets.

> *"Most strategic assessment efforts do not go far enough in thinking through approaches to operating ITS"*

At this stage, identification of the maintenance and operations requirements should be based on the assessment of the existing capabilities in terms of personnel, skills, and equipment; determining the necessary skills and work load impacts of the system (by agency and overall); comparing the existing conditions with what is required for the system; analyzing the deficiencies; and establishing the feasibility of providing any additional capabilities required for the system. This capability may range from adding capable staff to training existing staff to private contracting for specific services or even the primary operation and maintenance activity. This issue is critical to assure the system does not become obsolete due to lack of proper operation or maintenance activities. **Absence of proper staff to operate the system may result in the system losing its effectiveness and support by the region.** The level of analysis should be such that the need for additional capabilities and resources is identified and a plan to obtain the proper resources is established.

Exhibit 5-29 shows an evaluation matrix used in the San Antonio area to evaluate alternative operational/staffing approaches. The matrix highlights some of the key issues that tend to surface in these deliberations.

Exhibit 5-29. Overall Approach Decision Matrix

Characteristic	Priority	Traffic Engineers at Consoles	Traffic Engineer Pregenerated Scenarios, Technicians as Operators	Trained Operators, Traffic Engineer as Manager	Learning System
Response time	Very high	Moderately slow, responses must be generated fro each situation	Very fast, selection and implementation time minimized foremost situations	Slow, responses must be tailored and approved	Variable, initial slow, but faster as system learns more appropriate responses
Flexibility	High	Very high, traffic engineers can respond appropriately to each situation	Very high, scenarios can be generated to cover most expected situations, can also be combined or modified	Very high, response can be tailored for each situation	High, response can be tailored for each situation, but re-using responses may limit flexibility
Operational costs	High	Very high, requires experienced engineers as operators	Low, advantage of traffic engineer's experience without continual presence	Medium, some engineering presence required	Declining, initially significant engineering presence required, but not after the system comes up to speed
Time required for system to get up to speed	High	Low, no ramp-up	Low, scenarios can be generated before system is operational	Moderately low, some initial training required for operators	High, system must encounter problem before a scenario is generated
Initial effort required	Medium	Very low, minimum of advanced work or training required	Very high, scenarios must be generated for each potential situation	Medium, significant initial operator training will be required	Moderately low, some initial training, but little other initial preparation
Legal supportability	Medium	Moderately high, use traffic engineers, but under pressure	Very high, scenarios generated and approved by traffic engineers	Medium, non-engineers generate responses, approval under great pressure	Medium, non-engineers generating and selecting responses in real time

Further Project Refinement

The initial project definitions developed earlier in the strategic assessment process will be further developed and refined as the architecture is developed in greater detail and agency responsibilities are thought through. As indicated earlier, the development of projects is an iterative process. An example of an ITS-related TIP project description was provided in Chapter 3. These projects will be part of the ITS "vision plan" described earlier in this chapter. **Whether the projects become part of the financially constrained transportation plan and TIP will depend on the extent to which funding is available. These tradeoffs are ultimately made at a regional level. Some of the factors to consider in defining ITS projects include:**

- The projects will be refined from the initial list generated earlier, based on the discussions of architecture, operations and maintenance requirements, and review by various stakeholders.

- Having implementation take place in a way that will make sense to the customer. This means that elements most visible to the public should have the proper supporting features included as a package. For example, ramp meters or variable message signs should not be installed too far in advance of their operational date. The public may become skeptical of government actions when visible field equipment lies dormant for long periods.

- If it is uncertain whether certain low-payoff projects should be included in certain geographic areas, it is normally best to define them as projects, but give them a lower priority than other areas.

- Estimated quantities should be defined for major features: number and location of variable message signs, feet of new communications lines, number and location of AVI readers for transit fleet management, etc.

- Special effort should be provided to coordinate with other transportation projects, both transit and highway. In some cases, ITS projects will be best integrated with other transportation projects. In other cases, it will be critical to closely coordinate the efforts, particularly with respect to timing of construction or installation.

The definition of projects may be further modified as additional information is developed on costs and phasing later in this step.

Planning-Level Cost Estimates

Planning-level cost estimates are needed to develop and prioritize individual projects and to carry out the broader ITS program. The *Cost Analysis* document in the National ITS Architecture (available in CD-ROM from FHWA) provides a wealth of cost information that can be used in an ITS strategic assessment, corridor/subarea study, or other planning activity. This section provides an overview of planning-level costing for ITS. Some of the principles that should be considered in developing planning-level cost estimates include:

- Do not be overly conservative or liberal on cost estimates. Conservatively low estimates will result in problems in implementation when actual costs exceed budgeted estimates. Overly liberal estimates may jeopardize project approval. However, one should probably err on the high side so as to retain credibility of the program by minimizing cost overruns.

- Work on an installed unit cost basis (per intersection, per mile, per ramp, per bus, per control center, etc.), but taking into account major features, not minor options.

- Estimate operating and maintenance costs as well as initial installation costs.

- The early deployment of projects should be set to allow for several early "successes" to assist in consensus-building and in developing a solid framework of successes with the ITS program.

- Early (short-term) deployment projects should be capable of being environmentally cleared and ready for implementation in the next 1 to 2 years.

The above criteria can be incorporated into a priority-setting scheme along with other ITS criteria. Examples of other criteria could include: significance of existing problems addressed, relationship to regional goals and objectives, benefit/cost relationship, environmental and other benefits, etc. Alternatively, a less systematic negotiated approach can be used, but anchored in the evaluative information that has been developed through earlier steps.

A preliminary phasing plan should be developed displaying the general priority implementation of projects using a non-fiscally constrained condition. A sample phasing diagram is shown in Exhibit 5-30. This plan should be presented to the study's steering committee for preliminary buy-in of the concept and for consensus building of the subsequent activities, i.e. the development of the strategic assessment.

Exhibit 5-30. Orange County Phased Implementation Plan

		Implementation											
	Description	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2003-2008	2008-2013
TOC/TMACs	Caltrans TOC												
	TMSs												
Agency Traffic Operations Support	OCTA Technical Liaison												
	Maintenance Support (Contracted)												
Decision Support Systems	Smart Corridor Expert Systems												
Emergency Priority Systems	Signal Pre-emption Test bed												
Rapid Incident Clearance (RIC)	Tow Truck Deployment of Freeways												
	Interface with TIS												
	Mobile Data Terminal Interface with ITS												
	Accident Investigation Sites												
Adaptive Signal Control and Signal Synchronization	Adaptive Control Software												
	Signal Synchronization -- Upgraded												
Corridor Ramp Metering	Additional Ramp Meters												
	Software Development												
Integrated Signal/Ramp Meter Control	Software												

Lead and Supporting Agency Identification

One of the factors critical to the success of ITS implementation is the leadership for each individual project. This is true for virtually any transportation project. However, **the importance of assigning implementation responsibility for ITS projects is amplified, because ITS projects are more specialized, the risks**

are higher, and agency procedures are often not fully in place to govern the project implementation steps. Choosing project lead agencies, and the individuals responsible for moving projects forward, is therefore one of the most important decisions that can be made. This can also be a delicate issue, particularly with projects that cross jurisdictional boundaries or that do not follow the institutional norms.

Some of the factors that should be considered in choosing lead agencies include:

- Facility ownership or current operational responsibility. In most cases, the agency that owns the facility or facilities on which the ITS project(s) will be implemented would be the logical lead agency. The state DOT would be lead agency for projects on state roadways, cities would be lead for projects on local roadways, etc. However, in some cases, the ITS project is not implemented on a facility per se, or the project may be implemented on facilities with multiple owners.

- Knowledge and experience of personnel. The expertise to implement an ITS project may exist in an agency that is not necessarily the owner or operator of the transportation facilities or services in question.

- Contractual capabilities of the agency. In some cases, the contractual process for some agencies is more amenable to the unique features of ITS than for other agencies. The expedience of contracting may be a reason for not following traditional lead/support agency structures.

- Enthusiasm for or commitment to the project. This can mean a major difference in the likelihood of success. Most successful ITS implementations have had an agency "champion" or champions who have made it their business to ensure that the project works successfully. The level of commitment can be a major factor in a positive or negative outcome.

- Stability of project leadership. Agencies with a high level of turnover or rotation (especially in positions that could impact the project) can pose a serious problem in continuity over the full project implementation and operation period.

A key question in resolving the lead agency question is "What leadership structure will result in the highest probability of success?"

Procurement

Procurement alternatives should be identified, at least for the short-term projects. It is possible that different projects selected for deployment will have different methods of procurement. Traditional low-cost bid procurements that work well for simple construction projects do not, as a rule, work out well for implementing a system composed of computers, software, communication devices, electronic sensors, and other similar equipment. In addition, in-house staff is typically not qualified to perform many of the functions required to design, construct, inspect, operate and maintain a system or its components.

Several alternatives exist to accomplish the procurement of the ITS system and/or components. They include:

- C Low bid (single contract awarded to the lowest bidder who is responsible for all tasks identified in the scope request)

- C Two-step (process which adds a formal technical prequalification step to the bid approach; sets of qualified contractors are then requested to submit a bid and/or proposal)

- C Design/build (process where a single entity, i.e. designer/builder, is responsible for ALL work associated with the system development, including design, contracting, and system integration; once completed, system is turned over to agency to operate and maintain; this generally results in reduced implementation time over normal processes)

- C Sole source (contract is awarded to a named supplier without competition; this process is usually oriented towards implementation of standard, off-the-shelf products; it can be used to maintain continuity or compatibility of products).

- C Systems manager (primary system manager contract is awarded to design and manage the systems development process; separate contracts are prepared and awarded for implementation of individual components; however, the interface between subsystems is the responsibility of the systems manager/management consultant)

Selection of the procurement method can be based on several criteria, most notably: staff capabilities, bidding processes regulated by the agency, time constraints, needs of the system to be implemented (i.e. whether significant existing ITS infrastructure exists or are the programs such that existing staff/hired staff can manage the implementation), and operations and maintenance capabilities of the agency or region involved. Each of these factors/criteria should be assessed and the appropriate methods reviewed. In some cases, multiple methods may be feasible and should be considered.

Funding

Implementation of an ITS program for a region will require extensive amounts of funding to achieve the desired needs of most regions. Funding is required to initially implement the system as well as to operate, maintain and upgrade the system as technology and system needs evolve. In defining potential funding sources, key guidelines for success are to be creative, innovative, and flexible.

The funding process for ITS can be approached in at least two ways. If viewing ITS to be an integrated element of many other transportation strategies, ITS funding would be approached as a part of funding an entire package of improvements to address specific problems. For example, ITS funding could be included as part of the funding of a major corridor capacity expansion project or HOV lane addition project. In this case, ITS is likely a small part of the total funding package.

Alternatively, ITS can be treated as a separate set of actions with separate funding. In this case, ITS is often viewed to be in competition for funding against other projects, and obtaining funding tends to become part of an advocacy process. It is not the intent of this Handbook to prescribe an approach for advocacy of ITS funding over other types of projects. This is not to say that those agencies and individuals committed to moving ITS forward in their region should not be advocates of funding ITS projects. The allocation of funding at the state and metropolitan level, after all, often involves a process of advocacy. The extent to which agencies and individuals become advocates of ITS funding is a local decision. The intent of the information in this Handbook is to provide information that will allow agencies to explore and pursue funds for ITS either as an integrated part of other funding or as stand-alone funding for dedicated ITS projects.

Typically Available Funding Sources: The traditional funding sources are available to assist with the funding of ITS programs. The traditional funding sources include:

- Federal-aid National Highway System funds.
- Surface Transportation Program (STP) funds.
- Congestion Mitigation and Air Quality (CMAQ) funds.
- Federal Transit Act Funds.
- State and local sources.

These funds are available through the traditional methods of allocation, application, and obligation. Procedures in each state may vary regarding how funds may flow down to the metropolitan and local level. Some areas have made major commitments to allocate a significant portion of certain funding pools to ITS. For example, the Houston region's TRANSTAR system was funded largely from the commitment of CMAQ funds. Other areas have drawn funds from multiple sources over a long period of time, building and operating in increments as the funds became available. Two special funding sources that have been used extensively for ITS are U.S.DOT Operational Test funds and Defense Conversion Funds. Further discussion of funding sources is provided in Appendix C. Appendix C also describes some of the multifaceted funding approaches to ITS that have been used in the past in Southern California.

Private Funding Potential: A new and much-needed source of funds is based on the potential for public/private partnerships. The private role is increasing in this arena. It is one in which the private entity may provide ITS services and/or system elements; but, instead of direct reimbursement from the public agency, some or all of the private entity's costs for these functions are recouped by selling ITS-based services to other private entities (i.e. collecting a user fee or deriving revenue from advertising), or by receiving a non-monetary consideration for these services from the public agency. This offers advantages both in public cost reduction and in capitalizing on the private sector's market orientation. Several examples of this latter concept of public-private partnerships are being developed in the United States, including:

- Marketing and sales of in-vehicle and portable devices to provide real-time traveler information and routing;

- The government agency providing access to the highway right-of-way to a private communications firm, in return for which the private entity installs and maintains a communications network (e.g. conduit, cable, and electronics) for the government agency's ITS network. The private communications firm recoups the cost of the communications system by sizing it to provide telecommunications services to other users (e.g. other private entities) and charging for the service; and

- Collection, marketing, and sales of real-time traveler information and traveler services information supported by advertising (e.g. the Weather Channel, etc.).

Developing sustainable public-private partnerships is proving to be difficult. Private sector involvement is driven by the profit motive, and the potential profitability of certain ITS applications remains a major question in the eyes of potential private sector players. There is also general mistrust by public agencies of the profit motive, and a distrust by the private sector of the stability and timeliness of decisions that would be made in the public realm. Instability and delays increase risk.

Successful partnerships with the private sector will likely be initiated by private sector players who understand the market. However, additional exposure of the private sector to ITS is important and may generate other potential joint projects.

Areas or regions desiring strong, solid ITS programs must define and encourage the relationship between the public and private sectors, along with their respective responsibilities. Arranging joint meetings, conducting conferences on ITS, soliciting private input on typically public transportation issues, encouraging public/private cooperation, implementing legislation encouraging these relationships, becoming visible in private group concerns (without harm to public conflict-of-interest issues), developing a cooperative atmosphere/ business climate, and openly promoting the ITS advantages to the private sector represent steps needed to be taken by the public side to encourage private participation. Some basic principles in developing public/private partnerships include:

- **Assist the private sector in areas of ITS that make good business ventures.** While private companies may be “good citizens” in participating in ITS projects for a period of time, long-term commitment to ITS projects will need to be justified, ultimately, by whether the company can make a profit from that activity. It is critical that public agencies understand this as an essential element of a successful private venture.

- **Structure projects to be self-monitoring. The private entity should have a reason other than government regulation and enforcement to make certain that the project succeeds.** There should be a built-in motivation for customer service, that leads to additional profits. If the only force that holds the project together is the threat of governmental retribution, the project is likely to fail in the long run, and relationships will quickly turn adversarial.

- **Be willing to take calculated risks.** The private sector operates within an atmosphere of risk on a daily basis. From the government perspective, much of the risk will take place in either the perception of the public of "deals struck" with the private sector, or in the failure of the private sector to deliver on services traditionally provided by the government. These risks need to be addressed in the structure of the arrangements made for a particular ITS project.

- **Be willing to alter the traditional rules by which state, MPO, and local governments operate.** Legislative changes may be necessary to enable certain privately-sponsored ITS projects to occur.

- **Provide an atmosphere of stability.** Private partners are usually unwilling to move forward on projects where the public partner's decisions are unreliable. Unfortunately, there is only so much that staff can do to create this atmosphere. Political change introduces sometimes dramatic shifts in thinking concerning public decisions. Long term commitments need to be locked in to engender the confidence of the private partner(s).

- **Devise mechanisms that will protect both parties while not squelching the opportunity itself.** This is where a balance needs to be achieved between willingness to take risks and building in necessary protections. Because government agencies have not traditionally negotiated in these areas with the private sector, experts with experience dealing with the private sector may need to be retained to guide the government agency through the process.

- **Be willing to give up turf where there is a legitimate area for privatization.**

- **Leave room for competition.** If there are profits to be made, and if there are ways to allow for multiple providers, the customer is best served by creating a competitive environment. The extent to which this is possible will depend on the specific nature of the ITS activity.

Legal Issues and Agreements

In the ITS project definition process, a number of legal complications may occur due to the specialized nature of these activities. These issues may include:

- Development of multi-agency agreements.
- Development of public-private partnerships.
- Ownership/property of hardware/software rights developed with or in conjunction with the project implementation.
- Product liability and insurance.
- Regulatory limitations on resource sharing.

- Roles of private parties.
- Organizational conflicts of interest.
- Organizational roles.
- Others.

While the nature of these issues cannot be easily determined during the course of an ITS strategic assessment process, early discussion of several of these issues should be conducted by key officials in the region in hopes of minimizing any associated impacts or eliminating them from occurring through proper planning.

Several types of legal instruments exist for creating agreements among public agencies and between public agencies and the private sector. Several of these include:

- **Memoran dum of understanding (MOU):** An MOU is a non-binding statement of understanding between two or more parties. It can address a wide range of agreements, from operational responsibility to the exchange of funds among agencies.

- **Cooperative agreement:** A cooperative agreement is similar to a contract, but usually involves the exchange of funds for services, or other agreements involving financial matters.

- **Contract:** A common legal instrument between parties and would be the typical form for an ITS arrangement between the public and private sectors.

- **Partnership:** A legal instrument in which agencies take on joint responsibility for a project. Costs, rewards, and penalties would be shared or incurred according to formulas set up in the partnership agreement. A true partnership between a public and private entity for a transportation-related project would be unusual.

Agencies entering into agreements with the private sector should consult legal counsel early in the process, for obvious reasons.

Public Relations

Undertaking a major ITS project requires careful attention to public perception. **Poor public perception not only jeopardizes a given project, but may make elected officials and the agencies they oversee more reluctant to move forward on other ITS ventures.** There are numerous pitfalls of which an agency should be aware. The pitfalls are more present for ITS than for capital-intensive projects because of the day-to-day operational attention required to run a successful system. The provision of real-time traffic or transit information to the public is a case in point. It takes numerous repeated times of accurate information to gain the public's trust; it takes only a few times of wrong information to lose that trust. Media attention to those problems, even if they are infrequent, will make the image of credibility more difficult to rebuild.

Maintaining credibility of operations is perhaps the single most important objective that an agency involved in ITS can undertake. Even an excellent public relations program may not be able to salvage a reputation damaged by consistently poor operation. Credibility is maintained in several ways: by executing operation consistently and with few errors; by not extending the operation of the system beyond its capabilities for reliability; and by quickly correcting errors and restoring confidence.

"Maintaining credibility of operations is perhaps the single most important objective that an agency involved in ITS can undertake. Even an excellent public relations program may not be able to salvage a reputation damaged by consistently poor operation."

One of the agencies with a long history involved in ITS deployment has provided a number of lessons learned on public relations related to ITS:

- **Bring in public relations at the outset of implementing a significant ITS project.** It is easy to stumble in the early stages and have that affect the project throughout. Public relations can help with crafting messages to the public and elected officials at a level that will be easily understood.
- **Develop the public relations tools early.** There are a variety of audiences, each with their own concerns. Be careful not to neglect the internal audience.
- **Don't try to compete with the media.** Maintain an open, helpful relationship with the media, to make them an ally rather than a foe.
- **Don't rush the process, but make sure what is implemented for the public works well.** It is better to under promise and over deliver, rather than the other way around.
- **Do your homework.** Anything that is said or provided to the media could be tomorrow's headline. Be able to stand behind what you say.
- **Think in terms of teamwork and share the glory.** Be willing to give up some credit for the long term benefit of the program.

Toward the end of the formulation of the ITS strategic assessment, it may be advisable to consult the appropriate public relations individuals associated with an agency.

DEVELOP THE ITS IMPLEMENTATION PLAN

Key Activities:

- Confirm agency responsibilities.
- Develop the action plan.
- Identify connections to other elements of the planning process.

Key Products:

- C Documentation of the ITS regional framework, including an implementation.
- C TIP project summaries for near-term projects.
- C Potential material for integrating into the long range transportation plan.

In this step, the results of the earlier steps are organized into the ITS Implementation Plan document and the background for its development. Some agencies may wish to call the report an ITS Strategic Plan. The name should be chosen to convey the intent locally. The purpose of the plan will be to guide the implementation of the ITS projects on an area-wide scale commensurate with the needs and objectives of the system. It will serve as a primary resource in the ongoing consensus-building associated with the ITS program. It will also serve as a guide to those carrying projects forward into design and implementation.

The plan embodied in the report should strive for: fundability, sustainability, flexibility, integration of activities, measurable benefits to customers, and sensitivity to details. The plan will focus on the short and medium term components and highlight the long term needs in order to set a long range goal or "vision" for future activities.

Information to be documented in this plan will include the steps from earlier activities:

- C Transportation system vision, problems/deficiencies, opportunities, and objectives.
- C Institutional issues.
- C Recommended market packages.
- C System functional requirements by subsystem and technology area.
- C System architecture requirements.
- C Technology options.
- C Implementation and operational strategies.
- C Specific projects: description, benefits, and responsibility.
- C Funding issues.
- C System Implementation or Operations Plan.

While much of the report highlights the background material and the foundation for decisions, a section should be included on the Operations Plan for the ITS system (covered in previous section). The Operations Plan should include an approach to accommodate advances in technology, feedback from ongoing tests, changes in institutional conditions, sources of funding, and any new emerging opportunities. An Implementation/Operations Plan is required for Federal-aid funded projects per 23 CFR, part 655, subpart D.

The strategic assessment document should be a high-quality, user-friendly, and dynamic document. The document will be utilized as a consensus-building document, receiving scrutiny by a range of public and private sector representatives. As a result, the document should be written to best present this information in a marketable way to gain the support of the key parties and stakeholders that will be involved in guaranteeing the success of the plan and the ITS System. Several meetings or agenda items should be planned to guarantee proper display, presentation, and public relations/consensus-building of the plan.

The ITS Implementation Plan should also recognize its place within the broader planning process. It is not the ultimate determinant of regional or statewide project priorities; rather, it feeds information and recommendations to the legally established processes of transportation plan TIP development. It also receives input from these other processes, and makes adjustments accordingly in later updates.

> *"The strategic assessment must also recognize its place within the broader planning process."*

One final note in the preparation of the ITS Implementation Plan is that the plan properly addresses the "vision" statement and the problems/deficiencies identified originally. These were the issues that initiated in the consensus-building effort and which were highlighted in much of the previous work. They also were the main reason or purpose for the conduct of a strategic assessment. Gaining or adding to the support of the program and system will require that the reasons for implementing the plan be emphasized throughout the implementation (existing and future) of the plan.

FOLLOW-UP ACTIVITIES

Effective Operations: Key To Long Term Success of ITS

A key to success of any ITS program is an effective execution of system operation. This requires an adequate staff of available and well-trained operators and maintenance personnel, up-to-date documentation on all system components, adequate budget for spare parts and expendables, and a long-term commitment on the part of the transportation agencies to utilize the system to its full potential, including keeping the various displays and system algorithms up-to-date on a continual basis. A "set-it-and-forget-it" policy will *not* work.

Although it is arguable whether examination of operations, staff training, and maintenance belong within the planning process, it is clear that these issues must be a consideration in the selection and funding of projects. One of main benefits of bringing operations personnel into the planning process is not only better decisions but a better transition to project implementation for all stakeholders. It is important for agencies responsible for planning to understand the commitment needed to keep ITS systems operating on a daily basis. These issues are also an important consideration in full project costing. The importance of operations planning was addressed in Chapter 2.

An effective operations and maintenance program is not always easy. While the system is expected to operate on a continuous basis, it must do so in a very demanding physical environment which subjects components to extremes in weather, temperature, electrical noise, and disturbances, as well as possible physical damage from vandalism and accidents. The system's operational environment is perhaps even more demanding. Daily operation of some system elements may be in full public view of travelers who are directly affected by it as well as the decision makers who are responsible for allocating the funding so necessary to the continued success of ITS.

Agency management must be made aware that the investment in ITS is not simply a one-time expense for design and installation, but rather a long-term commitment requiring continuous support. The sophistication and capabilities of a transportation management system usually do not reduce the size of the operations and maintenance staff. However, certain ITS strategies provide a significant return to agencies in terms of reduced costs. For example, electronic toll collection systems greatly reduce the operational expense of manned toll lanes. It is truly a win-win proposition for both the traveler and the operating agency. The same would be true of other ITS strategies that stress operational efficiency. However, for those ITS market packages that provide an added service (such as improved traffic information), a commitment to providing the necessary personnel must be made to ensure quality service. In some cases, this can be a cost borne by the private sector, which will derive returns through other sources of revenue. Automation of as many of the components as practical will minimize staff requirements.

The successful operation and maintenance of an ITS-based system must be an integral part of the entire implementation process from the very beginning. For example:

- During the strategic assessment, the system architectures and technologies must consider the associated operations and maintenance requirements. The system must be in balance with the agency's ability to provide the required operations and maintenance resources.

- The system must be designed to facilitate proper operations and easy maintenance. Considerations in this regard include user-interfaces, specifying environmentally-hardened, modular components that can be swapped in the field, locating components such that they are not vulnerable to damage, providing safe and convenient access to hardware for maintenance personnel, and including provisions in the contract documents for spare parts, test equipment, training and documentation, and testing requirements.

- Thorough inspection during installation, and stringent testing of all hardware and software before acceptance.

Training and Documentation

Although training and system documentation is not part of the strategic assessment itself, it is essential to <u>anticipate</u> the need for training and documentation in the planning process. Specific projects and funding should be identified, where necessary, to ensure that proper training takes place. Successful operation and maintenance of an ITS-based system is dependent upon personnel having access to adequate documentation. The documentation must be easy to follow by future employees as well as those who have been through initial training. Documentation must be provided for every system component and for every aspect of the system's operation. Additionally, this documentation must be in sufficient detail to fully describe the maintenance requirements, methods of operation, and the expansion/modification procedures. In essence, the documentation should satisfy the requirements of all personnel involved with the operation and maintenance of the system, including:

> *"Although training and system documentation is not part of the strategic assessment itself, it is essential to anticipate the need for training and documentation in the planning process."*

- Operators who must understand the theory of system operation as well as the procedures and various traffic flow and incident conditions.

- Maintenance staff who must understand the theory of operation of all of the electronics devices within the system. They must have installation procedures and parts lists, and they must know whom to contact (e.g., original vendor) should problems arise. They must also have schematic diagrams, cabling plans, and any other details required to maintain the system.

- Programmers who must be provided with detailed descriptions of software operation, including up-to-date source listings of the computer programs and descriptions of where everything is located in memory, so that functional modifications can be made as required.

- Analysts who must be able to modify the system database to incorporate new algorithms and functions, and to expand the system.

- Engineers and managers who will require summary information to be used for public relations or planning purposes.

As a minimum, documentation to be provided with an ITS-based system should include as-built drawings; hardware documentation (e.g., manuals that describe the operational and maintenance details for all components and equipment); software documentation (e.g., flow charts of logic, source listings, license agreements); and operator's manuals. System brochures and videos may also be developed for public relations.

Training should be given to maintenance personnel and operators before the system is accepted. The purpose of this training is two-fold. Most importantly, it provides the technical skills and proficiency required to operate and maintain the ITS-based system. The training process also gives agency personnel an opportunity to be familiar with the overall system objectives, thus encouraging their acceptance of the system. Training is most successful when it is continuous -- consisting of both formal and informal elements. Formal training consists of classroom-style seminars and workshops; while informal training is more "hands-on," consisting of day-to-day interaction between the agency personnel and the system provider/installer.

Training and documentation go hand-in-hand. For example, the operator's manual should be used as the primary text during the training sessions on systems operation, and equipment manuals and related documentation should be extensively utilized during the training on system hardware maintenance. This approach lets personnel become familiar with the documentation, and also aids in identifying errors and deficiencies in the documentation so they can be corrected prior to final acceptance.

Operations

Implementing a regional ITS program constitutes a major action on the part of the transportation agencies, leading to the active management of the regional transportation network. As part of that commitment, it is essential that qualified staff be dedicated to the various transportation operations center functions and related management activities. For a roadway-based traffic management system, these activities may include:

- Monitoring the system to determine the current performance of the roadway network, and identifying incidents or unusual congestion.
- Verifying incidents and determining the cause of congestion through the use of closed-circuit television.
- Reporting of verified incidents and unusual congestion, along with their causes and other pertinent information, to the State Police, maintenance, and other impacted agencies.
- Operating variable message signs including developing and updating the message libraries.
- Testing new control strategies.
- Keeping records, and day-to-day care of the control center equipment.
- Planning and coordination for the system response to construction activities (e.g., analyze traffic data to determine permissible hours of construction operations, develop special sign messages, review construction plans to determine impact on system elements such as detectors).
- Preparing and updating incident response and management plans.
- Responding to inquiries from other agencies and the public.
- Administering contracts affecting system operations (e.g., construction, maintenance, freeway service patrols).
- Planning and design for the expansion of the system, including implementation assistance.
- Interfacing with media and other private entities for dissemination of traveler information.

The local operations center should be viewed as the nucleus of the agency's commitment to ITS operations, and staffing levels should complement that overall commitment. The operations staffing requirements are dependent on the complexity and functionality of the ITS-based system, as well as the hours of operation. On a local agency basis, personnel levels should not be expected to increase significantly over current levels. Existing personnel will, however, be responsible for increased areas of activity, e.g., monitoring and evaluating additional signal timing plans (by time-of-day). Additional maintenance personnel may be required for maintenance/operation of a regional surveillance system (although this is dependent on the quality of the implemented detection systems).

For transit-oriented ITS applications, such as automatic vehicle location systems for fixed route service, a typical set of operations activities could include the following:

- Referencing the AVL display to locate transit vehicles that have called in with maintenance or security problems.
- Dispatching maintenance personnel or other field units to manage the problem.
- Making decisions to hold or release transit vehicles at transfer points, based on vehicle location.
- Spot-checking on-time performance in real-time and reviewing records of on-time performance for input to route and schedule modifications.
- Ensuring that GPS and control center equipment are in proper working order and that necessary repairs and replacements are made.
- Making recommendations for system improvement and/or expansion.

Maintenance

Provisions will have to be made for maintaining the ITS-based system and the associated technologies and electronic components. The agencies may need to hire one or more qualified electronic technicians (along with the associated test equipment, vehicles, spare parts, etc.); utilize contract maintenance; or some combination.

Contract maintenance is utilized to some extent in nearly all transportation management systems. Maintenance of the computer hardware and peripherals is a prime example, by which the computer vendor provides both preventative and remedial maintenance, including parts and labor for a fixed monthly fee. Leased/privatized communication networks also involve a form of contract maintenance.

There is precedent for contract maintenance covering all system elements. The Chicago Freeway Surveillance and Control System relies heavily on contract maintenance, and the INFORM system on Long Island, New York utilizes contract maintenance exclusively. Maintenance contracts can be written such that the contractor is paid for each specific work item (e.g., repair/replace VMS module, repair/replace camera assembly, perform preventative maintenance per unit) at an established unit price; or the contractor can be paid on a per month basis which covers *all* maintenance activities required to keep the system operational, regardless of how many activities are actually performed each month. Whatever the contract language, agency staff must be dedicated to manage and oversee these contracts.

Enteringinto a software maintenance agreement with the system supplier can be a worthwhile and cost-effective endeavor. Under such an agreement, the supplier can correct any latent programming "bugs" (e.g., flaws that do not reveal themselves for a year or longer), make system enhancem nts based on the experience of the operators, and provide system upgrades. This software maintenance can often be accomplished over a phone link and dial-up modem.

6. ITS STRATEGY EVALUATION AND SYSTEM MONITORING

Chapter 6 covers three elements that comprise important parts of the overall planning process: ITS strategy evaluation, system monitoring, and effectiveness evaluation of implemented strategies. Strategy evaluation can take place in a variety of areas in the planning process: in the formulation of the transportation plan, in corridor or subarea studies, in an ITS strategic assessment, or in other analyses not connected to a particular type of study.

Performance evaluation and travel monitoring are a critical part of the planning process feedback loop, illustrated previously in Exhibit 2-1. System monitoring provides input into ongoing operations as well as future planning. Effectiveness evaluation of implemented ITS projects provides feedback for improved decision-making in ITS planning and operations as well. ITS strategy evaluation is discussed first, followed by a treatment of system monitoring and effectiveness evaluation.

ITS STRATEGY EVALUATION

Analytical tools that can adequately examine the benefits of ITS strategies are still in the formative stages. Chapter 6 provides an overview discussion of the evaluation of ITS strategies using tools that are typically available to the transportation planning and engineering community. Appendix E supports Chapter 6 with procedures for evaluating specific ITS strategies. The basic approach taken in this Handbook is to provide insights into how the most reasonable estimates of ITS benefits can be derived for specific applications using <u>existing, available tools</u> and <u>without an inordinate investment in evaluation</u>. It is recognized that agency budgets for studies and evaluation are limited. It is important to understand that reasonable estimates of benefit can often be obtained without a large, costly undertaking. As more sophisticated tools are introduced, more refined answers can be obtained. But even if more sophisticated tools are available, many agencies will either not have the expertise to use them, or their use will not be possible within the time and cost constraints of the agencies conducting the studies.

Overall Framework

In the context of this section, strategy evaluation involves estimating the benefits of ITS strategies for planning purposes, that is, for the purpose of making decisions on whether and how to invest in ITS. In some cases, the investment in ITS should be considered virtually an inseparable part of the on-going business of operating the transportation system. This is particularly true where ITS reduces the cost of current operations (e.g. electronic toll collection). In other cases, however, the choice of an ITS strategy may not be so clear, and there may be tradeoffs to be considered between ITS and other strategies. It is in the context of making these tradeoffs that planning-level strategy evaluation becomes more important. The evaluation information could be generated in a variety of contexts, including the development of the transportation plan, corridor/subarea studies, ITS strategic assessments, etc. Regardless of the context, the challenges of evaluating ITS strategies are similar.

The typical framework of an evaluation includes the following:

- Identification of goals and objectives (typically generated from the transportation plan, corridor/subarea study, or strategic assessment)

- Identification of evaluation criteria (or performance criteria) that can serve as the basis for making comparisons of strategies or alternatives. Chapter 5 discussed possible "core criteria" for evaluation. These are criteria that allow ITS strategies to be evaluated not only against one another, but against other strategies. Several criteria related to ITS that normally would be considered core criteria are vehicle miles of travel (VMT), vehicle hours of travel (VHT), number of accidents, and quantities of emissions generated. Secondary criteria can also be identified (examples in Chapter 5). Criteria can be both quantitative and qualitative.

- Identification of alternatives or strategies to be evaluated. The point was made in Chapter 5 that ITS strategies need to be defined to the level at which benefits and costs can be identified. This includes not only the definition of the strategy itself, but the geographic setting in which the strategy is being applied (e.g. which bus routes and which miles of freeway or arterial street).

- Evaluation of alternatives using appropriate tools. This produces estimates of impact related to the evaluation criteria.

- Use of the information generated to make strategy tradeoffs and other planning decisions.

It is important to recognize both quantitative and qualitative elements to ITS evaluation. Some of the benefits of certain ITS strategies cannot be quantified. For example, there are benefits to obtaining traveler information in addition to potential reductions in trip time (e.g. having enough information to call home or business associates that you may arrive late, or allowing additional time to reach the airport). Chapter 5 illustrated some of those benefits, as they relate to the stakeholder groups. The qualitative benefits should be identified by stakeholder group, so that the stakeholders better understand how an ITS project could benefit them. The emphasis of Chapter 6 is on procedures available to quantify the benefits of ITS, where possible.

There are three generic approaches to quantitative ITS evaluation that are currently available: sketch planning analysis, travel demand modeling, and traffic simulation. These are related to analysis contexts in Exhibit 6-1. An overview of the three approaches is provided below, followed by information on the evaluation of specific ITS strategies using each approach.

Overview of ITS Evaluation Using Travel Demand Models

It is recognized that travel demand models are not as sophisticated in treating even the more traditional strategies as many planners would like. Although approaches are quite unsophisticated at this point, procedures for evaluating ITS within travel demand models are included to provide agencies with at least some guidance, while recognizing the limitations of the tools. Where a region has a more sophisticated approach, they are encouraged to use it.

> *". . . procedures for evaluating ITS within travel demand models are included to provide agencies with at least some guidance, while recognizing the limitations of the tools."*

Exhibit 6-1. Applicable Analysis Tools for Evaluating ITS Strategies

	Travel Demand Model	Traffic Simulation	Sketch Planning	Emissions Inventory Models	CO Hot Spot Models
Transportation Plan	U		U	U	
Plan and TIP Conformity	U			U	
ITS Strategic Assessment	U		U	U	
Corridor/Subarea Study	U	U	U	U	U
Isolated location		U	U		U

One of the advantages of using a travel demand model to estimate ITS benefits is that it expresses ITS effectiveness in the same terms as for other strategies evaluated with the model. Typically, these include vehicle miles of travel and vehicle hours of travel as the primary regional measures. Changes in traffic volume or in transit ridership on specific facilities also tends to be very important. There are significant weaknesses in the approaches prescribed, but they represent the best available techniques for using traditional travel demand models as ITS evaluation tools. Realistic alternatives to traditional travel demand modeling are likely a number of years away.

Travel demand forecasting models estimate highway volumes and transit ridership through a four-step process that includes: trip generation, trip distribution, mode choice, and assignment. In most regional travel demand models, trip generation is a function of socio-economic characteristics such as the number of households, employment, income, household size, and/or auto ownership. The trip distribution model converts the trips created by the trip generation model to a matrix of trips (trip table) to and from specific areas based on the region's travel characteristics. The mode choice model splits the trip table into travel modes based on the relative travel characteristics of each mode. The assignment procedures load the trip tables to the corresponding network, resulting in estimated traffic volumes and other travel-related variables.

The majority of models consider travel for the entire day, almost always a weekday. Some models simulate mode choice based on peak and off-peak conditions and assign trips to peak hour or peak period networks. The model will be more useful in ITS planning if it simulates peak period conditions. The impacts of ITS strategies in a daily model will be more difficult to quantify.

To evaluate ITS strategies with a travel demand forecasting model, the strategy must be characterized according to the parameters used in one or more of the modeling steps. Exhibit 6-2 provides a list of the parameters within a typical travel demand model that ITS strategies could potentially influence. The order of magnitude of the likely impact of each change is also noted (negligible, low, moderate, and high influence). The ratings are made within each category and between categories. Recommended model evaluation approaches for various ITS strategies are described in Appendix E.

Exhibit 6-2. Ability of Travel Demand Models to Account for ITS Influences

Model Step and Parameter	Sample Related ITS Strategies	Potential of ITS to Influence Parameter
Trip Generation - Trip rates - Auto ownership	 Pre-trip travel info. Ridesharing & transit incentives	Low overall Low Negligible
Trip Distribution - Travel time - Travel Cost	 Ramp metering, signal systems Tolls, pricing	Moderate overall Low Moderate
Mode Choice - Travel time - Travel cost - Auto ownership	 Ramp metering, signal system Fares, tolls, pricing Ridesharing & transit incentives	Low overall Low Moderate Negligible
Assignment - Roadway capacities - Free flow speeds - Travel cost - Speed-flow relationships	 Ramp metering, incident management, tolls Ramp metering, signal systems, info. Tolls, pricing Ramp metering, signal systems	Moderate overall Moderate Low High High

Overview of Sketch Planning Methods

Sketch planning refers to simplified techniques that can provide reasonable estimates of the benefit of various strategies. These methods will usually require only a calculator or spreadsheet, using logical assumptions and estimates. However, substantial reliance is placed on experienced judgements by the analyst. To the extent possible, these judgements should be grounded in actual experience from similar situations and/or in research. Sketch planning methods have the advantage that they are normally relatively quick and inexpensive. With some ITS strategies, sketch planning may be as reliable as more sophisticated methods, given that travel demand models and simulation models have not been designed to address many of the ITS improvements. The additional cost of reflecting an ITS strategy in a simulation technique may not be warranted. It should be understood, however, that sketch planning estimates will normally provide only rough approximations. Analysts should be careful not to over-represent the accuracy of the information.

> *"With some ITS strategies, sketch planning may be as reliable as more sophisticated methods, given that travel demand models and simulation models have not been designed to address most of the ITS improvements."*

Some sketch planning approaches involve the concept of "market segmentation." This means breaking down the components of the market one is trying to address (e.g. certain segments of the trip-making market, such as commuter trips, truck trips, or trips affected by certain types of incidents), analyzing those individual market segments, and reassembling the segments to assess the total effect on the system. It may involve analyzing a "typical" corridor and extrapolating those results to other corridors to estimate the total regional effect. Specific procedures for market segmentation approaches to the evaluation of certain types of ITS strategies are provided in Appendix E.

Overview of Traffic Simulation

Traffic simulation may provide a more sophisticated approach to some ITS evaluations. However, there are significant limitations. Most ITS strategies cannot be directly simulated with existing tools, but must be indirectly simulated through the adjustment of volume inputs and other parameters. Simulation provides a significant advantage over highway capacity analysis, as it tracks congestion from section to section and provides outputs in terms of speed and delay, the primary ways in which ITS affects travel.

> *"Simulation ... tracks congestion from section to section and provides outputs in terms of speed and delay, the primary ways in which ITS affects travel."*

An important step in the simulation process is model validation, in which the existing condition is simulated and compared against known data. It is similar to the validation process undertaken for travel demand models. For freeway simulation, a primary validation criterion involves matching the known speed profile with the simulated speed profile. Simulation models can be highly sensitive to relatively small changes in volume, and it is important that the validated model reasonably reflect current speed profiles.
Short-term evaluations using simulation (e.g. 5 years into the future) can often be conducted using trend line traffic forecasts, unless a major transportation project could occur in the intervening years. Longer horizon years should consider factoring in results from forecasts using travel demand models. Normally, traffic volumes cannot be used directly from travel demand models; rather the travel demand model outputs need to be refined to account for the under prediction or over prediction of traffic. This is particularly important when forecasts are being input to simulation models because of the sensitivity of the simulation model results to traffic volume inputs.

Choosing the Analytical Approach

A variety of factors need to be considered in selecting the analytical approach to ITS. Exhibit 6-3 illustrates some of these factors. In some cases, the analysis could also be two-tiered: sketch planning might be used as a screening tool, with more in-depth analysis for selected strategies depending on the outcome. Sketch planning analysis may also be required to generate inputs for some of the more sophisticated tools.

Some of the basic rules in conducting ITS-related analyses include:

- Have key assumptions reviewed by multiple staff, not just a single individual.

- Sensitivity analysis may be warranted for conditions where the validity of key assumptions is highly uncertain. Sensitivity analysis shows how the outcome will change depending on changes in those assumptions.

! Ensure that staff have proper training in the use of travel demand models and simulation models, where used. Changes in model parameters can sometimes have unexpected effects that may not be readily apparent. The basic structure of the models must be understood to avoid problems.

Exhibit 6-3. Analytical Approaches Favored Based on Selected Factors and Circumstances

Factor or circumstance	Analytical approach favored
Relatively little time	Sketch planning
Relatively little budget	Sketch planning
Need to compare ITS results on consistent basis with other strategies	Travel demand modeling or simulation
Need to estimate regional impacts of alternatives	Travel demand modeling or sketch planning
Higher level of scrutiny may be given to the analysis, or analytical expectations are higher	Simulation
Detailed peak hour or peak period analysis is essential	Simulation
There are many interconnected problems; need to view their inter-relationships	Simulation
Data are available from similar situations for comparison to the corridor being analyzed (however, caution should be exercised not to assume similarity just because data are available)	Sketch planning
Model does not exist to treat ITS strategy or data are not available to support model	Sketch planning

! Maintain good records of assumptions used for each scenario analyzed. Variations may need to be tested later, or assumptions may be questioned. Good records will support the credibility of the process. The specifications for an alternative or strategy tested should be included in the computer-generated output, whether it be spreadsheet, simulation, or travel demand model.

! Expose the underlying assumptions so that decisions can be based on full knowledge.

! Ensure that the study area incorporates the full effects of the strategy being analyzed. Upstream and downstream congestion that may be influenced by a strategy should be included as part of the study area.

! Note any potential secondary effects that may not have been included in the analysis (e.g. diversions that were not accounted for, etc.).

! Make the results understandable to the intended audience. In many cases, the audience will be non-technical.

Approaches to Evaluation of Specific ITS Strategies

Specific approaches to the transportation evaluation of individual ITS strategies are discussed in Appendix E. The strategies are generally organized by ITS market package. However, it is necessary to go below the market package level to have adequate definition of the evaluation approach, in some cases. Not all ITS market packages are provided with a methodology. However, the analyst will either be able to adapt the material in Appendix E to the evaluation of other strategies or will be able to devise a similar methodology based on the principles described. (Author's note: many of the approaches in Appendix E are newly devised for this Handbook. The procedures will be tested and refined in the next project phase, with the provision of examples. Observations on these procedures should be directed to the FHWA contact manager listed in Chapter 1.)

The discussion on simulation is based on three freeway models (FREFLO, FREQ, and FRESIM) and two surface street network models (TRANSYT-7F and NETSIM). These represent the most available and used simulation models for most applications in the U.S. However, they are not the only simulation models available. The simulation approaches describe how to use the appropriate models in the analysis of the ITS strategies. Approaches to estimating vehicle emissions impacts are described below.

ITS-Related Air Quality Analysis

In areas that are nonattainment for a transpiration related air pollutant, the 1990 CAA requires that transportation plans, programs, and projects that require Federal approvals, or use Federal funds, meet the transportation conformity requirements for ozone, carbon monoxide, and particulate (PM-10). On July 16, 1997, new air quality standards were announced. The old and new standards, which will be phased in through 2005, are shown in Exhibit 6-4.

Exhibit 6-4. National Ambient Air Quality Standards for Mobile Source Pollutant Concentrations

Pollutant (Mobile source related)	Old Standard	New Standard
Carbon monoxide (CO)	9.0 ppm (8 hours) 35 ppm (1 hour)	9.0 ppm (8 hours) 35 ppm (1 hour)
Nitrogen dioxide (NO_2)	0.053 ppm (annual average)	0.053 ppm (annual average)
Ozone (O_3)	0.12 ppm (1 hour standard)	0.08 ppm (8 hour standard)
Course Particulate (PM-10)	50 $\mu g/m^3$ (annual average) 150 $\mu g/m^3$ (daily average)	50 $\mu g/m^3$ (annual average) 150 $\mu g/m^3$ (daily average)
Fine Particulate (PM-2.5)	None	15 $\mu g/m^3$ (annual average) 65 $\mu g/m^3$ (daily average)

The transportation conformity rule requires that regional emissions analysis include emissions resulting from:

1. The entire existing transportation network in the nonattainment or maintenance area (all regionally significant and non-regionally significant projects);

2. All regionally significant federal (FHWA/FTA funded) and non-federal projects expected in the nonattainment area (must cover the 20-year planning horizon), including traffic signal synchronization projects in the transportation plan and TIP; and

3. All other regionally significant non-federally funded projects which are disclosed to the MPO through interagency consultation.

In addition, the regional emissions analysis must estimate the total projected emissions in certain future years (including the attainment year) and may include the effects of any emission control programs which are already adopted by the enforcing jurisdiction (e.g., vehicle inspection and maintenance programs, reformulated gasoline and diesel fuel). Exempt projects which have no emissions impact and are considered to be neutral are exempted from conformity requirements. These exempt projects, as defined in EPA's Transportation Conformity Rule (40 CFR 93.126, August 15, 1997), mostly fall in the safety, transit, and air quality improvement categories. Some ITS projects such as railroad/highway crossing warning devices, and construction of transit information kiosk are among the list of exempt projects.

Project-Level Carbon Monoxide Hotspot Analysis: Project level emissions analysis (hot spot analysis) applies to CO and PM-10 concentrations and is based on quantitative analysis using applicable air quality (dispersion) models. For conformity purposes, EPA has selected CAL3QHC as the recommended CO intersection model. PM-10 hotspot analysis will not be required until EPA releases modeling guidance. A corridor level evaluation is the appropriate level in which to examine project-level conformity for carbon monoxide. Quantitative hotspot analysis is required for these projects:

- Projects that are identified in the applicable SIP as sites of violation or possible violation.

- Any project affecting one or more of the top three intersections with the highest traffic volumes, or worst level of service (LOS) in a nonattainment or maintenance area.

- Projects affecting intersections that are at LOS D, E, or F.

The examination includes the evaluation of CO "hot spots" to determine whether the project will increase the number or severity of violations. For any project to conform, the project must not cause new violations of NAAQS or worsen existing violations. The evaluation of ITS in this respect would incorporate the following steps:

! Identification of sensitive receptor sites that could incur a CO violation or incur existing CO violations. Sensitive receptors normally refer to areas that would be occupied on an extended basis, such as back yards of homes, playgrounds, parks, or building structures.

! Collection of data to support the dispersion model analysis. This would include items such as traffic volume, idling time in queue, etc. (see manuals for dispersion models).

! Perform traffic and emissions analysis.

! Run the dispersion model with and without the change in ITS strategy, using emissions factors consistent with the year of opening. Analysis of future years will also normally be required.

! Identify whether additional violations will occur. If so, mitigation measures will need to be identified for non-exempt projects (see discussion in Chapter 2). It should also be noted that violations could be displaced by the removal of other violations.

Those analyzing CO hot spots should refer to procedural documents associated with the dispersion models. It should be noted that there are acknowledged weaknesses in the emission factors used for these models with respect to how ITS strategies affect emissions. Additional research on improvements to the methods of estimating emissions is ongoing.

Emissions Inventory Analysis: Emissions inventory analysis refers to the estimation of the total amount of emissions (in this case, by mobile sources) within a corridor, subarea or region. The results are normally expressed in grams, pounds, or tons of emissions. Concentrations of pollutants can be estimated through emissions dispersion models such as CAL3QHC or CALINE4. Concentrations arenormally expressed in parts per million (ppm).

The calculations of emissions and fuel consumption are included in ~~the~~ simulation models, such as FREQ and FRESIM. The evaluation of ITS strategies requires the consideration of "modal emissions." Modal emissions refers to emissions produced at various points in the speed change cycle: acceleration, deceleration, idling, and a constant travel speed. Emissions models such as MOBILE5A use average speeds from a set of federally established driving cycles. Use of these averages does not adequately reflect the nature of the changes brought about by ITS. The use of modal emissions factors within simulation models will typically produce better estimates of change in emissions and fuel consumption. For analyses conducted using travel demand models, the MOBILE5A factors (or the latest version of EMFAC in California) will need to be used, recognizing their limitations.

Recent research has indicated the dramatic differences in emissions rates at high acceleration rates versus low acceleration rates. This suggests even greater benefits from ITS strategies that may deal with reduction in congestion (in which accelerations and decelerations are frequent) and reductions in stops. For some strategies (e.g. such as ramp metering), the air quality benefit will depend on the magnitude of stopping added at ramps versus the stop-and-go movements on the freeway mainline. Research to support improved analysis is underway, but not yet available at the level needed for evaluation of most ITS strategies.

ITS IN SYSTEM MONITORING

ITS has the potential to revolutionize the availability of data for transportation planning. Specific opportunities are available in the following areas:

! Reducing the reliance on manual or temporary traffic volume counting, thereby either reducing labor costs or allowing more extensive collection of data.

! Providing additional capabilities to monitor travel time and speed which, up to this point, have been very expensive to collect.

! Providing for additional collection of transit data to improve operational efficiency.

! Collecting incident data, which also has been very difficult to collect in the past

These topic areas are discussed in more detail in the following sections.

Volume from a Freeway Surveillance System: Freeway surveillance systems can be used to collect traffic volume data. While these capabilities readily exist, there are a number of factors that complicate the collection of this information:

! An agency could quickly be overwhelmed by the amount of information available. Only a relatively small proportion of all available surveillance data would be needed for planning purposes.

! Days and time periods of data collected from the surveillance system need to be screened to eliminate days that will skew the results. Typically, planning requires the use of "normal" days to build the planning database. A variety of influences may make the data unusable or not useful: occurrence of significant incidents, seasonal influences, weather, construction, etc. A process to identify incident-tainted data is described later in this chapter under "effectiveness evaluation." This is as critical for constructing a sound basis for planning as it is for effectiveness evaluation.

! Traffic surveillance, control, and information systems use "smoothed" data to provide stability in making traffic control decisions. For example, a common smoothing technique is to use a moving average, in which the most recent time period is averaged into the prior moving average based on an assigned weight. Those requesting data for planning purposes need to be clear in discussions with traffic control center personnel that the "unsmoothed" version of the data is desired.

In addition, it should be clear that full detector stations be represented. Normally, surveillance systems have algorithms to account for failed detectors (e.g. in any single lane) when generating a full directional value. The procedures for this should be checked. Likewise, the treatment of missing detector stations (i.e., no data in any lane) should also be examined. In some circumstances of detector failure, the system may be unable to create a pure data set according to the identified specifications for planning. Some systems will pick up historical data, which may be derived in a way that is not suitable for planning.

> *"It is critical that ITS designers work with the planning community to design capabilities that will serve multiple functions, including planning."*

It is possible that new software may need to be created to accommodate the necessary features for selecting useable planning data. It is critical that ITS designers work with the planning community to design capabilities that will serve multiple functions, including planning. This only increases the overall value of the system, and can save an agency many hours of labor.

Design criteria for a surveillance system to serve planning purposes include:

- Capability to create and store raw data sets (not just smoothed data)
- Capability to count ramp volumes as well as the mainline
- Algorithms acceptable for planning purposes to estimate volumes for partially failed or failed detector stations
- Flags identifying data that were estimated due to failed detector
- Capability to document locations and time periods affected by significant incidents, construction activity, weather problems, and other influences. The capability can be either manual or computerized.
- Storage of data in 15-minute increments

Volume from a Network Traffic Surveillance System: Many of the same precautions and criteria discussed for freeway systems also apply to network traffic surveillance systems. Depending on the detector layout and recording capabilities, it may be possible to capture vehicle turning movements as well as link volumes. Again, coordination with planning staff is critical.

Traffic Speed and Travel Time Monitoring - The Importance to Planning: Speed and travel time are being given more serious consideration by the planning community in the monitoring of traffic conditions. There are several reasons for this, including:

- The traveling public most directly relates to time-based measures. Other measures, such as traffic volume or density, are not as meaningful.

- Speed and travel time are direct measures of the quality of traffic flow. A volume/capacity ratio or volume-based level of service are indirect measures, as they require the calculation of traffic capacity. Estimating capacity is an inexact science, and is particularly difficult on signalized arterial segments. A high estimate of capacity under-represents congestion, while a low estimate of capacity over-represents congestion. Speed and travel time require no intermediate calculations.

One of the difficulties of working with speed and travel time is the cost of data collection. Most transportation agencies collect travel time on a spot basis, if at all. Few engage in a regular program of travel time data collection. ITS provides an opportunity to collect more comprehensive travel time data at substantially reduced cost over methods involving moving car runs with paid drivers. However, a number of precautions should be taken, and good planning is required to allow ITS to effectively provide this data. Some potential applications are discussed below.

Speed and Travel Time from a Freeway Surveillance System: Freeway detector stations are typically spaced at half-mile intervals. As indicated earlier, most surveillance systems use one detector per lane for most detector stations, with occasional speed traps (two closely-spaced detectors in a single lane). Alternative detector technology, such as video image detection systems (VIDS), provide speed data as well as vehicle classification at every detector station.

> *"ITS provides an opportunity to collect more comprehensive travel time data at substantially reduced cost..."*

These and other detector technologies represent point detection systems. This means that estimates of speed along the length of a freeway need to be derived from these point sources. In most cases, this would be done by assuming that the speed represented by the detector station applies half the distance to the next downstream station and half the distance to the next upstream station. Although the representation of link speed is not perfect, experience has shown that a properly calibrated system, with enough averaged data produces reasonably good agreement with field data. However, the averages can be biased depending on the location of detector stations with respect to congestion and queues. In any evaluation of a freeway management system, it would be important not to use two different techniques for comparison. Compare manual speeds before with manual speeds after, and compare detector speeds before with detector speeds after. Comparing manual speeds before with detector speeds after is likely to lead to erroneous results.

Travel Time from a Network Surveillance System: Efforts have been made to estimate link travel time from a network or arterial surveillance system. A signal system uses both intersection approach detectors and "system" detectors for surveillance. System detectors are normally placed at mid-block, but not usually every link. Speed data from these detectors would be of little value, even if the detector stations were designed to collect it, as the vast majority of delay occurs at traffic signals. Attempts have been made to estimate delay at signals on the basis of input/output volume counts from the mid-block and approach detectors, coordinated with signal timing data. Although estimates may be improving, they are still believed to be inadequate for estimating link travel time for planning purposes.

Travel Time from Alternative Surveillance Technologies: An emerging alternative to detector-based travel times is automatic vehicle identification systems. AVI systems are being installed in some networks for monitoring bus movements or other government-related fleets. The AVI readers used for the buses could also be used for other vehicles equipped with appropriate transponders or other communications devices. Experimentation is also underway with other vehicle probe systems, including vehicles equipped with global positioning systems (GPS) and vehicle location systems using cellular telephone signals as the location mechanism.

Vehicle Classification: ITS surveillance systems are able to provide vehicle classification data at stations with detector pairs. These pairs can be in the form of virtually any type of detection, but are normally inductive loops. VIDS provides more flexibility in locating detector pairs to capture vehicle classification across all lanes of traffic.

Transit Monitoring Data: There are a number of ITS technologies that could help to automate the collection of transit data, to benefit ongoing operations and planning. Some of these technologies include automatic vehicle location systems that provide logs of bus trips, schedule adherence, average speed, etc. This could replace more costly and less frequent manual methods traditionally used. Automated farebox systems and passenger counting equipment can provide improvements in revenue and passenger monitoring. As with the traffic data, a key to useful transit data monitoring is in the translation of data into meaningful information. Those responsible for planning need to be involved in the design concepts for such systems. In some cases, the packages may be off-the-shelf, in which case a careful selection of the system to be purchased is in order.

ITS IN EFFECTIVENESS EVALUATION

One of the reasons that estimating the benefits of ITS strategies has been so difficult is that there is limited information on the effectiveness of implemented ITS strategies. Estimating the effectiveness of implemented strategies is not a trivial task. There are numerous factors that complicate the process of obtaining a "pure" evaluation.

> *"One of the reasons that estimating the benefits of ITS strategies has been so difficult is that there is limited information on the effectiveness of implemented ITS strategies."*

It is not expected that all implemented ITS strategies should be evaluated. However, in certain cases evaluation will be easier to achieve, and will have benefits not only for the greater ITS professional community, but for the refinement and improvement of operation of the local ITS program. In many cases, the need for data for operational decisions and the need for data for program evaluation are very similar. To the extent that these activities can be accomplished together, the use of funds will be optimized.

There are three potential values to conducting effectiveness evaluations of implemented ITS strategies:

- The results can be used in making better decisions on the selection and prioritization of ITS strategies yet to be implemented.

- The data can be used to improve the accuracy and responsiveness of models and analytical techniques that are used to conduct transportation planning and air quality analysis.

- The results can be used to refine and improve current operations.

The last reason is one of the most often overlooked reasons to conduct effectiveness evaluations. In many cases, the implemented ITS strategies may not be optimized or may have room to improve. Feedback of data to operations personnel can yield additional benefits from the implemented strategies.
.

> *"In many cases, the need for data for operational decisions and the need for data for program evaluation are very similar."*

Lower-cost evaluations are typically more possible where there is extensive surveillance that has been implemented as part of the project. Unfortunately, a before/after framework cannot always be achieved using the ITS surveillance system, as the system will have been "turned on" prior to the collection of the "before" data. In some cases, however, the surveillance information is available before any control and information activities are initiated. In this case, data can be collected during an appropriate before period without any of the effects on traveler behavior. This approach was adopted on the INFORM evaluation. INFORM is a freeway surveillance, ramp metering, and information system along 35 miles of the Long Island Expressway. The surveillance data was instrumental in assessing changes in travel time, volume, laneoccupancy, and response to incidents. However, to use surveillance data to reduce the cost of evaluation requires integrating the effectiveness evaluation needs into the planning process, and phasing the construction of the system appropriately. These are issues that are rarely thought about at the design stage, but have important implications for system optimization and system expansion.

Guidelines for Effectiveness Evaluation of ITS Strategies

The remainder of this chapter provides an overview of approaches to evaluating the effectiveness of implemented ITS strategies. A representative sample of strategies is used to illustrate various approaches and issues. The approaches here are not as sophisticated or comprehensive as those being conducted for ITS operational tests but rather emphasize evaluation activities that can be undertaken at relatively low cost by states, MPOs, and local agencies. Two items are specified:

- Candidate measures of effectiveness.
- Approaches to data collection and analysis, including complicating factors to be aware of in designing the effectiveness evaluation.

In addition, implications are identified in the design of ITS projects and programs to allow for easier and ongoing effectiveness evaluation. Only a sample set of ITS strategies are covered. Approaches may be devised for other strategies based on principles and procedures similar to those provided here.

Evaluation of Ramp Metering

Measures of effectiveness:

- Average Speed on the Freeway
- Average Speed on Arterial Streets
- Delay at Ramp Meters
- Average Queue Length at Metered Ramps
- Number and Severity of Accidents
- Number and Severity of Other Incidents
- Public Reaction

General Approach:

The basic approach to evaluating a ramp metering application is to compare speeds on the freeway and parallel arterials before and after the ramp metering implementation. Complicating factors to this type of evaluation include:

- There are a variety of ramp metering operational strategies, ranging from very restrictive to fairly unrestrictive. The speeds on the freeway can be dramatically different depending on the restrictiveness of the ramp metering policy. Therefore, the ramp meterining operation needs to be stable during the evaluation period and must be carefully documented as part of the evaluation.

- Traffic incidents and weather can affect the evaluation periods disproportionately. For example, the after period could incur a substantial number of incidents, whereas the before period could encounter relatively few. Therefore, the effectiveness needs to be gauged using "non-incident" data. A definition of an incident needs to be provided so that it is clear which data should be screened out and which data should be accepted. In most urban areas, it is difficult to get a completely incident-free time period, as minor incidents typically occur on a daily basis. A suggested definition of an incident significant enough to eliminate data would be: "any incident that occurs blocking at least one lane for at least 15 minutes." It is important to note that these incidents may occur not only within the confines of the study section, but also immediately downstream or upstream of the study section. For example, if a major incident should occur upstream of the study section, traffic will be metered into the study section and traffic flow will likely be significantly better than normal. Thus, incident effects should be examined outside the study section as well. Careful logs should be taken at the control center for documenting incident conditions.

- Traffic volume may be different in the before and after periods. Therefore, an examination should be made of traffic volume levels in all periods being compared so as not to be substantially influenced by changes in traffic demand within the corridor. This means, normally, that data should be collected during "typical" seasons, not a peak season nor a low period.

Regarding sample size, a typical value of 10 "non-incident" days in each period is desirable. Another important point is that detectors should be calibrated for both traffic volume and speed. The most sensitive part of this process involves the calibration of speed, as many systems use single detectors for most detector stations, with less frequent deployment of detector pairs or speed traps. A single detector can be used to estimate speed based on volume, occupancy, and average vehicle length. In some systems, average vehicle length is calculated for the nearest speed trap and applied to single detector stations. Other studies have found reasonably good correlation between actual travel time and travel time from surveillance systems. However, caution must be exercised to ensure that all data are being collected accurately. This is an important issue not just for effectiveness evaluation, but for ongoing operations.

Evaluation of Traveler Information Systems

ITS strategies that provide traveller information represent one of the more difficult sets of strategies to evaluate. This is because the information provided can impact traveler behavior in a number of different ways:

- Travelers can change their route;
- Travelers can change the time during which they trave; and
- Some travelers could even change their mode of travel. For example, a major incident could persuade some travelers to take a train or car pool on an HOV lane when, under normal conditions, they would not.

Most evaluations of traveler information systems have worked with the concept of origin to destination trip-making patterns. This approach is important, since travelers may choose to change their normal route in response to the information received.

There are numerous complicating factors in evaluating the effect of traveler information:

- **The amount and quality of information through existing sources can vary.** For example, radio stations currently provide traffic reports which are heard by a wide cross-section of the public. Part of the improvement in traveler information that may be introduced by the ITS strategy is to provide the radio station with a real-time surveillance map, which they can use in improving their information delivery. In this case, the evaluation of effectiveness would be testing the extent to which trip time improved based on the additional information given to the radio station, as enhanced through variable message signs, highway advisory radio, etc.

- **Other factors, such as changes in traffic volume, new transportation facilities, construction, etc., influence trip time** at least as dramatically as an ITS information system, or more so. Providing evaluation periods that are devoid of these effects is difficult.

- **Drivers may make inappropriate choices** based on the information provided.

- **The delivery of messages may be inconsistent**. A traveler information system develops a "personality" based on factors such as the strength of messages and content of the messages. Motorists come to depend on consistency in the way that messages are provided so that they can make the appropriate judgements. Failure to provide a stable, consistent operation will result in ineffective use of the information by motorists.

Measures ofEffectiveness:

- Origin to destination trip time
- Amount and source of information received
- Frequency of route diversion
- Frequency of trip time changes

General Approach:

In most cases, a full before/after evaluation of the impacts of traveler information will be difficult. However, a long-term monitoring of the system could be undertaken by identifying volunteer drivers who would track their time from home to work and document the type and use of information. This approach could be used to evaluate a number of different ITS and non-ITS strategies. Often, depending on the location of government agencies, transportation department volunteers could be used to gather this type of information. Additional information about individual trips can be collected in a survey or log format to examine the potential benefit of the information received. Exhibit 6-5 illustrates a format that could be used. It would document the results of their trip on a daily basis.

Evaluation of Incident Management Programs

The evaluation of incident management programs can also be a difficult undertaking, primarily due to the difficulty of estimating incident duration. Close coordination with police and other emergency response agencies will improve the ability to generate meaningful incident duration data.

Measures of Effectiveness:

- Incident detection/verification time by incident type/severity
- Incident response time by incident type/severity
- Incident clearance time by incident type/severity
- Time periods and locations of incident occurrences

Exhibit 6-5. Sample Commute Trip Survey Log

Name: _______________________________ Date of trip:__________

Origin location: ___ Home ____ Office
Destination location ____ Home ____ Office
Time that you left your origin (nearest minute) _____
Time that you left your destination (nearest minute) ____

- Did you pull off the roadway to make any intermediate stops? (Yes/No) ____

- Were you aware of any significant traffic incidents on this trip? (Yes/No) ___

- If yes, how did you hear about this incident?
  - ____ Heard about it after I finished the trip
  - ____ Heard it on the radio during the trip
  - ____ Saw it on a variable message sign
  - ____ Heard it on highway advisory radio
  - ____ Heard it through another source: ________________

- Did you change your normal route on this trip? (Yes/No) _____

- If yes, did you change it because of the information you received (rather than just your observation of traffic conditions)? (Yes/No) ___

General Approach:

Elements of an incident management program evaluation can be addressed through the methodology prescribed under the traveler information section. Ideally, one would like to be able to use travel time as a primary measure of evaluating an incident management program, as this is one of its primary objectives (i.e., reducing travel time and delay). If incidents were of the same type and severity and occurred in the same locations, it might be possible to use travel time directly as a measure of effectiveness. Unfortunately, this is not the case. Incidents vary widely in type, severity, time period, and location, and there is little chance that a comparable set of incidents would occur in a before and after period, nor would it be advisable to "stage" a set of incidents for evaluation purposes, although transportation engineers may have sometimes been accused of that by the public. Therefore, the core of the evaluation must rest on examining the effect of the incident management program on incident duration.

Some situations are more amenable for documenting incident duration than others. For example, a system with CCTV can be operated with a log of incident occurrences and response times. However, staff must be well trained and diligent in this process for the data to be useful. Exhibit 6-6 illustrates an incident log that could be used to document data from the CCTV system. If operators are not too over-burdened with other activities, logging this information is useful not only for effectiveness evaluation but for ongoing operation. It can also be used as a documentation of activities that may assist in justifying ongoing operational expense. This documentation process should be built into a database, allowing easier operator entry, and a more disciplined, paper-free, environment.

If the incident management program has had an effect, there should be a noticeable reduction in incident duration over time. Once the incident durations have been documented, a process can be used similar to that described in the estimation of ITS benefits (Appendix E) to analyze the potential effect of the improvement on traffic delay (i.e., through a simulation or sketch planning process).

Evaluation of Traffic Control Systems

Arterial and network traffic signal systems clearly have been the most evaluated ITS strategy and perhaps one of the most evaluated strategies of any kind. Many signal timing improvements have required before and after studies of travel time to demonstrate that the change had a beneficial effect. The results of these evaluations have been well documented. The evaluation of specialized ITS applications within traffic control systems can be more complicated. One of the reasons for this is that, if reasonably good timing plans already exist, the computerization and more sophisticated optimization of timing may represent more marginal improvements than if the baseline was represented by only moderately good or poor signal timing plans. Much of the benefit of more sophisticated traffic control systems lies in the new management abilities they provide: failure reporting and correction, maintenance, and capability to respond to special events and incidents. Therefore, documentation of the applications of the system under these conditions can be an important part of the evaluation. For measuring the effect on traffic performance, the use of moving car travel time runs is still an effective approach.

Exhibit 6-6. Sample Freeway Incident Log (Manual or Automated)

Observer: ________________________________ Date: ______

Sources of observation: __ CCTV ___ Scanner ___ Phone ____ Detectors

Incident location: Roadway _____________________ Direction ______
Between _____________________ and _______________________
Milepost _________ or Distance from upstream interchange _______

Incident type: ____ Accident ____ Out of gas ____ Mechanical
____ HAZMAT spill ____ Other spill ____ Flat tire
____ Construction ____ Debris/animal ____ Car fire

If accident, severity: ____ No injury ____ Injury only ____ Fatality

Maximum no. lanes blocked: _____

Times of occurrence: Incident occurred: ____
(military time) Authorities notified ____

(NAS = not at scene)	Police arrived:	____
	Medical arrived:	____
	Fire arrived:	____
	First tow arrived:	____
	Last tow arrived:	____
	Other:	____
	Incident cleared to shoulders:	____
	Incident cleared off freeway:	____

Comments:

Measures of Effectiveness:

- Speed on a sample of arterial streets
- Traffic volume (as a control variable)
- Number of stops
- Average vehicle delay at signals
- Number and severity of accidents
- Number of special events, construction/maintenance, incident applications of the system

General Approach:

The general approach to evaluating traffic control systems is consistent with the methods traditionally used, that is, the use of moving cars to assess changes in average speed, vehicle delay at signals, number of stops, etc. While the general approach is the same, the instrumentation available for conducting the data collection is becoming more sophisticated. Automated systems are widely used to record time and distance on a personal computer and to analyze that information in an automated fashion. Potential new ways of measuring travel time within a network environment include:

- Use of vehicle probes equipped with a global positioning system (GPS) connected to a recording device. GPS is rapidly increasing in its use across a wide range of disciplines. Data can also be tabulated to calculate vehicle delay and stops at intersections. Either a staff driver or other paid driver can be assigned to collect this information (no observer is needed), or a volunteer drivers might be used if they travel the network regularly during the desired time periods.

- Automatic vehicle identification systems that may be operable within the network. In some cases, transit systems are employing AVI/AVL systems to track, monitor, and dispatch their vehicles more efficiently. While transit vehicles may be appropriate for the evaluation of specialized applications such as bus preemption, automatic fare collection, etc., regular automobiles will normally be needed to provide appropriate data for estimating the effectiveness of the traffic control system itself. It is important, however, that sample sizes be adequate (a rule of thumb of six travel times runs within the same general time period). It is important that the samples be concentrated within a fairly limited period of time (normally no more than 30 minutes) so that variations in traffic volume do not significantly affect the results. Traffic volume data should be collected at the same time as the travel time data so that days with unusually high or low volumes can be thrown out.

Evaluation of Electronic Toll Collection

Electronic toll collection is one of the easier ITS strategies to evaluate. The number of vehicles through an electronic toll lane can be readily monitored, and the benefits to reduction in overall delay can be calculated. Operational information is also important, such as violations (i.e., vehicles passing through without an automatic tag), number of erroneous ID's, etc. Because the systems have been designed to be highly accurate, the likelihood of missed vehicles and wrong ID's is relatively low. These will have been worked out during the system shakedown phase.

Measures of Effectiveness:

- Traffic flow rate through electronic lanes
- If mixed lane, number of regular and tagged vehicles through those lanes
- Operational problems with system/downtime

General Approach:

Most AVI toll operations are set up to capture the above information. The systems are becoming routine and virtually self-evaluating. However, for ITS planning purposes, an estimate of the benefits of electronic toll collection systems needs to be conducted. This process can be undertaken as follows:

- Identify the number of tagged vehicles using the system
- Estimate the additional delay that would have occurred had those vehicles not been tagged vehicles
- Estimate any labor savings that may have been incurred due to the automatic operation (an agency benefit)

Evaluation of Automatic Fare Payment Systems

The principal expected benefit from automatic fare payment on transit systems is the reduction of dwell times at bus stops. This, in turn, could translate to travel time savings, making bus ridership slightly more attractive, and allowing more efficient use of the bus fleet. The approach to effectiveness evaluation is described below:

Measures of effectiveness:

- Number of passengers with automated fare payment
- Average amount of time for an automated payment versus a normal payment (including bus passes)

- Reduction in average dwell time per boarding passenger for buses with automated fare payment
- Gains in operational efficiency (accounting, reduced theft, etc.)

General Approach:

The tracking of data on automated fare payments is relatively straightforward. The recording devices on the bus will provide that information as part of its ongoing operation. The more complicated element has to do with tracking bus dwell time. This can be readily done with an on-board observer with a stopwatch or a recording device that provides the time between fare payments. It is expected that, before a significant impact can be realized on dwell time, a substantial proportion of bus riders will need to be on the automated fare payment system. Therefore, it is suggested that evaluations wait until perhaps at least one-third of patrons are using these systems. If most of the patrons are changing from monthly passes to the automated fare payment system, little change in dwell time may be realized. However, other benefits may accrue, such as reduction in cash handling requirements, reduced theft, and reduced losses due to forgery of bus passes. This type of information can also be tracked.

If significant reductions are realized in dwell times, the benefits to travel time, fleet efficiency, etc. can be estimated from this base data. In addition, modest effects may be estimated for improved traffic flow along bus routes. Even if there are benefits to traffic flow, it is highly unlikely that these could be detected through traffic data collection in the field. Therefore, it is recommended that the potential benefits be estimated indirectly by examining changes in dwell time and travel time of buses on a given route.

Evaluation of Transit Management Systems

The most visible part of a typical transit management system would be automated vehicle location with a possibility of providing information on bus location and schedule adherence to transit users. The approach to effectiveness evaluation would depend on which specific elements are included. Comments on each individual transit management system strategy are provided below.

AVL/Dispatching Systems

Measures of effectiveness:

- Schedule Adherence
- Bus Replacement Response Time

General Approach:

The primary benefit of an AVL system from the agency side is continuous knowledge of bus locations so that operational problems in the field can be quickly responded to. For example, buses caught in a major incident could have a rapid replacement for the remainder of the route through on-line dispatching. It is difficult to gauge the benefits of this directly, but it should improve the confidence of transit riders in the system overall, provided an agency uses the information to improve responsiveness.

Real-Time Transit Information (displaying schedule adherence information at home, office, or bus stops)

Measures of effectiveness:

- Change in passenger wait time at bus stops
- Perceived convenience to passengers
- Increase in transit patronage linked to information (e.g. identified through survey)

General Approach:

One of the most direct benefits of a real-time transit information system is that passengers could better time their arrival at bus stops. This would allow them to use their time more productively, and would potentially reduce the opportunities for crime at bus stops, and improve passengers' sense of security. The approach to evaluation would be to have passengers measure their wait time at bus stops with and without this information. It would require that passengers be surveyed prior to and after they had received the capability of obtaining this real-time information. It is also possible that, due to the greater convenience of this system, some individuals may be persuaded to begin taking transit. Thus, a survey instrument could be devised to identify the extent to which people begin riding transit because of this feature. This would likely be combined with other survey data that are periodically collected by transit systems.

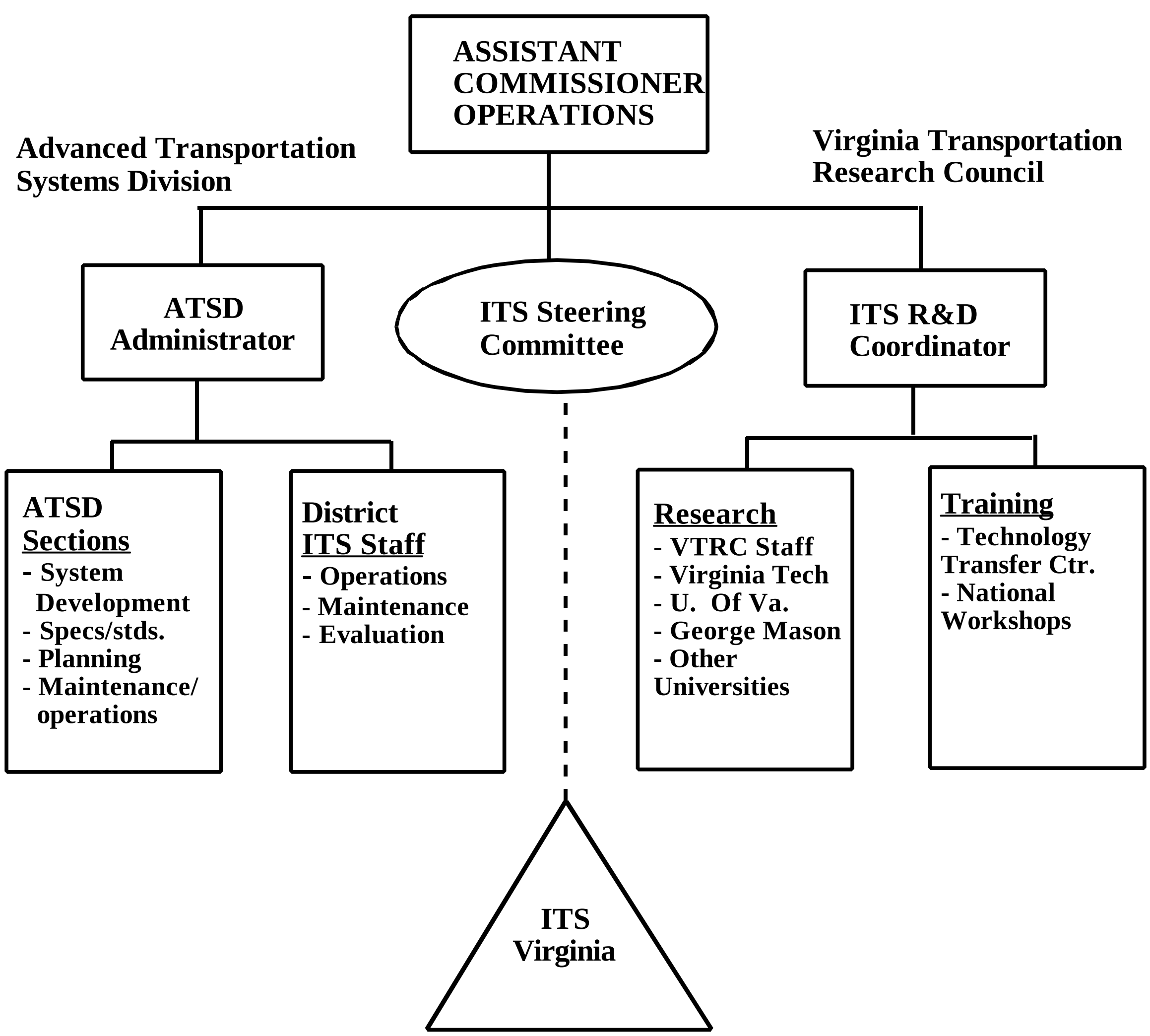
7. ITS PROGRAM ADMINISTRATION

ORGANIZING TO ADDRESS ITS

Like any other major transportation program, ITS can present management challenges. One of the common remarks among agencies who are planning and implementing ITS projects is that ITS has presented a challenge to their personnel practices and to the way that they generally do business. State and local transportation departments involved in ITS require individuals with greater electronics and software backgrounds. ITS also crosses geographic, institutional, and modal boundaries, presenting unique challenges to putting cohesive projects together.

Exhibit 7-1 shows one organization from the Commonwealth of Virginia. Within Virginia DOT, an administrator of the Advanced Transportation Systems Division (ATSD) reports to the Assistant Commissioner for Operations. The ATSD Administrator guides the activities of both the central office ITS staff and district staff. The Virginia Transportation Research Council manages ITS research and development.

Exhibit 7-1. ITS Program Organization in Virginia DOT



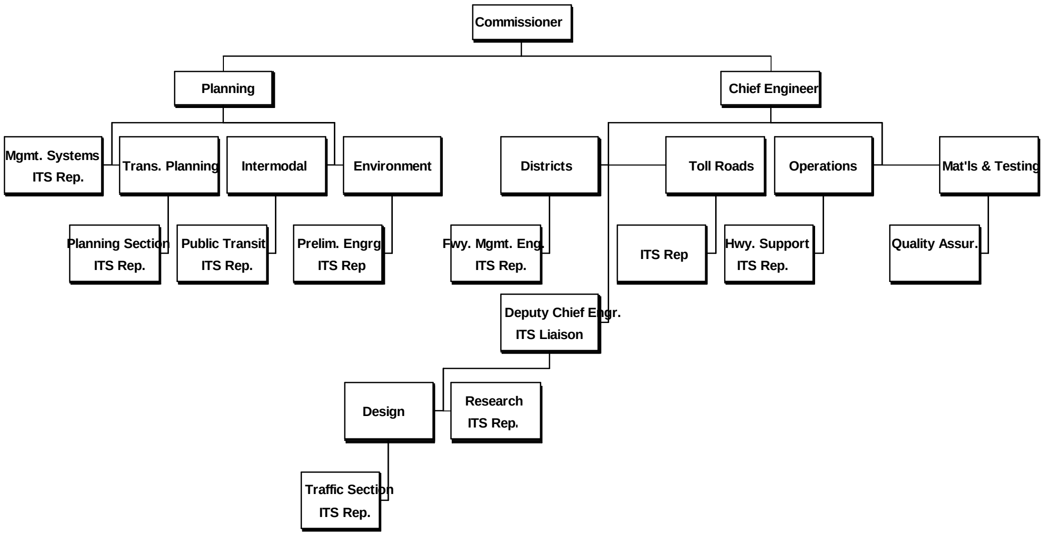


Exhibit 7-2. Partial Indiana DOT Organizational Chart and ITS Representatives

The State of Indiana has identified "ITS representatives" within major branches of its organization, recognizing that ITS may have application in a broad range of departmental activities (Exhibit 7-2). A number of MPOs have also organized themselves to address ITS through the transportation planning process, as discussed in Chapter 3.

Although organizational structures are not the complete answer to institutional problems, a recognition of the special needs of ITS within an existing organizational structure can help to create an atmosphere of collaboration and success.

> *"a recognition of the special needs of ITS within an existing organizational structure can help to create an atmosphere of collaboration and success."*

STAFFING FOR ITS MANAGEMENT, OPERATIONS, AND MAINTENANCE

Finding the right staff to support ITS is critical to success. At the management level, existing staff that have worked in related fields or have a particular interest in ITS can sometimes be adapted to that role. This is typically not true of operations and maintenance. The skills are much more specialized.

ITS job functions

The very nature of ITS means that attention must be paid to its operation, and that this requires knowledgeable staff. The staff requirements can vary widely from one application to another. In some cases, as with ITS-related transit maintenance system or fare collection system enhancements, existing staff can often handle the requirements at even a higher level of proficiency than was possible before. In this sense, ITS can be a benefit in terms of improved productivity. Even here, the skill levels and need for training increase, as the methods for operating a transit or highway system become more sophisticated.

In other cases, such as major traffic operations centers, staffing requirements can increase in both the maintenance and operations areas. Agencies need to understand that the systems will not run themselves. Equipment must be maintained, and individuals need to be assigned to operational tasks. A typical ITS traffic operations application (either freeway or surface street) would require staff support from among several possible functions: System Manager, transportation engineers, transportation technicians, system operators, software support programmer, and electronics maintenance specialists. Each system would not necessarily require all these functions. The method for recruiting these individuals, and the level of expertise and experience, depends on the tasks required. Normally, the system implementer or contractor will have advice on where these individuals might be found and the specific skills require. Although systems cannot be expected to run themselves, it is advisable to automate as many functions as possible. This may reduce the number of staff required for operations, reduce demands on the operators, and provide more consistent system operation. In general, systems should be designed to present options or recommendations to the operator, who will then make decisions on whether to accept, reject, or modify system recommendations.

Maintenance by contract is also a common option, particularly in the embryonic stage of system implementation. A period of operation is often included in system integration or system management contracts. This can have the following benefits:

- Provides a testing period to ensure that the system is operational before final acceptance

- Provides for a period of training agency staff, preparing them to take over the system

> *"A long-term commitment to ITS may mean setting up a distinct ITS-related career path for the individuals with a critical skill or knowledge base that supports ITS."*

Staff Rotation and Career Path Issues

ITS-related staff skills are not nearly as plentiful as with traditional highway design and construction programs or transit operations. Therefore, the impact of staff rotation on the development of an effective ITS program can be significant. It can also have a significant adverse impact on agency coordination and integration efforts. Agencies that are not on a rotation cycle are often frustrated by agencies who are, because there is a sense that they are always trying to bring staff up to speed. While staff will change for many reasons (promotions, retirements, job changes, etc.) there is a sentiment that the problem should not be made worse than it needs to be. Staff training needs can be satisfied in a variety of ways without impacting on the progress of actual projects. A long-term commitment to ITS may mean setting up a distinct ITS-related career path for the individuals with a critical skill or knowledge base that supports ITS. This is important when one recognizes that implementing ITS projects will require multiple years.

ITS CHAMPIONS

The institutional and technological complexity of ITS presents significant challenges in moving projects forward through implementation to operation. Projects often do not become reality unless there is an individual or group of individuals that is committed to crossing all the expected hurdles. Behind many successful projects is a "champion," an individual who was attending to the details to ensure that projects did not end with a planning report. An ITS champion must have the tenacity to continue working constructively toward implementation even when institutional issues and technical barriers have potential for impeding progress. Some of the activities in which the lead individual must engage include:

- Chairing or co-chairing meetings of the ITS steering committee associated with an M.O. or assigned oversight to an ITS planning effort
- Listening carefully to agency concerns
- Providing work assignments to committee members and consultants and seeing that they are followed through
- Introducing new ITS committee members to the accomplishments and expectations of work on the committee
- Making presentations to other agencies, business and community groups
- Meeting with elected officials and management to secure commitments of cooperation, funding, etc.
- Working to develop partnerships with the private sector, where appropriate
- Ensuring that the development of plans, specifications, and estimates are consistent with the ITS vision and available funding
- Trouble-shooting the implementation of ITS projects

- Seeing that adequate resources and training are provide to operate and maintain the system

- Promoting continuing communication among agency and private sector partners

A successful ITS initiative must have people who are committed to the program, who are willing to go out of their way to explain the technology and the benefits to be realized. Staff need to be available to spend time on the project. It cannot be a half-hearted effort.

THE INSTITUTIONAL ASPECTS OF FUNDING: EXPERIENCE ON COLLABORATIVE EFFORTS IN SOUTHERN CALIFORNIA

Funding ITS is not always a straightforward exercise, particularly in the institutionally complex environment that exists in most metropolitan areas. A case study in Los Angeles County, California provides a good example of how agencies have been brought together, funds identified, focused and leveraged into accessing a significant source of funds for the incremental development of an ITS program. One of the problems of funding ITS in Los Angeles County was the lack of coordination of activity. The County was losing out on opportunities for funding signal projects and other ITS activities through the state's Transportation System Management (TSM) program because of not being focused. There were many agencies in the County pursuing small portions of funding for traffic operations and signal projects. Other larger projects in transit and freeway capacity enhancements consumed most of the available funding. This led to the creation of the Signal Support Group within the Los Angeles County Metropolitan Transportation Authority (MTA). The County was divided into areas of, on average, 10 cities each for the purpose of coordinating traffic signal projects. Each of these groups of cities then put together an action plan for signalization in that subregion.

In conjunction with the creation of the Signal Support Group and subregions, the County decided to pool TSM funding and related ISTEA funds. They subsequently allocated $134 million over a four-year period for specific improvements which allows for a four-tier approach building up to a full ITS deployment. The tiers include:

1. Signal synchronization
2. Coordinated systems
3. Transit preferential treatments
4. Smart corridors

The Smart Corridor in Los Angeles has provided other opportunities for cooperative arrangements among agencies for implementing ITS projects. The Smart Corridor is a freeway/arterial corridor approximately 12 miles long and approximately five miles wide, running from just east of downtown Los Angeles to the west toward Santa Monica. Responsibilities for funding and implementation of Smart Corridor projects have been shared among agencies. The agencies identify a project element, decide who is the logical lead for first, obtaining funding and second, managing the contract. The same agency does not always secure the funding and manage the contract. One agency may have access to funding, set up a memorandum of understanding to transfer dollars to another agency who actually manages the contract. This is a frequent occurrence in the Smart Corridor.

WORKING WITH ELECTED OFFICIALS AND THE PUBLIC

Elected officials tend to know relatively little about ITS. ITS is not particularly visible, nor is it easy to convince elected officials and the public of its benefits. Like any other program, convincing elected officials to spend public dollars on ITS requires that meaningful information be provided frequently and in a readily digestible format. Some of the types of information that should be considered include:

! Summary literature on ITS applications. Examples include:
  - *ITS Success Stories*, Public Technology, Inc., for FHWA, October, 1995
  - *Intelligent Transportation Systems Action Guide*, by ITS America
  - Brochures on ITS implementation from other areas

! Videos of ITS implementations from around the country. Examples include:
  - U.S.DOT Operation Timesaver Video
  - Moving Transportation Into the Information Age, by ITS America

! Visits to other operational ITS sites

! Briefing papers prepared through the ITS strategic assessment process or through other ITS planning activities

> *"...convincing elected officials to spend public dollars on ITS requires that meaningful information be provided frequently and in a readily digestible format."*

Elected officials have many issues to deal with other than transportation, many of which are more visible or sensitive. Providing visibility for ITS and encouraging substantive thought about ITS can be difficult in the midst of busy agendas. Separate half-day or full-day workshops have been used in some cases, but again, there is substantial competition for elected officials' time, and this opportunity may not occur. Some of the techniques for overcoming these problems include:

! Provide for occasional <u>brief</u> presentations at regularly scheduled council meetings, board meetings, etc. to educate elected officials.

! Provide separate material to newly-elected leaders who may have missed prior presentations. Individual meetings may be needed for education through the continuing turnover that occurs in the political arena.

! Support elected official education with outreach to the media. Press releases can be provided at project milestones, or press conferences can be arranged for the most significant events, such as initiation of operation of major ITS elements.

- Provide videos or reading material that elected officials can view or read at home.

KEYS TO SUCCESSFUL ITS PLANNING, IMPLEMENTATION, AND OPERATIONS

There are many keys elements that could be cited for successful ITS implementation and operations. The keys to success in one area may be different than the keys to success in another. However, there are elements that are common among many of the systems that have been implemented, have good reputations, and are providing a useful service to the community. Some of these include:

- Customer orientation: The delivery of ITS projects and programs needs to address the needs of the customer: the commuter, traveler, transit rider, goods transporter, etc. Long term success will depend on the perception that a useful service is being provided.

- Problem-solution emphasis: This reinforces the customer orientation. The focus should be on how ITS is addressing problems or is improving travel convenience and safety to the public. Elected officials must understand how ITS can be their ally in gaining the favor of their constituents.

- Integration: ITS is one of a broad array of techniques to address today's transportation problems. ITS is often used to best advantage when integrated with other techniques. It must work in coordination with other approaches, not merely be in competition with them.

- Partnerships: Substantial ITS deployment cannot be achieved by a single agency. Partnerships must bring agencies together across geographic boundaries and across lines of functional responsibility. For the purposes of long term funding and coordination, partnerships must bring the public and private sectors together.

- Communication with elected officials: Elected official support is essential to long term success. This support must extend across election cycles to maintain continuity. Developing this continuing support requires continued attention, information, and education.

- Maintaining credibility: The public will mistrust projects that do not work predictably and consistently. Failure to maintain credibility will ultimately erode support for ITS. Maintaining credibility goes hand-in-hand with the customer orientation mentioned above.

- Attention to details: Success in ITS is in the details. The details are important in all phases of ITS implementation, from construction to maintenance, to operations. Decisions need to be carefully weighed on striking the balance between relying on proven technology versus moving forward with the latest technology.

- Patience: Like most transportation projects, many ITS projects take a significant time to materialize. Patience and persistence will ensure that ITS ultimately makes its mark in improving transportation system efficiency.

APPENDIX A

DESCRIPTION OF ITS MARKET PACKAGES

(Source: National ITS Architecture Implementation Strategy)

2.4 Market Package Synergy

One of the unique attributes of the National Architecture Program is the breadth of ITS services that it covers. This scope allows each potential service to be considered in context with all other ITS services, identifying common features and shared functionality. Questions such as: "Once I implement electronic toll collection in my region, what other services can I implement by extending the beacon infrastructure?", and "What sorts of efficiencies are possible when advanced traveler information and traffic management systems are implemented in the same region?" are readily answered through the National Architecture. These inter-relationships, or synergies, are presented for each of the defined market packages in this section.

Consideration for these market package synergies can result in more efficient deployment of ITS services over time. The architecture can only identify the potential synergies, it is up to the local implementor to develop a deployment strategy that capitalizes on these efficiencies.

Synergies have been identified and analyzed for each equipment package and then aggregated and presented in this section at the market package level. A large number of synergies can be derived from the Architecture Framework by examining the data flows that are shared between equipment packages. Only the most significant synergies are brought forward and discussed in this section.

Several different types of synergies have been identified, from most restrictive to least restrictive as follows.

> Interdependent: Interdependent equipment packages are the most closely coupled. Two equipment packages are interdependent if both must be deployed to achieve an ITS service. If interdependent equipment packages are not deployed at the same time in the same region, the resulting service will be marginal or non-existent. All interdependent equipment packages have been allocated to the same market package to reflect this required association. Since interdependent equipment packages are not allocated to different market packages, there are no interdependent relationships between market packages.
>
> Common Functions: Equipment packages which reside in the same subsystem can share common functions to more efficiently implement the required services. This type of synergy reflects the potential sharing of hardware and/or software to perform a function that is required by both equipment packages. The shared functions are included in only one of the equipment packages and synergy is noted between the equipment package which includes the common equipment and the remaining equipment package(s) which utilize it. Many equipment packages rely on equipment included in more basic equipment packages to support more advanced capabilities. Such "incremental" equipment packages allow efficient deployment over time by building on existing equipment capabilities. In other cases, equipment packages which share functionality are of the same relative

sophistication. In such cases, the dependent equipment packages may be implemented in either order based on the needs (and preferences) of the end user. The common equipment is purchased with the first equipment package to be deployed.

Shared Information: Some equipment packages rely on information provided by a equipment package in a separate subsystem. In many cases, if the equipment package which supplies the information is not deployed, the equipment package which relies on the information will still provide degraded capabilities but not satisfy all user service requirements allocated to it. Typically, this “Shared Information” synergy reflects information that is shared between an information collection/provider equipment package in the infrastructure and an information user equipment package which is part of a second infrastructure subsystem or a mobile subsystem.

Complementary: Even when equipment packages may be independently deployed and operated to achieve the required user services (i.e., the equipment packages are not part of the same market package, do not share equipment, and are not required to share information), there may still be synergy between the provided services which should be considered in an implementation strategy. Complementary equipment packages provide compatible services which, taken together, enhance net system performance. In most cases, this relationship reflects the sharing of optional information between equipment packages within the architecture definition. In such cases, the information generated by one equipment package, if available, enhances the service provided by a second equipment package. In contrast, a Shared Information dependency, if not satisfied, prevents the associated equipment packages from meeting all of the user service requirements.

A series of five diagrams and accompanying discussion describe the principal synergies identified for the market packages. In each diagram, the connections represent the synergies between the market packages. Tracing the diagrams along the flows provides various efficient deployment sequences that leverage the incremental nature of the market packages.

The connections are coded to represent the types of synergies between market packages. When market packages are related in more than one way, the most restrictive dependency type is shown. (e.g., If two market packages share common functions and share information, the flow connecting the two market packages would reflect a “Common Functions” synergy.). Note that the “Interdependent” relationship is not represented in the figure since this synergy exists only between equipment packages within the same market package.

Each of the diagrams illustrate the market package synergies for a particular stakeholder area (e.g., Traffic Management, Traveler Information, etc.) Often, synergies will cross stakeholder boundaries (e.g., Traveler Information market packages are often reliant on information from Traffic Management market packages). These synergies are documented by "off-page references" which indicate the stakeholder area in an oval along with the associated market package. The text accompanying each diagram briefly describes, and justifies, the major synergies.

Advanced Traffic Management Systems

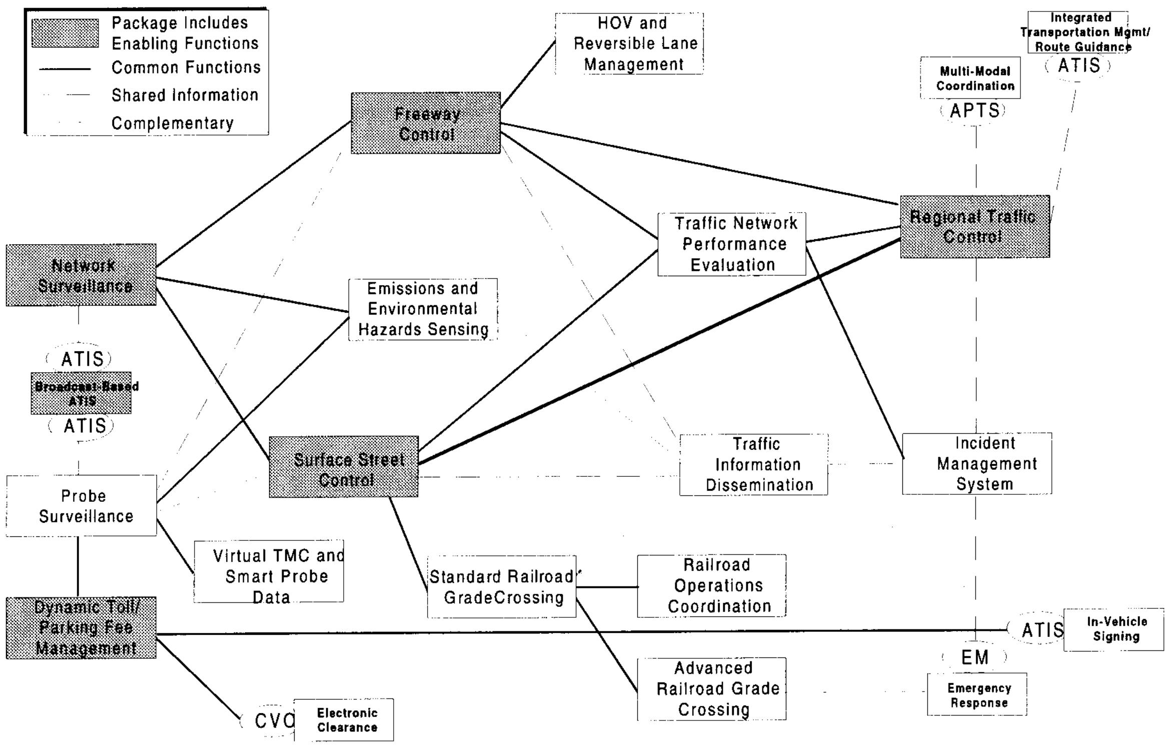


Figure 2.4-1. Advanced Traffic Management Systems Market Package Synergies.

The most significant common feature of the Traffic Management market packages is the shared need for traffic information. Each of these packages are supported by the basic surveillance infrastructure that is implemented through the two surveillance market packages. The information provided by this equipment (e.g., traffic counts and speeds) can be used for many purposes, including control and management of the traffic signals, incident management, emissions management, and traveler information. The surveillance data can also be saved as historical data for planning purposes or for evaluating the effectiveness of previous system enhancements. Each of the synergies that have been identified between the Traffic Management market packages are elaborated in the following descriptions.

Network Surveillance Market Package

This market package implements the basic roadside sensors, controllers, and communications infrastructure equipment which is leveraged by most of the other ATMS market packages. In addition to providing the information necessary to support more advanced traffic management implementations, this package also shares traffic information with the ATIS market packages.

Probe Surveillance Market Package

This market package provides an alternative approach to surveillance which provides many of the same fundamental benefits as the network surveillance market package. The dependency to the Surface Street and Freeway control market packages is denoted as data sharing since this package does not require implementation of the extensive distributed roadside infrastructure that may be directly utilized by the other ATMS packages. Dedicated Short Range Communications and AVI technologies may be shared between this package and the Dynamic Toll/Parking Management package. The Virtual TMC and Smart Probe Data market package adds additional “smart probe” capabilities such as road condition monitoring to the basic probe capabilities offered by this package.

Dynamic Toll/Parking Fee Management Market Package

This market package shares common functionality with the Electronic Clearance, In-Vehicle Signing, and Probe Surveillance market packages. Each of these market packages are additional potential applications for the dedicated short range communications, AVI, and rudimentary driver interface capabilities offered by this Toll/Parking market package.

Freeway Control Market Package

The infrastructure implemented to support this market package facilitates implementation of the HOV and Reversible Lane Management market package. HOV management should be able to utilize much of the same wireline communications, surveillance, and control infrastructure provided by this market package. Several more advanced traffic management market packages build on the fundamental infrastructure and control strategies supported by this package by increasing the level of coordination and/or increasing the sophistication of the control strategies.

Surface Street Control Market Package

This market package provides a basic surface street control building block, analogous to the Freeway Control Market Package above. The highway-highway intersection management capabilities provided by this market package are closely related to the highway-rail intersection capabilities provided by the market packages which support grade crossings.

Standard Railroad Grade Crossing Market Package

This market package manages traffic at highway-rail intersections using equipment that has potential commonality with equipment used for surface street control. The active warning systems and ancillary supporting equipment included in this market package provide the basic equipment that is augmented with additional features in the Advanced Railroad Grade Crossing market package. In the same way, the basic communications between Traffic Management and Rail Operations that is established in this market package is expanded and leveraged in the Rail Operations Coordination Market Package. The basic intersection status provided to the driver by this market package may be expanded and also provided through the Traffic Information Dissemination market package (e.g., variable message sign displays) and the In-Vehicle Signing market package. The communication of intersection status to the vehicle provided by the In-Vehicle Signing market package can be further extended and applied to intersection safety warning and intersection collision avoidance as will be seen in the analysis of the ATIS and AVSS market packages.

Advanced Railroad Grade Crossing Market Package

This market package adds additional surveillance, physical barriers, and enhanced driver information systems to the core equipment included in the Standard Railroad Grade Crossing. The surveillance capabilities can enable real-time detection and reporting of collisions which can speed Emergency Response.

Railroad Operations Coordination Market Package

This market package provides additional coordination between railroad operations and traffic operations by building on the same interface established for the Railroad Grade Crossing market packages. This market package provides area-wide, accurate forecasts of grade crossing closures that can be factored into regional control strategies provided by the Regional Traffic Control market package.

Emissions and Environmental Hazards Sensing Market Package

This market package provides emissions and hazards information to the Traffic Information Dissemination market package. It may be interconnected with the basic surveillance infrastructure deployed at the roadside for cost-effective implementation.

Traffic Information Dissemination Market Package

This market package provides basic roadside information dissemination infrastructure which is applicable to a wide variety of traffic management market packages. The basic infrastructure which provides an information dissemination interface located at the roadside which is controlled by the traffic management subsystem may be extended to provide in-vehicle signing capabilities in more advanced applications.

Incident Management System Market Package

This market package utilizes the traffic information dissemination and traffic control capabilities deployed through other market packages to adapt traveler information and traffic control strategies to account for incidents. The communications infrastructure and working relationships established to support Incident Management can also be used to support the coordination required for the regional traffic control market package. This market package shares information with the Emergency Response market package to enable coordination between traffic management and emergency management subsystems in incidents and other emergencies impacting traffic management strategies.

Regional Traffic Control Market Package

This market package enhances the coordination between traffic management systems within a region. It directly leverages the existing traffic control systems (freeway and arterial) already implemented in the region through improved coordination between traffic management systems in the region. It also benefits from the same coordination between agencies within the region that is established in the Incident Management System market package. The regional scope of this market package provides the opportunity to fully realize the benefits of enhanced coordination with the transit systems and railroads operating in the region.

Advanced Traveler Information Systems

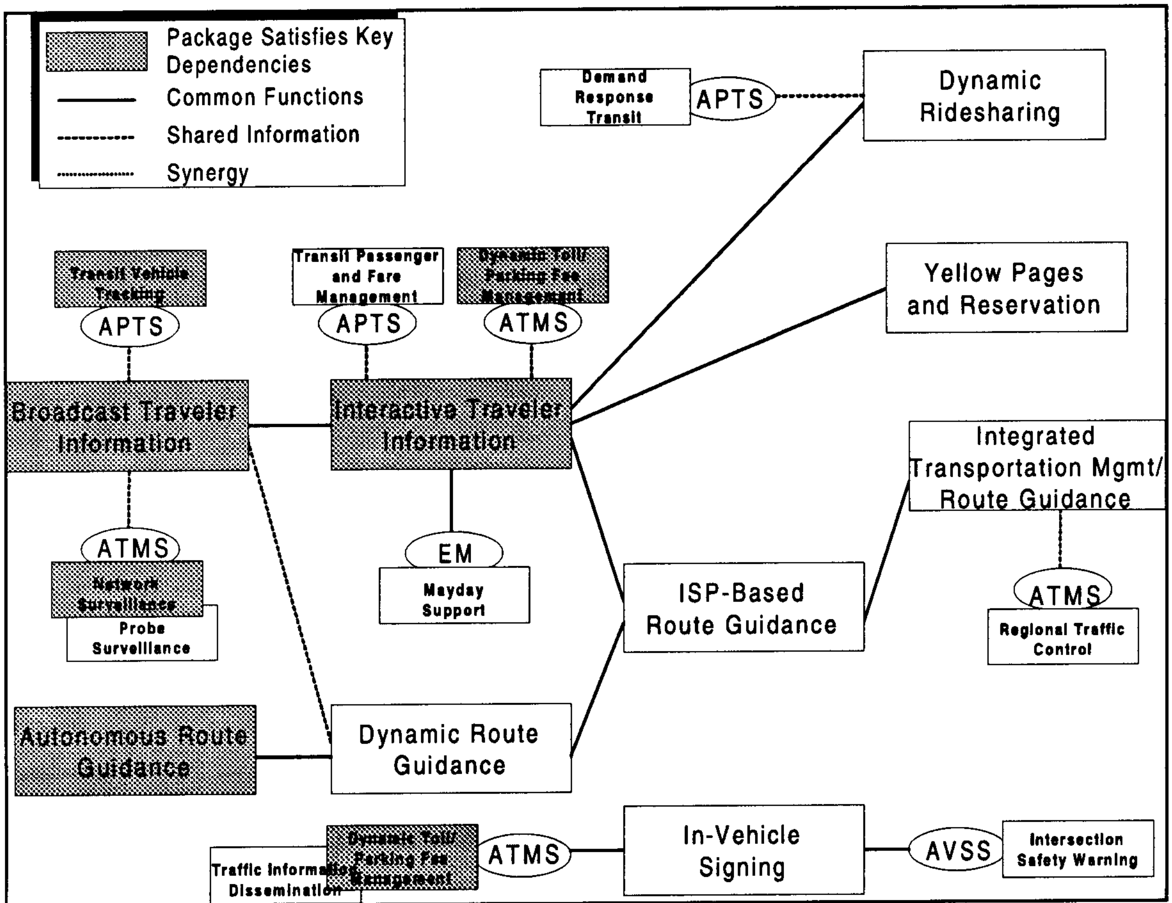


Figure 2.4-2. Advanced Traveler Information Services Market Package Synergies.

Broadcast Traveler Information Market Package

This market package shares many of the basic transportation data collection and management functions with more advanced interactive traveler information packages. This market package and its interactive counterparts each collect traffic, transit and other traveler information for processing and disseminating. In addition to providing advisories and other basic traffic information, this market package can be extended to provide real-time traffic information in a format supporting dynamic route guidance.

Interactive Traveler Information Market Package

This market package shares the basic traveler information collection and management and interactive communications capabilities with more advanced or specialized traveler information market packages. The basic interactive traveler information service can be extended to support centralized route planning services offered by the ISP-Based Route Guidance market package. The interactive capabilities of this market package allow it to better use information provided by the Transit Passenger and Fare Management and the Dynamic Toll/Parking Fee Management market packages for transit, toll, and parking fees and transit schedules and parking occupancy and reservation.

Autonomous Route Guidance Market Package

This market package provides a rich set of in-vehicle functions that can be utilized by enhanced route guidance services that require interaction with the infrastructure. Each of the more advanced route guidance market packages provide successive enhancements to the infrastructures role in supporting the autonomous vehicle equipment included in this market package.

In-Vehicle Signing Market Package

This market package communicates between the vehicle and roadside using the same dedicated short-range communications used by the Dynamic Toll/Parking Fee Management market package. The infrastructure in the Traffic Information Dissemination market package which provides dynamic driver advisories to roadside variable message signs may be extended to support provision of information to the vehicle for in-vehicle display. The communications of road status to the vehicle for in-vehicle display provides a incremental step towards more advanced intersection safety warning and collision avoidance implementations.

Advanced Public Transit Systems

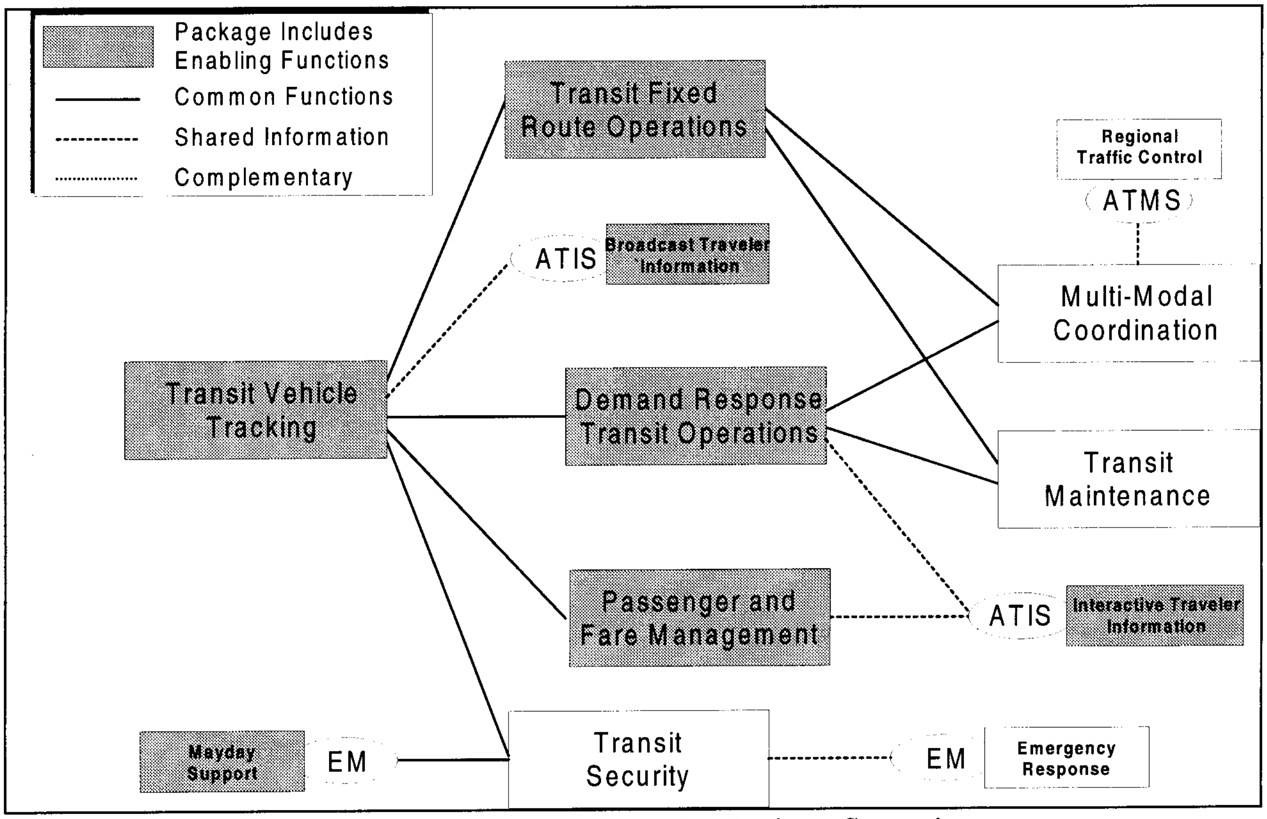


Figure 2.4-3. Advanced Public Transit Systems Market Package Synergies.

Transit Vehicle Tracking Market Package

This market package provides a fundamental vehicle location service that is required by many of the other APTS related market packages since accurate and current knowledge of transit vehicle position is key to many other services. The automated vehicle location and tracking capability provided by this market package is necessary to support the advanced operations packages, passenger and fare management, and transit security. Current transit schedule information, derived through this package, also supports the traveler information market packages.

Transit Fixed Route and Demand Response Transit Operations Market Packages

These two market packages support operations and dispatch and provide key database management functions which are utilized to support more specialized Transit Maintenance and Multi-Modal Coordination market packages. The Demand Response Transit service is only well supported by the more advanced interactive traveler information services which enable a convenient, real-time request/response interface to travelers seeking transit.

Transit Security Market Package

This market package shares emergency notification and status information with the Emergency Response market package. It provides many of the same safety features that are provided by the Mayday Support market package which is oriented towards individual subscribers rather than a transit provider.

Passenger and Fare Management Market Package

This market package shares information with the Interactive ATIS Driver and Traveler Information market package for providing real-time fare information to prospective transit passengers.

Multi-Modal Coordination Market Package

This market package shares transit signal request information with the Regional Traffic Control market package.

Commercial Vehicle Operations

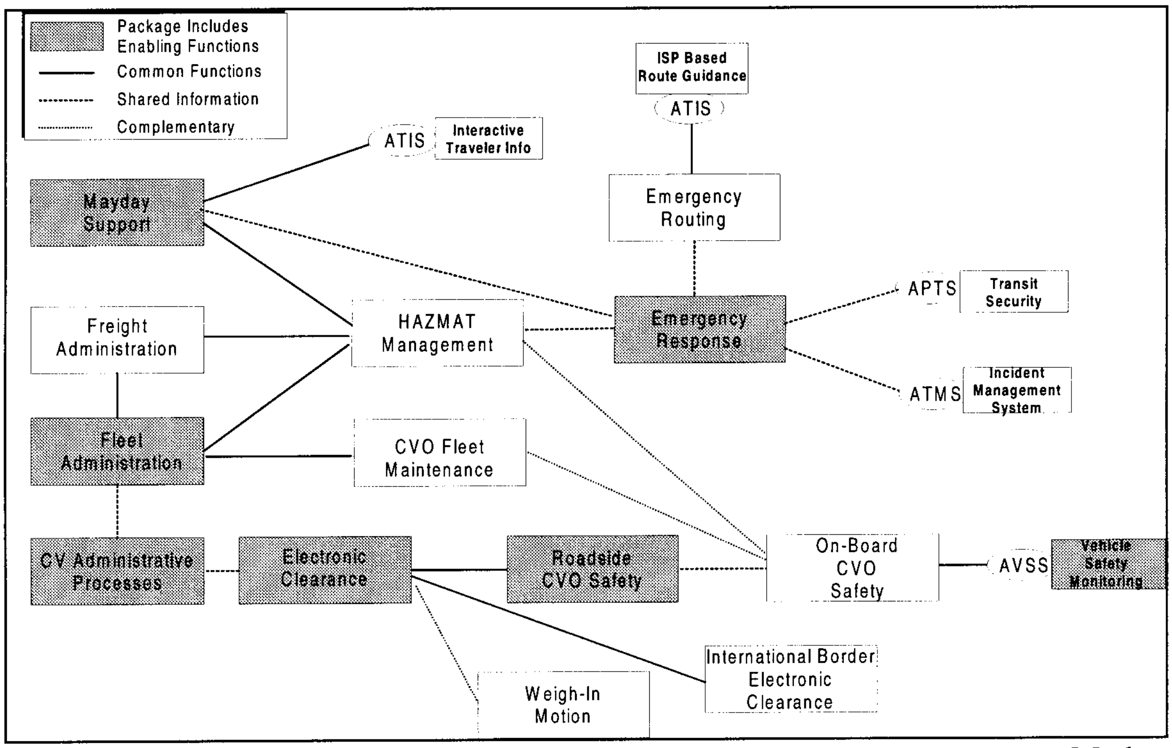


Figure 2.4-4. Commercial Vehicle Operations and Emergency Management Market Package Synergies.

Fleet Administration Market Package

This market package shares common tracking, management, and dispatch capabilities with the Freight Administration, CVO Fleet Maintenance, and HAZMAT Management market packages.

Freight Administration Market Package

This market package adds more specific freight monitoring capabilities to the basic tracking capabilities provided by fleet administration. These more advanced cargo tracking capabilities also support the HAZMAT Management market package.

CV Administrative Processes

This market package enables the Electronic Clearance market package since participants must both enroll (through this package) and be cleared electronically (through the Electronic Clearance market package) before a service is actually provided to participating carriers. As well, this market package supports various one-stop shopping applications which facilitate and expedite the administration of commercial vehicles.

Electronic Clearance

The International Clearance market package extends the basic clearance functions provided by the Electronic Clearance package by adding an interface to customs and permitting to support entry and exit from Canada and Mexico. The Weigh-In-Motion market package provides a logical enhancement to the AVI and commercial vehicle screening capabilities offered by this package. The Roadside CVO Safety Market Package provides another potential enhancement that enlists the basic AVI functions established for Electronic Clearance.

Roadside and On-Board CVO Safety Market Packages

This On-Board CVO Safety market package provides advanced sensory and diagnostic capabilities on-board the vehicle that complements the services provided by the HAZMAT Management, CVO Fleet Maintenance, and Roadside CVO Safety market packages by making additional diagnostic data. The roadside checking and verification against database entries and safety standards provided by the Roadside market package will be enhanced by the on-board safety verification provided by the CVO On-Board Safety market package.

HAZMAT Management Market Package

This market package provides HAZMAT spill notification information to the Emergency Response market package.

Emergency Management

Mayday Support

The Mayday Support market package requires a portable traveler interface and interactive, wide area wireless communications between the traveler and the infrastructure. This same portable traveler interface and interactive communications capabilities can be leveraged to support other traveler information capabilities addressed by the Interactive Traveler Information market package. This progression reflects a likely scenario in which the consumer is motivated by the potential for enhanced safety, installs the equipment, and then becomes part of a larger market for more advanced interactive information services.

Emergency Response Market Package

The Emergency Response market package enables a rapid response to the emergency notifications provided by the Mayday Support, Transit Security, and Incident Management System market packages. The Emergency Routing Market Package provides the basic dispatcher support capabilities which may be extended and integrated to support the required multi-agency coordination supported by the Emergency Response Market Package.

Emergency Routing Market Package

The emergency routing capabilities supported by this market package are a special application of similar route selection algorithms and processing capabilities provided by the traveler-oriented ISP Based Route Guidance Market Package.

Advanced Vehicle Safety Systems

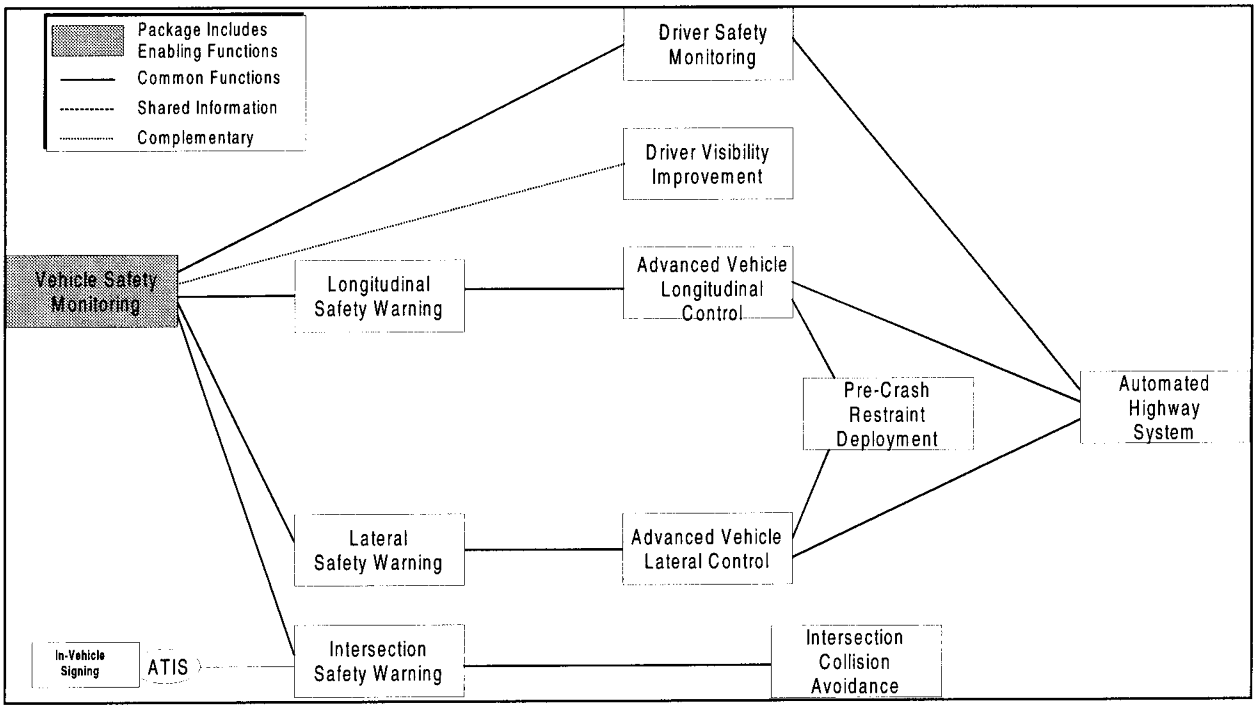


Figure 2.4-5. Advanced Vehicle Safety Systems Market Package Synergies.

Vehicle Safety Monitoring Market Package

> This market package shares common functions with the Driver Safety Monitoring, Longitudinal Safety Warning, Lateral Safety Warning and Intersection Safety Warning market packages since each of these packages includes common sensory, processing, and driver interface capabilities. Each of these safety-related market packages may include separate sensing devices, however similar processing algorithms as well as the same or similar processors can be expected. The status and warning displays can be expected to be similar as well.

Longitudinal Safety Warning Market Package

> This market package shares common sensory functions with the Advanced Vehicle Longitudinal Control market package. The sensing and detecting of obstacles in the longitudinal direction performed in this market package is directly applicable to the Advanced Vehicle Longitudinal Control market package.

Lateral Safety Warning Market Package

> This market package shares common functions with the Advanced Vehicle Lateral Control market package. The proximity sensing and lane following functions

performed in this market package may be applied to the Advanced Vehicle Lateral Control market package.

Intersection Safety Warning Market Package

This market package has common functions with the Intersection Collision Avoidance market package. The sensing and detecting of obstacles and conditions in the vicinity of an intersection and communicating this information to on-coming vehicles performed in this market package is directly applicable to its successor, the Intersection Collision Avoidance market package. The provision of basic intersection status to the vehicle supports intersection safety warning and is a logical extension of the in-vehicle signing function provided by a separate market package.

Advanced Vehicle Longitudinal and Lateral Control Market Packages

These two market packages share common functions with the Pre-Crash Restraint Deployment and Automated Highway System market packages. The capability to sense, detect, and act based upon longitudinal and lateral detection is a requirement for the Pre-Crash Restraint Deployment market package. This market package provides these functionalities that would be integral to the Pre-Crash Restraint Deployment market package. Complete automated control of the vehicle is an extension to these predecessor packages.

APPENDIX B
Intelligent Transportation Systems (ITS) Toolbox

Federal Highway Administration
Office of Traffic Management and ITS Applications

1. GENERAL ITS INFORMATION

Operation TimeSaver, US DOT. Abstract: Brochure.

An Integrated Intelligent Transportation Infrastructure for Your Area, January 1996, US DOT Publication No. FHWA-JPO-96-005 prepared by FHWA and FTA. Abstract: Brochure.

Intelligent Transportation Infrastructure Benefits: Expected and Experienced, January 1996, Publication No. FHWA-JPO-96-008, Prepared for FHWA by The MITRE Corporation, 19 pages.

Traveling With Success, How Local Governments Use Intelligent Transportation Systems, 1995, Prepared by Public Technology Inc. under cooperative agreement with FHWA, 55 pages.

Assessment of ITS Benefits --- Early Results, August 1995, Prepared for FHWA by The MITRE Corp., MP-W950000192R1, 43 pages.

Operation TimeSaver Speech by Secretary Pena, January 10, 1996 at TRB. Abstract: There is a transportation problem. ITS can fix it. ITS has measurable benefits. ITS is a cost effective investment.

Accelerating ITS Deployment: A Report from the U. S. DOT, December 1995, Christine Johnson, pages 64-67, ITE Journal.

Commercial Vehicle Information Systems Network (CVISN) Statement of Direction, November 3, 1995, Prepared for FHWA by The Johns Hopkins University Applied Physics Laboratory. Publication No. FHWA-JPO-96-006, 8 pages. Abstract: "...CVISN refers to the ITS information system elements which supports Commercial Vehicle Operations (CVO). CVISN includes information systems owned and operated by governments, carriers, and other stakeholders. It excludes the sensor and control elements of ITS/CVO..."

Review of ITS Benefits: Emerging Successes, September 1996, Prepared by Mitretek Systems for Federal Highway Administration. Publication No. FHWA-JPO-97-001, 40 pages. Abstract: "...This paper continues the process of documenting and publicizing experience with, and prediction of, benefits from ITS in the context of continuing assessment of the ITS program...This document summarizes major ITS benefits findings while referring the interested researcher to detailed studies or contacts..."

Key Findings from the Intelligent Transportation Systems (ITS Program): What Have We Learned?, September 1996, Publication No. FHWA-JPO-96-0036, Prepared for FHWA by Mitretek Systems, 35 pages. Abstract: "...Accordingly, this paper provides answers to the question "What Have We Learned?" on the ITS program. Some of the key findings in the various program areas are summarized in the executive summary. Additional findings may be found in the body of the paper..."

Intelligent Transportation Systems Assessment of ITS Deployment, Review of Metropolitan Areas: Discussion of Cross-Cutting Issues, July 1996, Publication No. FHWA-JPO-96-0035, Prepared for JPO by FHWA's Research and Special Programs Administration, many pages. Abstract: As part of the assessment of the development and deployment of ITS products and services in metropolitan areas sponsored by the U.S. Department of Transportation's (U.S. DOT) Joint Program Office for ITS, analysts from the Volpe National Transportation Systems Center, ...interviewed a broad cross section of state, regional, and local transportation officials from June through October 1995. This review had a fourfold purpose:

- To understand, within a metropolitan area, local, regional, and state transportation officials' view of ITS, including their perception of ITS, their motivation to deploy ITS, the extent to which ITS is considered, and the future role of ITS.
- To assess the degree to which ITS are being planned and deployed and the funding sources for these activities.
- To understand the interaction among agencies responsible for ITS, including the interaction among public sector agencies, the interaction with the private sector, and the interaction with elected and appointed officials.
- To gain insights from their expectations, including the benefits of deploying ITS, the barriers to deployment, the keys to success, and the lessons shared.

Realizing the Benefits, Intelligent Transportation Infrastructure, Abstract: Brochure.

U.S. Department of Transportation's Intelligent Transportation Infrastructure Deployment Database: *Interim Report*, June 1996, Publication No. FHWA-JPO-96-0018, Prepared by FHWA, 99 pages. Abstract: "... This report summarizes the deployment of Intelligent Transportation Infrastructure (ITI) in the largest 75 Metropolitan Areas in the United States and answers the question: "What Intelligent Transportation Infrastructure is operational and in the field today?" This report showcases the deployment of ITI components..."

ITS at a glance, July 1996, Publication No. FHWA-JPO-96-0019, Prepared by JPO, Abstract: Newsletter.

ITS Publications Catalog, September 1996.

2. **ARCHITECTURE & STANDARDS**

***Intelligent Transportation Systems* Building the ITI: Putting the National Architecture into Action,** April 1996, Report FHWA-JPO-96-011 , Prepared by Mitretek Systems for FHWA, 46 pages.

***Intelligent Transportation Systems* The National Architecture for ITS *A Framework for Integrated Transportation into the 21st Century* ,** 1996, Report FHWA-JPO-96-012, Prepared by FHWA-JPO and ITS America, 11 pages.

Assumptions for the Intelligent Transportation Infrastructure Cost Estimate, April 1996, draft by FHWA, Office of Traffic Management and ITS Applications, 7 pages.

3. **INSTITUTIONAL/LEGAL ISSUES**

Shared Resources: Sharing Right-of-Way for Telecommunications *Guidance on Legal and Institutional Issues* , April 1996, Report FHWA-JPO-96-0015, Prepared by Apogee Research, Inc. For FHWA, 26 pages.

4. **FREEWAY MANAGEMENT**

Ramp Metering Status in North America, 1995 Update, June 1995, Report DOT-T-95-17, Prepared by Gary Piotrowicz of FHWA and James Robinson of FTA, 65 pages. Abstract: "This document represents an update to a previous report published by James Robinson and Mark Doctor in September 1989 entitled "Ramp Metering Status in North America."

Operational Design Guidelines for High Occupancy Vehicle Lanes on Arterial Roadways, November 1994, Report DOT-T-95-14, originally published by Ministry of Transportation of Ontario, Canada, 193 pages. Abstract: "The purpose of this document is to summarize relevant information and proven guidelines in the areas of planning, design and operation of high-Occupancy Vehicle (HOV) lanes on arterial roadways in Ontario Municipalities.

An Assessment of High Occupancy Vehicle (HOV) Facilities in North America, Executive Report, August 1992, Publication DOT-T-94-17, Prepared for FTA by Texas Transportation Institute, College Station, Texas 77843, 77 pages. Abstract: "This executive report provides an overall summary of the major elements of the assessment of high-occupancy vehicle (HOV) lane projects located either on freeways or in separate rights-of-way in North America. The report includes a discussion of the purpose of the assessment, an overview of the status of HOV facilities in North America, suggested procedures for evaluating HOV projects, detailed information on selected HOV case studies, proposed future HOV projects, and areas for further research. This report summarizes information contained in the four major reports that have been prepared as part of the three year assessment. Those reports are: *A Description of High-Occupancy*

Vehicle Facilities in North America; Suggested Procedures for Evaluating the Effectiveness of Freeway HOV Facilities; High-Occupancy Vehicle Project Case Studies; History and Institutional Arrangements; and *High-Occupancy Vehicle Project Case Studies: Historical Trends and Project Experiences.*"

High-Occupancy Vehicle System Development in the United States, December 1990, Report DOT-T-91-16, Prepared by Dennis L. Christiansen for Texas Transportation Institute, 35 pages.

Predicting High Occupancy Vehicle Lane Demand, August 1996, Publication FHWA-SA-96-073, Prepared for FHWA by Dowling Associates, 275 pages. Abstract: "This report presents the results of the Federal Highway Administration Project #42-10-4172, "Predicting the Demand for High Occupancy Vehicle Lanes". The report provides: A review of the available literature and the experiences of public agencies with current methods for predicting the demand for HOV lanes; the recommended new methodology for predicting the demand for HOV lanes; and the data on existing HOV lane projects in the United States that was used to calibrate and validate the new HOV lane demand estimation methodology."

National Conference on High-Occupancy Vehicle Systems HOV Systems in a New Light, June 1994, Transportation Research Circular 442, Presented by TRB National Research Council in cooperation with FTA, 117 pages.

Guidelines on the Use of Changeable Message Signs--Summary Report, May 1991, Publication No. FHWA-TS-91-002, Prepared for FHWA by Dudek & Associates, 46 pages. Abstract: "This report is a summary of some of the information that was assembled and presented in final report FHWA-TS-90-043 entitled, "Guidelines on the USE of Changeable Message Signs". The final report provides guidance on 1) selection of the appropriate type of CMS display, 2) the design and maintenance of CMSs to improve target value and motorist reception of messages, and 3) pitfalls to be avoided, and it updates information contained in the 1986 FHWA publication "Manual on Real-Time Motorist displays". The guidelines and updated information are based on research results and on practices being employed by highway agencies in the United States, Canada and in western Europe. CMS technology developments since 1984 are emphasized. This summary report focuses on matrix-type CMSs, with particular attention to the newer light-emitting signs. Although there are many types of new and emerging CMS technologies, CMSs that have actually been installed for highway applications are emphasized.

5. TRANSIT MANAGEMENT

Advanced Traveler Aid Systems for Public Transportation, September 1994, Publication DOT-T-95-07, FTA report, 129 pages. Abstract: "Information is an essential element of urban public transportation services. The manner by which information is managed and presented has great effects on the image, attractiveness and, consequently, the ridership of public transportation. In the case of a transit trip, the traveler is responsible for obtaining the tables of schedule and fare and interpreting it to develop a trip itinerary. Further, the availability of a return trip must be checked in order to initiate a trip by transit. Compared with a trip by auto, a trip by transit imposes a much greater task in trip planning on the part of the traveler. For a transit system which has a complicated multi-modal network, interpreting the schedules and making an itinerary, which usually involves transfers among different modes (including a check for return trip), demand significant effort and time to the non-captive riders. Lack of systematic and consistent information is one reason that many transit systems in the US are used only by the captive or repeat users who are familiar with the services. With advances in computer and communications technologies, however, it is conceivable to devise a system which delivers information of the transit services and operating status to the potential users at the time when they need it. The information can be tailored to the needs individual users and presented in a relevant form. We call this system an Intelligent Transit Mobility System (ITMS). Based on the premise that technologies for ITMS will materialize in the near future, this study identifies the information which ITMS should deliver, and defines the function and structure of the system components. It then evaluates the feasibility with respect to technical and non-technical aspects.

Review of and Preliminary Guidelines for Integrating Transit into Transportation Management Centers, July 1994, Publication DOT-T-94-25, 94 pagesAbstract: "The advent of Intelligent Vehicle-Highway System (IVHS) technologies has fostered the development and implementation of automated systems that control traffic and provide traffic information to drivers. However, one very element of traffic has been overlooked in the past - public transportation. Traditionally, the impact of public transportation on traffic flow and volumes has not been factored into these automated systems. Also, providing transit information along with traffic information to travelers (rather than just drivers) has not been done in the past. The recognition that multi-modal information can influence a traveler's decision on route(s) selection and mode(s) is not recent, but the provision of transit and traffic information has not been done until very recently. Thus, there are two key issues that could be addressed by today's IVHS technologies - the coordination of transit and traffic operations and the dissemination of transit and traffic information to the public. The basic objective of the study described in this report was to address these two issues by reviewing existing "transportation management centers" (TMCs) and those under development. This review determined the extent to which transit has been or will be integrated into TMCs."

Advanced Vehicle Monitoring and Communication Systems for Bus Transit, Benefits and Economic Feasibility, Revised March 1993, Publication DOT-T-94-03, Prepared for FTA by University of Pennsylvania Department of Systems, 72 pagesAbstract: "This report analyzes the feasibility of advanced vehicle monitoring and communication (AVM/C) systems for bus transit in the United States. Such systems are widely used in Europe and Canada to provide more reliable and efficient bus services, but have seen little deployment in the US Many systems are now available both from American and from foreign vendors, and thus the question of whether or not to deploy such a system is coming to the forefront in many transit agencies. In this report, the potential benefits of such a system are discussed, including benefits to current and new riders in the form of better service, to the agency in the form of increased revenues and reduced costs, and to communities in a variety of ways including :town watch" functions. This sets the stage for a discussion of the actual experience of foreign and domestic agencies that have introduced such systems, is presented, for both outright purchase and for leasing - a very attractive alternative that conserves scarce capital resources. Calculations for typical U. S. conditions suggest that these systems should be quite cost effective, improving both agency finances and passenger satisfaction. Agencies should consider them carefully.

Benefits Assessment of Advanced Public Transportation Systems, July 1996, Publication No. FHWA-JPO-96-0031, Prepared for FTA by Volpe, 42 pages. Abstract: This report documents work performed under FTA's Advanced Public Transportation Systems (APTS) Program, a program structured to undertake research and development of innovative applications of advanced navigation, information, and communication technologies that most benefit public transportation. This report presents the results of analysis conducted by the Volpe Center, for the FTA, to provide an "order-of-magnitude" estimate of the expected benefits to the transit industry with the application of APTS technologies. Specifically, the study identified and quantified the major benefits derived from current applications of APTS technologies within the transit industry and projected current APTS benefits to a national level based on forecasts and reasonable assumptions on the potential future applications of such technologies within the transit industry.

Advanced Public Transportation Systems Deployment in the United States, August 1996, Publication No. FHWA-JPO-96-0032, Prepared for FTA by Volpe, 29 pages. Abstract: This report documents work performed under FTA's APTS Program, a program structured to undertake research and development of innovative applications of advanced navigation, information, and communication technologies that most benefit public transportation. This report is a compilation of existing and planned deployments of APTS technologies and services. The information was collected during the fall of 1995 and was obtained through contacts with one or more persons at each agency. The objective was to include information from all agencies who submitted information for the 1993 National Transit Database (NTD) Report year, the last year for which NTD data was available at the time. A total of 464 agencies provided information for this study. Those with no existing or planned APTS systems are not included herein.

Advanced Public Transportation Systems Brief #1, Spring 1993, FTA, Abstract: Newsletter "What is APTS?"

Advanced Public Transportation Systems Brief #11, February, 1996, FTA, Abstract: Newsletter "An Intelligent Transportation System for Atlanta for the 1996 Olympics."

Advanced Public Transportation Systems Publications Catalog, March 1996, FTA

Advanced Public Transportation Systems Benefits, March 1996, FTA, Abstract: A list of advanced public transportation systems with measurable benefits.

Advanced Public Transportation Systems Project Summaries, June 1996, FTA, Abstract: Project summaries.

6. TRAFFIC SIGNAL CONTROL

Improving Traffic Signal Operations, A Primer, February 1996, Publication FHWA-SA-96-007, Prepared for FHWA by J. M. Morales, Reviewed by ITE, 16 pages. Abstract: "Some relatively simple, low-cost adjustments to a traffic signal system can significantly improve traffic flow. This report describes how adjusting your city's traffic signals can reduce congestion and lead to, big payoffs in time savings, environmental benefits, and safety."

7. TRAVELER INFORMATION SYSTEMS

Development of Human Factors Guidelines for Advanced Traveler Information Systems and Commercial Vehicle Operations: ATIS and CVO Development Objectives and Performance Requirements, September 1995, Report FHWA-RD-95-109, Prepared for FHWA by Battelle, 96 pages.

White Paper, Design and Deployment Alternatives, ATMS and ATIS Components of IVHS, draft report February 1992, DTFH61-92-P-00284, Prepared for FHWA **by JHK & Associates,** 27 pages.

Advanced Traveler Information Systems for Rural Areas: Preliminary Concepts, January 1995, Prepared by JHK & Associates for FHWA, Abstract: Newsletter.

TravTek Evaluation *Orlando Test Network Study*, January 1996, Report FHWA-RD-95-162, Prepared by Inman, V.; Sanchez, R.; Bernstein, L.; and Porter, C. of SAIC, 89 pages.

8. ELECTRONIC TOLL COLLECTION

Electronic Toll & Traffic Management (ETTM) User Requirements for Future National Interoperability (Final Draft Version 3.0) January 23, 1995, Reference No. B-95-1, Available from: ITS AMERICA, 48 pages.

9. ELECTRONIC FARE PAYMENT

Intelligent Transportation Systems (ITS) Projects, January 1996, U. S. DOT, Highlighting the following projects:

– Delaware County Ridetracking, FTA contact Sean Ricketson,(202) 366-6678
– Washington, D. C. Advanced Fare Media, FTA contact Irv Chambers (202) 366-0238

Intelligent Transportation Infrastructure, Electronic Payment Systems: Traveler Convenience, Operator Efficiency, September 1996, Publication No. FHWA-JPO-96-

0020, Abstract: Brochure.

10. RAILROAD GRADE CROSSINGS

11. EMERGENCY RESPONSE MANAGEMENT

12. INCIDENT MANAGEMENT

Freeway Incident Management Handbook, July 1991, Report No. FHWA-SA-91-056, Prepared for FHWA by Dunn Engineering Associates, 128 pages. Abstract: "This handbook was written to assist responsible agencies in managing the ever increasing number of roadway incidents. It has been designed to aid:

Transportation officials with operational responsibility in state and local departments of highways, traffic or transportation
Police, fire and emergency medical services personnel
Environmental protection officials
Tow truck operators and
Administrators involved with managing roadway incidents.

The handbook will serve as a guide for agencies wishing to initiate an effective incident management program. It will prove useful in both rural and urban regions by presenting a menu of responses from which the appropriate selections can be made."

13. TELECOMMUNICATIONS

Fiber Optic Training Videos, a pamphlet by The Light Brigade. Abstract: Brochure.

14. REFERENCES

GENERAL ITS INFORMATION

National ITS Program Plan, first edition March 1995, prepared by FHWA and ITS America.

IVHS Strategic Plan, December 1992, Publication No. FHWA-SA-93-009, prepared by FHWA Abstract: "This document is Department of Transportation's IVHS Strategic Plan Report to Congress. The purpose of this report is to set forth and describe the Department of Transportation's programs and program delivery processes for supporting the development and deployment of intelligent vehicle-highway system (IVHS) technologies and services in the United States."

ARCHITECTURE & STANDARDS

ITS Architecture *Implementation Strategy* , June 1996, Prepared by the Joint Architecture Team, Loral Federal Systems, Rockwell International, many pages.

INSTITUTIONAL/LEGAL ISSUES

IVHS Deployment and Public/Private Sector Issues, The Purely Private Model: A White Paper, May 1992, Prepared for FHWA by Battelle, 28 pages. Abstract: "This white paper is written in response to a request by the Federal Highway Administration (FHWA) to investigate possible business organization approaches that could be used by the private sector in their deployment of intelligent vehicle/highway systems (IVHS). This final version of the white paper takes into account comments from a peer review. The paper also took into account comments that were made at the FHWA Workshop on Public/Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment conducted in Rockville, Maryland April 8-9, 1992."

An Analysis of Public/Private Cooperation in European, Japanese and North American IVHS Efforts, March 1992, Prepared for FHWA by Castle Rock Consultants, 47 pages. Abstract: "This paper presents an analysis of mechanisms to support private sector involvement and public/private cooperation in IVHS activities. The principal focus of the paper is a comparison of approaches adopted in European and Japanese initiatives with those of North American efforts. This paper seeks to draw conclusions from this analysis concerning opportunities for beneficial improvements in North American practices."

Economic Issues Associated with the Definition of Public/Private Roles in the Deployment of IVHS, January 1992, Prepared for FHWA by Farradyne Systems, 53 pages. Abstract: "This paper evaluates the economic issues associated with realizing the near term vision of IVHS: That accurate and comprehensive traffic data will be available for dissemination to travelers in all the nation's urban areas within the next five years. In essence, this vision foresees the accelerated development of an electronic interstate traffic surveillance and information system. It will be difficult to achieve this vision because of the high costs of implementing, operating and maintaining a national system of urban surveillance systems. The cost of this system is estimated in this paper to include approximately $25 billion for construction and $1.3 billion per year for operations and maintenance. These costs represent a significant portion of all funding allocated to the nation's highway system. However, an analysis of alternative business models demonstrates the potential for financing this infrastructure cost through the award of IVHS franchises in urban areas. The analysis indicates that up to two competing franchises can operate a profitable traffic information dissemination "utility" with adequate return to fund the surveillance system installation. The estimated costs and anticipated returns on investment in this system presented in this paper, lead to the unavoidable conclusion that there is a need for a national policy for private participation in IVHS implementation that can be justified based on the potential return on this investment. While this type of private participation is rare in the surface transportation industry, there are precedents in other industries such as telecommunications and air traffic control. Without such a policy, it is unlikely that the vision will be accomplished within five years and may never be met. In view of the fact that there are no efforts currently underway to define public and private sector roles (other than the one represented by this paper and its counterparts funded under a common Federal Highway Administration program), it is strongly recommended that following steps be taken immediately to develop a national policy:

Develop a consensus for a national policy incorporating a higher level of private involvement than has been anticipated.

Explore legal issues associated with the development of such a policy.

Prepare a national policy incorporating the franchise concept for implementation of urban area surveillance systems.

The components of this policy are discussed in the conclusions of this report. Unless these steps are taken, it is unlikely that the near-term IVHS vision will be realized within the next five (and probably the next ten) years."

IVHS Deployment and Public/Private Sector Issues, April 1992, by Sigmund Silber

Abstract: "This paper addresses certain issues that are relevant to private participation in IVHS in general and telecommunications company participation in particular." Specific issues addressed in this paper are:

Roles
Scope
Revenues /Benefits
Investment Models
Need for Models by the Public Sector
Characteristics of Telecommunications Companies
Regulation
Use of Existing Communications Infrastructure
Other Technological Considerations
Models of Public/Private Cooperation
EDI - A Case Study
Summary of Recommendations

FREEWAY MANAGEMENT

Traffic Control Systems Handbook, February 1996, Publication No. FHWA-SA-95-032, Prepared for FHWA by Dunn Engineering Associates, many pages. Abstract: "This *Traffic Control Systems Handbook* updates the 1985 version (FHWA-IP-85-11) and broadens the scope to include ITS technology and concepts. The handbook recommends decision-making processes in selection, implementation and operations of a traffic control systems and describes ITS plans and programs.

Communications Handbook for Traffic Control Systems, April 1993, Publication FHWA-SA-93-052, Prepared for FHWA by Dunn Engineering Associates, 292 pages. Abstract: "This handbook was written to enable transportation engineers to plan, select, design, implement, operate, and maintain communications systems for traffic control. It has been designed to aid:

Transportation officials overseeing traffic control systems;
Communications engineers; and
Traffic control systems engineers.

The handbook provides information on communications media, system architectures, decision-making processes, and trade-off analyses. The handbook will serve as a guide for agencies wishing to:

Initiate a traffic control system that incorporates functional, effective, reliable and economical communications.

Update and modernize an existing communications system for traffic control.

High Occupancy Vehicle (HOV) Guidelines for Planning, Design, and Operations, Final Report, June 1991, Report DOT-T-91-17, Prepared by California Department of Transportation, 136 pages. Abstract: "The goal of these guidelines is to provide a "how to" document for planners, designers and operators of mainline HOV facilities. Since individual site characteristics vary, only typical scenarios can be presented. For situations not discussed, Districts are advised to consult the appropriate District and Headquarters representatives for advice and consent. These guidelines are not intended to supersede Caltrans' Transportation Planning Manual, Project Development Procedures, Highway Design Manual, Traffic Manual, or other established manuals, procedures or practices. They are not, and should not be used as a set of standards. The guidelines are advisory in nature and are to be used only when every effort to conform to established standards has been exhausted. When conformance is not possible, the deviation must be documented by a sound and defensible engineering analysis and an approved design exception fact sheet."

Guidelines on the Use and Operation of Changeable Message Signs, November 1992, Publication TTI: 2-18-90/4-1232, Prepared for Texas Department of Transportation by Texas Transportation Institute, 101 pages. Abstract: "This report is intended to be a primer on the characteristics that affect the design, use and operations of changeable message signs (CMS), and to provide guidance on the selection of the appropriate type of CMS display. Guidelines on the selection and design of CMS messages are presented in a companion Report No. FHWA/TX-92/1232-10 entitled, "Guidelines on the Selection and Design of Messages for Changeable Message Signs". This report is an update and consolidation of the following reports:

C. L. Dudek and R. D. Huchingson, "Manual on Real-Time Motorist Information Displays", Report FHWA-IP-86-16, August 1986

C. L. Dudek, "Guidelines on the Use of Changeable Message Signs", Report FHWA-TS-90-043. May 1991

C. L. Dudek, "Portable Changeable Message Signs in Work Zones", Report FHWA/TX-85/07+292-4, July 1984."

Traffic Detector Handbook, Second Edition, July 1990, Publication FHWA-IP-90-002, Prepared for FHWA by JHK & Associates, 338 pages. Abstract: "This handbook is a revised, updated version of the Federal Highway Administration's (FHWA) Traffic Detector Handbook, originally published as Implementation Package FHWA-IP-85-1. This upgraded version of the handbook supersedes and replaces the previous edition. It has been restructured, corrected, and revised to update discussions of concepts and equipment to reflect the current state of the art, particularly as it relates to the microprocessor revolution, advances in control technology, real-world application experience. The overall objective of this handbook is to provide a single resource and basic reference to aid the practicing engineer and technician in planning, designing, installing, and maintaining detectors. It provides a compendium of existing detector technology to facilitate the understanding of all aspects of detector systems. Best current practices are described with emphasis on proper design, applications, and installation processes and techniques."

Responsive Multimodal Transportation Management Strategies and IVHS, February 1995, Publication No. FHWA-RD-94-086, FHWA report in cooperation with FTA, 156 pages. Abstract: "The purpose of this study was to investigate new and innovative ways to incorporate IVHS technologies into multimodal transportation management strategies. Much of the IVHS research done to date has addressed the modes individually. This project focused on integrating Travel Demand Management (TDM) strategies with the IVHS to provide the synergy and cost saving achievable by utilizing an [assumed] already available IVHS infrastructure for implementation of TDM strategies. Specifically this study was aimed at developing multimodal IVHS applications for: (1) increasing the market share of mass transit, HOV, and ride-sharing, (2) enhancing the efficiency of urban goods movement, (3) reducing transportation demand in congested areas, (4) improving mobility in urban and rural areas, (5) improving operations at ports, rail facilities and airports, and (6) addressing air quality issues. A process was also developed for evaluating the potential utility and costs of these new applications. Supplementing these evaluations were a series of 8 1-day workshops held at sites across the country to obtain input and feedback on these scenarios from transportation professionals."

TRANSIT MANAGEMENT

Advanced Public Transportation Systems: The State of the Art *Update '96*, January 1996, Report FTA-MA-26-7007-96-1, Prepared for FTA by USDOT Research and Special Programs Administration and Volpe Transportation Systems Center, 212 pages.

Advanced Public Transportation Systems: Evaluation Guidelines, January 1994, Publication DOT-T-94-10, Prepared for FTA by John A. Volpe National Transportation Systems Center, 166 pages. Abstract: "This document presents guidelines for planning, implementing, and reporting the findings of the evaluation of Federal Transit Administration's (FTA's) operational tests. These evaluation guidelines are intended for use by organizations engaged by the Research and Special Programs Administration/Volpe National Transportation Systems Center (Volpe Center) to evaluate APTS operational tests. In addition, the guidelines will be useful to state and local organizations involved in the design and evaluation of Advanced Public Transportation Systems

TRAVELER INFORMATION SYSTEMS

Opportunities for Private Sector Involvement in the Deployment and Operation of Advanced Traveler Information Systems, February 1992, 26 pages. Abstract: "The US private sector is already a major player in the field of IVHS. Private industry is the major developer and supplier of electronics, communications, computer and navigation equipment that goes into IVHS systems and subsystems. Private industry is also performing the bulk of the proprietary and contract research and development in support of IVHS activities. It is estimated that approximately 80% of the investments in IVHS hardware and software development will be dine by private industry. Clearly, the central role of private sector in research, development, manufacture and marketing of IVHS equipment and technology is already secure. What is less clear is the role that the private sector will play in the deployment and operation of IVHS. The operation of the highway system and of its supporting traffic management subsystems has been historically a government function. Insofar as IVHS is merely a technological enhancement of conventional traffic management, shouldn't its deployment and operation be likewise a public responsibility? The aim of this paper is to assess and, to some extent, to challenge this point of view. We shall look at the potential role of the private sector in the context of the ATIS -- one of the functional areas of IVHS. We have chosen ATIS as our case study for two reasons: ATIS offers the most tangible opportunities for private sector involvement -- and probably involves the most complex choices of public and private roles. ATIS also happens to be the functional area with which we are most familiar, and in which we are presently conducting an FHWA-sponsored pilot project focused on institutional issues."

ELECTRONIC FARE PAYMENT

Integrating ETTM With Transit Fare Collection and Parking: The MAPS Concept
Source: UC, Berkeley, Institute for Transportation Studies, TRIS No. 839374 DA.

Electronic Fare Payment to be Tested on Buses in Los Angeles, Source: Northwestern University Transportation Library, TRIS No. 845415 DA.

INCIDENT MANAGEMENT

Framework for Developing Incident Management Systems, Executive Summary, August 1991, Report No. WA-RD-224.1, Prepared for Washington State Department of Transportation by Washington State Transportation Center of the University of Washington, 32 pages. Abstract: "A variety of techniques have been developed to manage incidents efficiently. However, very little guidance exists for agencies wishing to initiate such efforts. The study, serves to provide this guidance by discussing the process of developing and implementing an incident management system. Generally, the process consists of several steps: defining the problem, setting goals and objectives, developing alternatives, evaluating and selecting from those alternatives, implementing, re-evaluating after a specified time, and refining the system. The alternatives that were developed in the document fall under five basic categories, depending on how they benefit incident management efforts. These categories include incident detection, response, site management, clearance and motorist information. Specific information, including technique description, relative costs and benefits, operational requirements, and funding variations is given for each incident management technique included in these categories. More generally, concerns such as jurisdictional issues, geographical constraints, available resources, operational procedures, training requirements, and administrative coordination are discussed in detail to aid in mitigating difficulties early in the incident management system development process."

TELECOMMUNICATIONS

Intelligent Vehicle Highway Systems Mobile Communications Guidelines, September 1993, Prepared for FHWA by The MITRE Corp., WP-93-W0363, 88 pages. Abstract: "The Intelligent Vehicle-Highway Systems (IVHS) Mobile Communications Guidelines was developed to provide practical guidance in the area of mobile communications to those planning for IVHS operational tests or deploying IVHS-related systems and services. The document provides guidance, in determining communications needs and requirement, in understanding basic mobile communications concepts, on technologies that are applicable to IVHS, and on regulatory issues pertaining to the acquisition and use of frequency spectrum for IVHS applications."

15. VIDEOS (Reference)

TravTek, Test Driving the Future, October 1995, video prepared for FHWA by SAIC, run time 20 minutes and 39 seconds. Abstract: "The TravTek video has been developed to provide a vehicle for disseminating information on the TravTek evaluation to a broad group of public and private sector individuals. The video serves as an executive summary for the project, providing information on the overall project goals and objectives, the public/private partnership created to carry out the effort, the system design approach, the key evaluation questions, and finally a summary of the results of the evaluation activities."

NTCIP - The Key to Managing the ITS Infrastructure, Video prepared for FHWA.

Traffic Management Lab., January 1996, Video prepared for FHWA.

APPENDIX C

FUNDING FOR ITS
INCLUDING A CASE STUDY OF ITS FUNDING APPROACHES
IN ORANGE COUNTY, CALIFORNIA
(Excerpts from the Orange County IVHS Master Plan)

FUNDING ISSUES

The successful development and implementation of an ITS Strategic Plan will largely depend upon the availability of funds to cover the costs of such systems. Beyond the initial funding for program implementation, a critical factor to the success of ITSthroughout the country will be the continued availability of funding for operations and maintenance. The implementation of ITS elements for the detection, surveillance, and management of transportation will necessarily increase the operations and maintenance demands of those agencies responsible for transportation. Funding strategies were discussed in Chapter 5 of the Handbook.

GENERAL FUNDING SOURCES

This section presents details of funding opportunities for ITS and traffic management projects at the local, state and federal level. Of particular concern to all agencies interested in the advancement of ITS when reviewing the identified funding opportunities, should be the lack of funding currently available for the continued operations and maintenance of implemented technologies. Only a few sources currently allow for the operations and maintenance of programs and, traditionally, these funds have not been allocated for these purposes.

One of the primary reasons operations and maintenance funding has not been made available or allocated is that typically this allocation is viewed as diminishing the funding available for new programs, politically a more favorable undertaking. It must be stressed to all agencies that the earmarking of funds for operations and maintenance purposes will diminish the scale of new programs which may be funded. However, because the continued operations and maintenance of ITS may be beyond the financial reach of the average local agency, establishing funds for operations and maintenance is necessary to maintain functional programs. It is strongly recommended that funds currently available for operations and maintenance are used as such, and that new sources of operations and maintenance funding are identified.

<u>Locally and Regionally Generated</u>

These funds represent specially-appropriated funds by local areas for dedicated uses. Means of supporting these funds can include:

- local sales tax
- motor vehicle registration fee tax
- transit-related funds
- toll-road funds
- privatization

The funding sources are legally endorsed and typically require voter approval for implementation. Millions of dollars can be developed from these sources as exemplified by the Orange County (California) Measure M (one-half cent local tax expected to generate $3.1 billion over its 30-year lifetime). In this way, funds are directly appropriated to the localized area in which they were developed.

State Funding Sources

State Gas Tax Funds

Many states levy a gas tax on each gallon of fuel sold. The gas tax is dedicated to transportation improvements, with state and local agencies as the recipients. The gas tax fund has classically been a major source of funding for regional freeway systems. It can be used to "match" Federal funds for selected major projects. It is also a funding source for continuing operations and maintenance. State gas taxes may go toward funding sources of particular significance to the implementation of ITS and traffic management programs.

State ITS Research

Many states have allocated funding to conduct ITS research projects. For example, in California, District 12 and the University of California at Irvine led a multi-agency team and submitted a program for the region. The project, oriented toward a Test Bed for ITS, is receiving strong support and $7 million or more is programmed for funding over a three year period. The project includes elements that can support expanded signal operations and interties to other agencies. The project will also provide some traffic system infrastructure in the test bed area. While research is the prime target, such test beds are useful to test and evaluate emerging technologies and establish their utility in traffic signal operations.

Petroleum Violation Escrow Account (PVEA)

Under existing Federal law, funds in the Petroleum Violation Escrow Account (PVEA) have been dispersed to states by the Federal government and deposited in the Federal Trust Fund. PVEA monies have been used in the past to fund statewide programs to relieve traffic congestion, such as vanpool grants and loans. While future proposals could be formulated to provide some funds for implementing suitable corridor projects which might include ITS elements, it should be recognized that PVEA funds are almost exhausted.

Federal Highway Administration Funds (FHWA)

Intermodal Surface Transportation Efficiency Act (ISTEA)

In December 1991, the Intermodal Surface Transportation Efficiency Act (ISTEA) became law. While retaining more traditional funding programs for Interstate maintenance and bridges with minor modifications, the ISTEA restructured the federal aid highway program by creating broad funding categories. Within this new structure, the emphasis of the ISTEA for highways is on preservation, operation and better management of existing transportation facilities. As such, several funding programs are compatible with the objectives associated with developing an ITS.

ISTEA comprises several funding programs ranging from Air Transportation to Research. The Act includes several sources which are of direct interest to the funding of ITMS:

- Surface Transportation Program
- National Highway System
- Congestion Mitigation and Air Quality Improvement (CMAQ)
- Intelligent Vehicle Highway Systems Act

These funding opportunities are discussed below. It should be emphasized that project readiness is a key requirement for Federal funds. The availability of ready-to-go projects will put an agency in an advantageous position where demands to deliver on the program are made.

Surface Transportation Program (STP)

Section 1007 of ISTEA describes the STP. Eligible projects include operational improvements and capital costs, as well as operating costs for traffic monitoring, management and control facilities and programs. Funds lapse four years after they are available and competition for available funds is introduced into the obligation process annually. The definition of operational improvements includes capital improvements that will improve or enhance the operational efficiency of a highway. The STP provides funds directly to the region.

Total funding for the STP is $23.9 billion over the six years of ISTEA. Funds are distributed to states based on their share of all funding made available to the states between FY87 and FY91. Following distribution to the states, allocation is as follows:

a. 10% - safety construction
b. 10% - transportation enhancement
c. 50% - to urban areas over 200,000 on the basis of population
d. 39% - for use anywhere in the state

ITS and Traffic Management projects are not eligible under categories a and b, above, and while STP funding for FTA projects requires a local match of at least 20%, traffic projects require only 11.5% local matching funds. State TSM funds will provide a local match in the future.

While there is obvious application of STP funding to capital expenditure for ITS and traffic management projects, its application to operations and maintenance is not so well defined. While there is provision at the Federal level making such expenditures eligible, current local guidelines are that local agencies provide funding for operations and maintenance. Such guidelines need to be modified, given the new ITS technologies to be supported and the increasing budget limitations on even routine operations and maintenance. These must be a strong regional and local lobbying effort assembled, which can identify operations and maintenance requirements and manual funding needs to maintain ITS.

National Highway System (NHS)

ISTEA designates a new highway system of approximately 155,000 miles to be known as the National Highway System (NHS). The NHS is funded at $21 billion over the six years of ISTEA, apportioned in the same fashion as the STP. An additional $17 billion is authorized for Interstate Highway system upkeep making a total of $38 billion. States can, at their discretion, transfer up to half of their NHS funds to the STP and may transfer up to 100% with DOT approval. Through FY95, all principal arterials are to be considered eligible for NHS funds.

Under the NHS, "start-up" funding for the operations of traffic management and control systems for up to two years can be provided. As with the STP, definition of operational improvements, start-up costs includes those for traffic signals and systems. Also, eligible projects include operational improvements to the NHS and operational improvements to non-NHS highways in a NHS corridor. Clearly, therefore, NHS provides a major opportunity for ITS funding on principal arterials and corridor systems. However, using NHS funds for operations and maintenance have been viewed as reducing the funds for NHS construction for which these funds are the support. As with STP, the costs of operations and maintenance should be addressed and a condition of regional and local agencies should identify (based on the Action Plan developed elsewhere in this study) the needs of the agencies in terms of operations and maintenance. NHS funds are managed by the State Departments of Transportation.

Congestion Mitigation and Air Quality Improvement (CMAQ) Program

The Congestion Mitigation and Air Quality Improvement (or CMAQ) Program directs $6 billion over the life of ISTEA to urban areas not in compliance with the Clean Air Act. Funds are distributed to states based on each state's population in non-attainment areas. Areas with very poor air quality are given greater weight in the formula.

Projects which help to attain air quality standards, or contribute to air quality attainment, through reduction in vehicle miles traveled (VMT), fuel consumption or other factors, are eligible. Traditionally, ITS and traffic management programs have been viewed as being effective in reduction in fuel consumption and pollution, although their effect on VMT is still to be established.

The Federal share for most eligible activities is 80% or 90% if used for certain activities on the Interstate System. Some activities, including traffic control signalization and certain transit related ITS elements may be eligible for funding at 100%.

Clearly, because of the broad array of projects eligible under CMAQ, use of these funds for ITS will necessarily compete with numerous alternative funding requests. Moreover, it will be important to establish ITS strategies as an effective use of funds early in the CMAQ program life cycle. Specifically, the air quality benefits to be derived for ITS should be demonstrated in the early years of the program. As it is likely that this source will be attractive to several regional initiatives, consensus regarding the use of CMAQ funds for ITS purposes will be required on a countywide basis.

Intelligent Vehicle Highway Systems (ITS) Act

The ITS Act falls under Title VI: Research of ISTEA (while STP/NHS/CMAQ funds all come under Title I: Surface Transportation) and establishes $660 million of funding for ITS over the life of ISTEA. This is divided into $501 million for an ITS Corridors program and $158 million for other ITS research and development. The applicable federal share for these categories is 80%.

The ITS Corridors program funds are not to be used to create infrastructure but are targeted at ITS planning, early deployment and operational tests. The FHWA, which administers these funds and directs them to individual projects, has identified four priority corridors in ozone non-attainment areas to receive funds under the Corridors program. Initial allocation of FY1993-94 funding was done through a request for proposals; 102 proposals were received by the FHWA.

These funds can be usefully expended to be of use in defining future technologies for ITS programs and giving local agencies first hand experience with them. This puts those agencies in a stronger position when seeking larger funding for full-scale deployment following successful testing. The Early Deployment program, which will allow the development and design of initial projects.

Under the ITS planning and research program, $27 million of funding is available each year for fiscal years 1993 through 1997. However, these funds are competitive on a national basis, due to the earmarking of much of this money for specific projects and project types. Moreover, funding a certain portion of funding for any given year will be used to support previously funded projects. Therefore, the feasibility of tapping this fund source decreases somewhat over time.

Transit Funding

The following summarizes transit funding availability from a number of sources, including federal ISTEA funding, State funds, and countywide Measure M funds.

Federal Transit Funds

ISTEA included $31.5 Billion nationally in transit funding over the 6 year period of the Act. Potentially applicable funding to ITS includes: Section 9 Formula Programs; Section 3 Capital Program and Planning and Research Programs.

Section 3: This section of the Act includes a capital grant program for innovative techniques and practices "in the management and operation of public transit services." Approximately $10 million is available nationally within the Section 3 bus capital grant program. OCTA has traditionally used Section 3 funds for the acquisition of buses. The OCTA Short-Range Transit Plan (SRTP) anticipates approximately $177 million in Section 3 funding between 1993 and 1999 pending a current grant application approval. Much of these funds are planned to acquire express coaches and help construct the I-405/SR55 transitway connector. These funds require a 20% local match.

Because these funds are competitive on a national basis they provide a limited opportunity for ITS funding.

Section 9: The section 9 formula grant program makes funds available on the basis of a statutory formula to all urbanized areas in the country. Operating expenses are an eligible expenditure under this program.

Although both capital and operational aspects are technically eligible under this program, diversion of these funds to ITS purposes would necessarily curtail alternate application of these funds.

Planning and Research Funds: Approximately $378 million nationally is available over the next six years for transit technology development. These funds are distributed through a new Transit Cooperative Research Program through calls for projects and through the National Planning and Research Program. Because of the emphasis on technological advancement, these funds are potentially available for the more advanced aspects of ITS.

State Transit Funds

Many agencies receive transit operating and capital revenues from several state sources including the local Transportation Funds and various other sources (such as State Rideshare funds). Transit elements of ITS may be eligible expenditures under these sources. Application of any portion of these funds to such use would, of course, impact other transit expenditures plans. Moreover, state fiscal conditions make these sources vulnerable to invasion to balance the state budget.

Private Sector Role

The nature of ITS, due to its inclusion of the vehicle as a "smart" system element, involves the development of privately-developed technologies. Thus, technological vendors and investors could be considered partnership sources of private funds for ITS implementation. Candidate private-public joint ventures may include in-vehicle navigation systems (implementation and support), development of new technologies for collection and dissemination of data, and various control system elements.

Many local governments charge transportation impact fees or designate special transportation districts that contribute revenues to transportation facilities that are constructed to benefit the designated area. These are put in place principally to fund major highway improvements, new freeway interchanges, etc. This same approach could be applied to fund ITS projects that benefitted the areas being developed. However, it is usually more difficult to make that association with ITS than with larger projects.

The City of Irvine, California, has taken a unique approach in this area in which developers have the option to pay part of their impact mitigation fee to support the traffic control system in the city. An allowance is provided in their calculation of level of service for impacted intersections if they choose this option, reducing the costs for geometric improvements.

ITS FUNDING OPPORTUNITIES IN ORANGE COUNTY

Locally and Regionally Generated

Measure M

Measure M, a one-half cent local tax was passed by Orange County voters in November 1990. This sales tax is expected to generate $3.1 billion over its 20 year lifetime. The revenue generated by this source is administered by OCTA. Funding is distributed into four categories:

- 43% to Freeway Projects
- 25% to Transit Projects
- 21% to Local Streets and Roads Projects and
- 11% to Regional Streets and Roads Projects.

These expenditure categories are further broken down into seven specific funds. Elements of IVHS are technically eligible for several Measure M Programs, including Superstreets, Signal Improvement and TDM/TSM. Additionally, the fundingof IVHS and signal pre-emption projects with Measure M funds has been preliminarily approved by the OCTA Citizen's Oversight Committee and is anticipated to receive formal approval.

Clearly, Measure M funds are an ongoing, available source for funding IVHS. This year provides a critical opportunity to define IVHS's place within the Measure M Program schemes for the next four years.

However, the overall role of Measure M funds in the implementation of IVHS is undefined. If this source is to become truly viable, more guidance within the Combined Transportation Funding Programs is needed. As stated above, OCTA will be evaluating IVHS eligibility criteria this year. As Measure M is the most significant local source of transportation funding, it is necessarily competitive. For this fund to play a significant rolein IVHS development, consensus regarding its use for this purpose will be indispensable.

AB 2766 Discretionary Funds/Transportation Control Measure Program

In 1990, the California Legislature passed a motor vehicle registration fee increase (Sher-AB 2766), to be assessed to drivers in the South Coast Air Basin, to provide funding for mobile source air quality mitigation programs withinthat area. Beginning April 1991, an add-on fee of $2.00 per vehicle was assessed annually, with the fee being increased to $4.00 in 1992. 40% of this revenue is allocated to the South Coast Air Quality Management District (SCAQMD), 30% to local governments on a per capita basis, and the remaining 30% toward a "discretionary fund." Any type of project, whether sponsored by government or by the private sector, having some direct connection with air quality would be able to compete for the revenues within this discretionary fund.

As an indication of the revenue expected to be generated, it is estimated that with the $4.00 per vehicle fee, Orange County vehicle registration alone will generate over $1.3 million for FY1993-94 towards the discretionary fund. Funds will be divided, per legislative formula, to fund both regional and local projects.

With the direct relationship between the traffic signal improvements and air quality, there should be a strong case for pursuing the discretionary element of these funds. There is also a possibility that authorization will be given to local agencies to increase these fees. Consideration may also be given to establishing an annual fee dedicated to supporting continuing operation and maintenance of signal systems.

To summarize, these funds could be used for implementation of the IVHS Programs, especially where a direct benefit to air quality is apparent. Further, given the continuing nature of the funds, opportunities may exist for funding of a portion of the continuing operations costs. However, the funding levels are not large, given the likely demands. Also, a clear tie to air quality improvement (ideally carbon monoxide emissions) must be made.

Transit-Related Funds

Several sources fund OCTA transit services, including the Local Transportation Fund (LTF- sales tax proceeds from 1/4 of the $.065 per dollar collected from retail sales in Orange County), Measure M and federal grants. Although there are numerous programming needs to be met using these funds, there may be an opportunity to use a moderate amount of funds for transit-related IVHS components. The most current OCTA Short-Range Transit Plan also indicates that several federal grants (some dating back to 1985) should be reevaluated for continuation. Depending on the nature of the grant, there may also be a possibility to redirect unused grant funds to IVHS development. As an additional example, OCTA also receives state funding to implement a rideshare program for Orange County. To the extent that a component of IVHS (such as a transit related traveler information system) could be defined within the eligibility of the state's funding guidelines, such funds could provide partial funding for IVHS transit elements.

Transit-related funding provides some opportunity to pay for transit-related IVHS components. Further evaluation of specific sources would be required to fully determine this potential.

Funding for transit is limited. Utilization of any transit-related funds for IVHS would necessarily impact other priorities. Additionally, depending on the nature of the proposed use of funds, eligibility impediments may be encountered.

Transportation Corridor Agencies (TCAs)

The TCAs have been established to construct three "toll road" facilities within Orange County. Funding for construction is to come from two primary sources, dedicated developer fees and tolls. After the facilities are constructed, they are to be turned over to Caltrans for operation and maintenance. The TCA projects are to be implemented over the next 7-8 years. While there is some uncertainty with funding due to the slow down in development over the last several years, the projects are moving forward toward construction.

The TCA facilities will include complete traffic operations systems and HOV lanes. The toll collection system is also to emphasize automated collection using AVI technology. A number of IVHS components are planned for incorporation in the TCA facilities, and TCA funds will be directed toward this purpose.

At the same time, however, TCA funds cannot be used for infrastructure outside their roadways. Moreover, to ensure the inclusion of IVHS elements which are compatible with the rest of the County's IVHS network in the corridor projects, specific agreement on the type and extent of IVHS system architecture must be reached concurrently with design and construction timetables. Specific parameters for linking the corridors to the overall system architecture must also be defined and funded.

Privatization Projects (Toll Roads and other Facilities)

There are two "privatization" toll roads being developed in Orange County, one parallel to SR91 and another extending SR57 south along the Santa Ana River to I-405. The developer of the SR91 project has received environmental clearance and project approvals and is currently negotiating financing. The developer of the SR57 is seeking equity participation to fund the requisite Environmental Impact Report (EIR) for the project.

As with the TCAs, there is an opportunity to incorporate certain IVHS components into the privatized facilities construction by directing funds dedicated to these project toward IVHS components. This would require early consultation with the project developers regarding common objectives concerning IVHS.

State Funding Sources

State Gas Tax Funds

The State of California levies a gas tax on each gallon of fuel sold. The gas tax is dedicated to transportation improvements, with Caltrans and local agencies as the recipients. The tax has recently been raised from nine cents per gallon to a programmed eighteen cents per gallon. Five cents of the new tax increment is in effect and an additional cent willbe added each year until the full value is reached. The new tax increment includes special funding for TSM and Congestion Relief programs which are discussed below.

The gas tax fund has classically been the major source of funding for the California freeway system. It is used to "match" Federal funds for selected major projects. It is also a funding source for continuing operations and maintenance ("4 R program"). Prior to the recent increase, the funds were stretched to the limit in order to provide continuing operations and maintenance and to match federal funds.

State gas taxes go towards two funding sources of particular significance to the implementation of IVHS and traffic management programs: the Traffic System Management (TSM) Program and the Flexible Congestion Relief (FCR) Program. The TSMprogram is wholly funded by state gas tax contributions, while FCR monies are derived from several sources. However, neither of these programs may be used to fund on-going fund operations and maintenance.

Traffic Systems Management (TSM) Program

The recently established TSM Program of the gas tax fund has already been of considerable use in supporting IVHS and traffic management system implementation. The TSM Program Guidelines that were established by the California Transportation Commission (CTC) in October 1989, define the appropriate uses of these funds to be "*those projects designed to increase the number of person-trips which can be carried on the highway system without significantly increasing the design capacity of the highway system...*" According to the CTC guidelines, eligible project types specifically include "*traffic flow improvements such as computerized synchronization of traffic signals and intersection improvements on conventional arterial roads and TV surveillance, computerized message signs, and traffic operations centers on freeways;*" also mentioned are "*traffic metering systems, including meters on freeway on-ramps, freeway-to-freeway connectors, and freeway mainlines.*" Further, "*demonstration projects to implement research and development in the field of traffic operations control systems*" are also identified as an appropriate use.

Since its inception, TSM funds have been used for many traffic signal implementationand synchronization projects, several of which are located in Orange County. The FY1992-93 list of projects approved for funding included: $1.2 million for ATMS projects in Santa Ana, including expansion of the existing signal system, $5.3 million for TOS central and field equipment, including fiber optics trunk communications, and $2.9 million for a TMS expansion in Anaheim in the SR91/La Palma corridor. Many other cities have also been successful in securing signal improvements through the TSM program, especially those that have linked such projects with benefits to the freeway system. These are significant allocations for a fund which intends to make between $50 million and $100 million available for eligible projects per year.

The TSM application process is carried out on an annual basis. Traditionally, applications were submitted via Caltrans Districts during the month of August. Candidate projects were then evaluated and a priority list created for publication in December. The amount of funding available, and the ability of the agencies to meet deadlines for various stages of the design and construction of the project determined the number of projects actually funded from the list.

This process changed for FY1993-94. The passage of Senate Bill 1435 linked the TSM program with the Federal ISTEA of 1991 by using the TSM funds to match Surface Transportation Program (STP) and Congestion Management and Air Quality (CMAQ) program. STP and CMAQ funds are programmed through the Metropolitan Planning Organizations (MPO's) such as the OCTA. In order to ensure that the state TSM and regional STP and CMAQ programs are compatible, the TSM program for FY1993-94 was canceled and funding has been apportioned through the February 1993 Call for Projects which consolidates the application of funding from several sources (see Section 2.5.1). TSM funds through 1993-94 will most likely be exhausted in meeting mandated match requirements for federal CMAQ and STP funds. Beginning in 1994-95, TSM projects will be drawn from project priorities that are developed by Caltrans District 12 in cooperation with the OCTA. Toward this end, District 12 is developing athree-year plan to target approximately $18.7 million in TSM funds forfiscal years, 1994-95, 1995-96 and 1996-97. In the future, funding targets will be issued by OCTA for a four year period. Within those limits, OCTA will establish a project priority list with Caltrans.

TSM funds will continue to be a major source for IVHS deployment and their use as leverage for larger federal funds only adds to the funds utility. However, there is significant competition for

TSM funds. They have also been the principal source for Caltrans operational elements such as Traffic Operations Centers and system improvements such as ramp metering, changeable message signs, closed circuit television and communications. Senate Bill 1435 added HOV lanes and park and ride facilities to the list of eligible projects. TSM funds may not be used for operations and maintenance activities. Because of the nature of the TSM Program, many IVHS elements will qualify under TSM, plus Federal ISTEA (CMAQ and STP) programs. It is therefore important that District 12 and OCTA work together closely to develop joint programming strategies covering all three statewide process to a District-based multi-year evaluation process, the need for well-coordinated implementation scheduling and financial planning is critical for the best utilization of this source. The following page indicates the criteria for TSM projects.

Flexible Congestion Relief (FCR) Program

Flexible Congestion Relief funds are derived from a variety of state and federal sources which include state gas tax, rail bonds and ISTEA. These funds are collected in the State Highway account and allocated according to prescribed formulae for each county. FCR funding is estimated to be at the level of approximately $300 million per year.

Eligible projects under the FCR program include new roadways, transit guideways, expansion of existing roadways and rail transit. The efficient addition of capacity to a corridor is the prime intention of these funds. Hence, traffic signal projects face significant competition for these funds and are at a disadvantage due to competition from major freeway projects. One significant advantage that the IVHS projects do have, however, is cost-effective capacity enhancement. For example, in Los Angeles County, some $2.55 million of FCR funds have been allocated for the first phases of a multi-agency signal coordination project and Smart Corridor conceptual design for the northern San Gabriel Valley. Operations and Maintenance are not eligible for funding under the FCR program.

Caltrans IVHS Research

Caltrans has allocated funding to conduct IVHS research projects and has requested proposals from the various districts. District 12 and the University of California at Irvine led a multi-agency team and submitted a program for the region. The project, oriented toward a Test Bed for IVHS, is receiving strong support and $7 million or more is programmed for funding over a three year period. The project includes elements that can support expanded signal operations and interties to other agencies. The project will also provide some traffic system infrastructure in the test bed area. Funding in the FY1992-93 has been made available by Caltrans to local universities, and further funds are forthcoming under the IVHS Corridors program (see Section 2.3.3.5) for equipment deployment. While research is the prime target, such test beds are useful to test and evaluate emerging technologies and establish their utility in traffic signal operations.

Petroleum Violation Escrow Account (PVEA)

Under existing Federal law, funds in the Petroleum Violation Escrow Account (PVEA) have been dispersed to the State by the Federal government and deposited in the Federal Trust Fund. PVEA monies have been used in the past to fund statewide programs to relieve traffic congestion, such as vanpool grants and loans. Existing state law, however, does not provide for optimized signal timing and corridor demonstration projects. Recently specific bills have been formulated to require county transportation authorities, using funds allocated by the California Transportation Commission (CTC), to coordinate Smart Corridor demonstration projects on the state highway system. The bills would further require local transportation commissions to report on these projects to the Legislature.

In the 1992-93 legislative session, two such bills went before the State senate for the appropriation of over $6 million of these PVEA funds to the CTC for allocation to these corridor demonstration projects. Unfortunately, competition for PVEA funds resulted in only $1 million being allocated.

While future proposals could be formulated to provide some funds for implementing suitable corridor projects which might include IVHS elements, it should be recognized that PVEA funds are almost exhausted. This, combined with competition from other urban counties will limit PVEA funding availability for IVHS Programs in the County.

State and Local Transportation Partnership Program (SLTPP)

This Caltrans program consists of funding local projects which are ready for construction with a minimum of review. Eligible projects are those which increase capacity, extend public transportation service to a new area, or rehabilitate existing facilities. As discussed with FCR projects, IVHS and traffic management projects can be shown to increase capacity. SLTPP funds are available only for actual construction costs, as well as State and Local-furnished materials. The funds do not cover preliminary and construction engineering. The maximum state share is 50%. In the first three years (cycles), the state match is 21.47%, 30.2% and 21.6% respectively. Projects nominated by local agencies are selected by Caltrans annually. A one year application period begins on July 1. Project reimbursement proceeds after the final match ratio and list of eligible projects is published 13 months after the application deadline. $200 million is available annually statewide.

State Transit Funds

OCTA receives transit operating and capital revenues from several state sources including the Local Transportation Fund (1/4 of the $.065 collected per dollar as sales tax in Orange County); State Transit Assistance Fund (STAF); and various other sources (such as State Rideshare funds). Transit elements of IVHS would be eligible expenditures under these sources. Application of any portion of these funds to such use would, of course, impact other transit expenditures plans. Moreover, state fiscal conditions make these sources vulnerable to invasion to balance the state budget.

OCTA projects receive $10.6 million per year in state rideshare funds between 1993 and 1999. This source may contain some potential for application toward development of HOV programs as defined in the IVHS Master Plan.

Measure M

Twenty-five percent (25%) of Measure M funds are devoted to transit, including rail and guideway development. The current SRTP allocates $8.3 million toward transit for the 1993-1999 period. To the extent that IVHS components are transit-related, Measure M funds could be applied for these purposes.

APPENDIX D
AN OVERVIEW OF TRAFFIC SIMULATION MODELS

Traffic simulation models are mathematical methods of approximating real-life traffic situations. Simulation models are used to assist in planning, design and operations of transportation facilities. From a theoretical viewpoint, there are two types of traffic simulation models: macroscopic and microscopic simulation models.

! Macroscopic models are based on deterministic relationships developed through research on highway capacity and traffic flow. The simulation for a macroscopic model takes place on a section-by-section basis rather than tracking individual vehicles. Macroscopic models have considerably less demanding computer requirements than microscopic models. They do not, however, have the ability to analyze improvements and designs in as much detail as microscopic models.

! Microscopic models simulate the movement of individual vehicles, based on theories of car-following and lane-changing. Typically, vehicles enter a transportation network using a statistical distribution of arrivals (a stochastic process) and are tracked through the network on a second-by-second basis. Computer time and storage requirements for microscopic models are large, usually limiting the network size and amount of time that can be reasonably simulated.

Nine traffic simulation models are discussed in this report. Table D-1 shows the nine simulation models categorized by their operating environments. Historically, simulation models were developed to model traffic in distinct transportation subnetworks such as freeways, corridors including a freeway and major arterials, surface street grid networks, and rural highways. Typically, these transportation subnetworks have distinct operational characteristics that were reflected in simulation modeling. As traffic congestion increased -- both in time and in space -- the assumption that each subnetwork operates independently has become invalid. Simulation models were enhanced to address/model the emerging traffic inter-dependency. Table D-1 summarizes operating environments for traffic simulation models by describing existing (X) or partially existing (P) capabilities of each model to simulate the four distinct operating environments.

CORFLO

CORFLO is a family of surface street and freeway macroscopic models that can simulate traffic at different levels of detail for large urban networks. It is one of the component models of the FHWA TRAF system that includes both microscopic and macroscopic models. ROADSIM, FRESIM, and NETSIM are microscopic simulation models for rural highways, freeways and urban streets, respectively. CORFLO consists of the following four macroscopic submodels.

! FREFLO is a macroscopic freeway simulation model.

Table D-1

OPERATING ENVIRONMENTS FOR SIMULATION MODELS

Model	Freeway	Corridor	Arterial Network	Rural Hwy
1. CORFLO	X	X	X	
1A. FREFLO	X			
1B. NETFLO1		X	X	
1C. NETFLO2		X	X	
2. FREQ	X	P		
3. INTEGRATION	X	X	X	
4. FRESIM	X			
5. TRANSYT7F			X	
6. NETSIM			X	
7. SATURN	P	P	X	
8. CONTRAM	P	P	X	
9. ROADSIM				X

X: Existing
P: Partially Existing

! NETFLO1 is an event-based model that simulates surface street networks.

! NETFLO2 is a simulation adaptation of the TRANSYT7F signal timing optimization program.

! TRAFFIC is a highway assignment program with user and system equilibrium capabilities.

Each CORFLO submodel can be run independently or be applied to a specific subnetwork which is a part of a larger network. The interface of adjoining subnetworks is accomplished by defining "Interface Nodes". Continuity of flow from one subnetwork to another (including spillbacks) is preserved by the program logic.

TRAFFIC produces minimum paths between each O/D pair, link volumes, turning fractions, and congested times. NETFLO 1 and 2 generate volumes, speeds, travel times, delays, fuel consumption, and emissions rates. These MOEs can be obtained at the network-wide, link-specific, and movement-specific levels. FREFLO reports information for both the end of each time slice as well as a cumulative total for the relevant MOEs. Congested speeds, densities, volumes, and delays on freeway sections are produced by FREFLO. All of the MOEs are derived from density, volume and speed. Derivative MOEs include VMT, VHT and other measures. Mainline and ramp statistics are reported by timeslice for each subsection.

CORFLO can assess the operational impacts of incidents, reconstruction, bottlenecks, design alternatives, and control strategies in networks composed of both freeways and surface streets. Incidents are represented as lane reductions or in the form of capacity restraint on the highway section. Currently CORFLO is not sophisticated enough to handle advanced traffic control strategies. CORFLO explicitly handles passenger cars and trucks, buses, and carpools on freeways and surface streets in a single, integrated environment. In its present form, FREFLO cannot directly model ITS strategies that are related to information (CMS, In-vehicle information). Given the macroscopic (non-microscopic), freeway (non-network), and static (non-dynamic) nature of FREFLO, modeling of information would require drastic changes to the model structure. In its present form, CORFLO cannot simulate traffic actuated ramp metering. Only pre-timed ramp metering control can be evaluated.

CORFLO is not designed for analysis at a microscopic level. The absence of any car-following logic or lane-changing logic prevents the user from conducting traffic analysis at a detailed level such as traffic operations at freeway-ramp junctions. Further, only one-ring controllers, with limited features, were implemented in the actuated control logic. These limitations could be overcome by linking CORFLO with microscopic simulation models such as NETSIM and FRESIM. The main weakness of CORFLO in evaluating ITS benefits is the distinct separation of the assignment and simulation processes of the analysis, that does not provide for feedback into the assignment model based on simulation results.

Assuming data availability, the development of a validated simulation model including freeways and surface streets could be accomplished in as little as three person-months. The simulation of alternatives could be accomplished in two additional person-months, assuming that forecasts are available and alternatives have been defined. These time estimates assume that the user is already familiar with the models.

FREQ

FREQ is a macroscopic model that can simulate corridor traffic operations including a freeway and one parallel arterial. FREQ operates on the basis of speed/volume and demand/capacity relationships. The classic speed/volume relationship is used to compute speed for subsections. Several curves are resident in the program, one of which can be selected for any simulation, or a user-developed curve can be specified. The curves resident in the program were derived from multiple sources (mainly Caltrans and FHWA) and can be selected by choosing the appropriate freeflow speed. For most freeways the default 65 mph curve is appropriate. However, the FREQ speed/volume curves are likely to be revised based on new research. Based on ramp/mainline/arterial volume inputs, FREQ synthesizes a balanced trip table from each entry origin to each exit destination. This trip table is used to generate weaving volumes.

FREQ is best suited to corridor evaluations covering 5 or more miles of freeway, with emphasis on computing the effectiveness portion of a cost/effectiveness analysis for various geometric alternatives, and evaluating traffic management and traffic control alternatives (such as incident management, ramp metering, mainline HOV lanes, and HOV bypass lanes at ramp meters). FREQ has incorporated a modal shift capability for HOV strategies (HOV lanes and ramp meter bypass for HOV). The modal shifts are based primarily on travel time differential between the HOV and the mixed flow lanes.

FREQ outputs are more informative and comprehensive than most simulation models. MOEs include VMT, VHT, PMT, PHT, ramp-to-ramp travel time, emissions, noise, and a variety of others. A typical FREQ timeslice report shows subsection number, number of lanes, length, traffic demand based on the O/D data, modified traffic volumes based on subsection capacity and unserved volume, freeway capacity, capacity reduction due to weaving, queue length in feet, storage rate (whether a queue is growing or dissipating), v/c ratio, average speed, fuel consumption and emissions.

FREQ can assess benefits resulting from ramp metering and HOV lane implementation in a corridor. Mobility, congestion, emissions, and fuel consumption are comprehensively assessed by the model. Especially in the assessment of congestion, FREQ outputs speed and v/c contour diagrams that provide graphic congestion information by corridor subsection by timeslice.

In modeling detection/surveillance, FREQ can be used to simulate freeway accidents/incidents and assess corridor performance measures under alternative detection/response scenarios. Safety can be assessed indirectly as a function of MOEs that are readily available from the model.

In its present form, FREQ cannot model ITS strategies that are related to information (CMS, in-vehicle information). Given the macroscopic (non-microscopic), corridor (non-network), and static (non-dynamic) nature of FREQ, modeling of information would require drastic changes to the model structure. These changes would be equivalent to building a new model.

If data are available, the development of a validated freeway simulation model over a significant length of freeway could be accomplished in as little as two person-months. The simulation of alternatives could be accomplished in one additional person-month, assuming that forecasts are available and alternatives have been defined. CORFLO and FRESIM will require slightly longer time than FREQ primarily because of user orientation. These time estimates assume that the user is already familiar with the model.

INTEGRATION

INTEGRATION was developed specifically to evaluate and optimize the operation of integrated freeway/signalized arterial networks during recurring and non-recurring congestion. INTEGRATION is less data intensive than other simulation models in its class.

INTEGRATION simulates traffic flows in terms of individual vehicles that have self-assignment capabilities. The model assigns individual vehicles sequentially to a network that is already loaded with any previous departures that have not reached their destination. The turning movements of each vehicle at each node and time are dictated by the minimum path tree existing at that instant. Minimum path trees are recalculated every 6 seconds. The INTEGRATION modeling approach consists of a discrete simulation that traces the path of each vehicle throughout the network. The vehicle self-assignment capability circumvents the need to use either an explicit time-slice or iterations during the traffic assignment. Consequently, one can consider continuously variable demands and controls, both freeway and signalized networks, as well as any links that join them.

At the conclusion of a simulation run, the model produces two types of summary outputs. The first provides user-oriented statistics on the trips between each OD pair. The second provides system-oriented statistics on the operation of each network link.

INTEGRATION can model varying levels of driver/vehicle information. This is accomplished by differentiating between the following five distinct driver/vehicle types:

- Driver/vehicle type 1 represents a background vehicle type that has only historic information on congestion.
- Driver/vehicle type 2 is provided with continuous updates of real-time link travel times.
- Driver/vehicle type 3 represents drivers who have anticipatory knowledge of expected future link travel times.
- Driver/vehicle type 4 is intended to replicate the characteristics of TravTek vehicles.
- Driver/vehicle type 5 represent the behavior of drivers of HOVs.

The model has the ability to model and assess the effect of changeable message signs (CMS) at any location in the network. The user can specify duration of travel information displayed by the CMS. Also, INTEGRATION can model traffic signalization at both intersections and freeway on-ramps. Intersection control can be fixed-time or actuated. As part of the TravTek project, the model is being enhanced to optimize ramp metering and traffic signal control.

INTEGRATION is the most complete model for ITS benefits assessment at a freeway/corridor/arterial integrated network. It was specifically developed to perform traffic assignment in an integrated freeway/arterial network. INTEGRATION can simulate dynamic traffic demand patterns and a variety of traffic controls, takes explicit account of queue size and delay through traffic assignment, has individual vehicle self-assignment capabilities, and routing of traffic can represent the behavior of drivers with varying knowledge of traffic conditions. INTEGRATION is that it is still at an early stage of development. Potential problems may arise when applying the model to real-life situations. The model requires a significant amount of further development. Based on ITS-UC Berkeley experience, applications of INTEGRATION require approximately as much effort as macroscopic simulation model applications.

FRESIM

FRESIM is an extension of the microscopic freeway simulation model INTRAS, developed under FHWA contract in the early 1980s. It is now part of CORSIM, FHWA's integrated microscopic simulation modeling package (which also includes NETSIM). FRESIM is an extensive enhancement of INTRAS to improve its operational performance and enhance portions of its logic dealing with lane-changing behavior, freeway incidents, traffic composition and other variables. FRESIM is linked to the TRAF family of models including NETSIM, CORFLO, and ROADSIM. This linkage could provide a model framework that could comprehensively evaluate ITS strategies at a macroscopic level.

The primary relationships governing traffic flow within a simulated FRESIM network are the car-following logic, the lane-changing logic, and other aspects of gap acceptance. Vehicles are released into the study section according to a probability distribution based on the traffic volumes provided by the user in the input data. Upon entry, each vehicle will be assigned a destination, a vehicle type, and a driver type. Destinations are assigned based on a gravity model type formulation. Vehicle types are assigned stochastically based on the vehicle type distribution input by the user.

FRESIM provides a number of powerful and flexible features that permit the evaluation of traffic operational and ITS strategies. These features include:

- the capability to simulate ramp metering under several control options;
- the capability to define incidents by lane and by begin/end time;
- the capability to locate detectors for either testing incident detection algorithms or reporting volume/occupancy/speed data at user selected locations; and
- the capability to examine the impact of truck lane restrictions on traffic operations.

Because of its microscopic nature, FRESIM can simulate more features directly than macroscopic models. FRESIM is a powerful model for testing detailed freeway design features, weaving areas, complex ramp merging areas, grades, and the interaction of these elements with certain traffic management measures.

The input data requirements for FRESIM are only slightly more demanding than FREFLO and FREQ. However, FRESIM requires considerable computer processing time. FRESIM frequently takes more than 12 hours to model a heavily congested section, although this can be reduced with a longer time step, such as two seconds.

TRANSYT-7F

TRANSYT-7F is capable of simulating a given, non-dynamic traffic flow in a signalized network, optimizing signal timing, and evaluating the effectiveness of new signal timing plans in reducing stops, delays and fuel consumption. TRANSYT-7F is a macroscopic model that considers platoons of vehicles rather than individual vehicles and simulates traffic flow in small time increments. Its representation of traffic is therefore more detailed than other macroscopic models that assume uniform distributions within the traffic platoons. TRANSYT-7F assumes that delayed vehicles are also stopped. TRANSYT-7F is not capable of dynamic traffic assignment.

The model is capable of assessing different signalization scenarios (with and without coordinated sub-sections) and can assist in evaluation of ramp metering scenarios. Indirectly, TRANSYT-7F is also capable of modeling detection and surveillance technology by simulating accidents or incidents along a corridor or at an intersection and assessing the performance of the network under alternative response scenarios. This effort, however, requires linkage to some traffic assignment mechanism. Assignment (preferably dynamic) can reroute traffic and thus it can distinguish benefits from alternative ITS strategies. Such a linkage was attempted in the CORQ1C model, where FREQ was combined with TRANSYT-7F and with an assignment decision model. The major weakness of this model structure was the absence of an effective feedback loop from the network performance evaluation back to the initial traffic assignment.

TRANSYT-7F offers a number of different outputs including tables, plots, and reports. These outputs include a table of all MOEs, a table of controller timing settings, stopline flow profile plots (arrival and discharge flow rate profiles), space-time diagrams, cycle length evaluation summary and a route summary report. TRANSYT is also capable of several special outputs that can be used by several available post-processor programs. The post-processor programs are capable of creating platoon progression diagrams and graphic display files.

TRANSYT-7F simulation is very data intensive and requires a considerable amount of effort. Past performance of TRANSYT-7F suggests that it does not handle oversaturated traffic conditions very well. It is clear that this model should not be used for estimating the delay for long periods or high degrees of oversaturation.

NETSIM

NETSIM is the most detailed urban model of the TRAF models and is suitable for urban networks requiring detailed intersection analysis, and for which detailed input data or ample resources for data collection are available. Several major enhancements have been added to the model, including actuated controller logic, conditional turning-movements feature, identical traffic streams, and signal transition logic.

NETSIM applies interval-based simulation to describe traffic operations. Updates are made every second for each vehicle, every variable control device and every event. Furthermore, each vehicle is identified by category (auto, car pool, truck, bus) and by type. Up to sixteen different types of vehicles, with different operation and performance characteristics, may be specified, defining the four categories of the vehicle fleet.

Each vehicle's behavior may be simulated in a manner reflecting real world processes. A "driver behavioral characteristic" (passive, aggressive) is assigned to each vehicle, and the kinematic properties (speed, acceleration) and status (queued, free flowing) of the vehicle are determined. Turn movements are assigned stochastically, as are its free flow speed, queue discharge, headways and other behavioral attributes. Each time a vehicle is moved, its position (both lateral and longitudinal) on the link and its relationship to other vehicles nearby are recalculated. Its speed, acceleration and status are also recalculated. Actuated signal control and interaction between cars and buses are explicitly modeled. Vehicles are moved according to car following logic, response to traffic control devices and response to other demands. For example, buses must service passengers at bus stops, hence their movements differ form those of private vehicles. Congestion can result in queues extending throughout the length of a link and blocking the upstream intersection, thus impeding traffic flow there. Pedestrian traffic can delay turning vehicles at intersections.

NETSIM can generate congestion (queues and delay) resulting from a user-specified incident (time duration and capacity reduction). However, NETSIM will not re-route traffic in the event of that incident. NETSIM is not capable of dynamic traffic assignment.

The model can evaluate alternative traffic signal coordination strategies one at a time. There is no traffic assignment (dynamic or other) incorporated in NETSIM. Simulation is based on a fixed set of traffic volumes and turning movements that are input to the model. In the absence of traffic assignment, the model cannot reroute traffic as a result of any ITS strategy. An iterative process could be employed in which an ITS strategy is introduced, model parameters are modified, and the model is rerun to optimize traffic signals under the new scenario. This process would need to be accompanied by a traffic assignment methodology external to NETSIM, but sensitive to the same parameters as NETSIM.

The model outputs estimates of several measures of effectiveness, including average vehicle speed, vehicle stops, vehicle-miles of travel, average queue length and fuel consumption. NETSIM is tedious and cumbersome to use. Data requirements are very intensive and data coding is tedious. Several data input directs are recommended to minimize errors. Although the model is very data intensive, it is equipped with default values.

SATURN

SATURN (Simulation and Assignment of Traffic to Urban Road Networks) is a simulation model developed to analyze and evaluate traffic management schemes over relatively localized networks (typically 100 to 150 intersections). Due to a highly detailed simulation of delays at intersections, SATURN is primarily intended to be used as a sophisticated traffic assignment model. SATURN can produce extensive graphical outputs, and allows trip matrices to be obtained from traffic counts.

SATURN requires an O/D trip matrix representing the analysis period. SATURN has the option to create an O/D trip matrix from traffic counts. SATURN allows networks to be coded at two levels of detail, an inner or simulation network which is coded and simulated in detail and an outer or buffer network coded in much less detail. SATURN is based on an iterative loop between the assignment and simulation phases. Although SATURN appears as a single program, the simulation and assignment sages can be run automatically without user intervention until either convergence has been achieved or a specified number of iterations has been performed.

SATURN provides a complete modeling of signalized networks and thus can evaluate ITS technologies related to traffic signalization. However, the model cannot perform freeway simulation nor does it address information-related issues. SATURN, which is on the verge of release, will contain a number of options oriented towards the modeling of vehicle route guidance systems.

SATURN can perform assignment for a network consisting of traffic signals while giving considerations to the platooning structure of vehicle arrivals and the phasing of the signals. The model incorporates a platooning structure of vehicle arrivals at signalized intersections and allows networks to be coded at two levels of detail (inner and buffer networks).

Outputs from the SATURN assignment stage include flows and travel times for links and turns plus various aggregate measures such as average speeds, total vehicle-kilometers, and interzonal travel times, etc. Outputs from the simulation stage are detailed and mostly intersection-based. The level of effort required to run SATURN is similar to that required in other simulation models.

CONTRAM

CONTRAM (Continuous Traffic Assignment Model) is a macroscopic traffic assignment model developed for use in the design of traffic management schemes in urban areas. The program models time-varying traffic demands on urban road networks subject to capacity constraints and predicts the variation through time of the resulting routes, queues and delays. Generation of a synthetic origin-destination trip table is possible through an associated program called COMEST. The model can perform detailed modeling of traffic signals with coordination and optimization capabilities. CONTRAM does not adequately address modeling of freeway ramps and freeway merging and weaving sections.

Traffic for each origin-destination movement is processed in groups called packets. Each packet consists of an integral number of vehicles assigned at the same time between the same origin and destination. The grouping of vehicles into packets can be regarded, for assignment purposes, as a process in which the behavior of one vehicle in a packet is taken as typical of the behavior of the other vehicles in that packet. The model does not take into consideration vehicle platoon progression.

CONTRAM can perform modeling of signalized networks and can evaluate ITS technologies related to traffic signalization. The program incorporates a superior dynamic traffic assignment technique that updates vehicle flows and travel times for each link for each specific time interval. On the negative side, the model does a poor job with freeway simulation and with modeling of information.

There are six forms of output information. A summary report provides data on total journey time, total distance traveled, overall network speed, total final queues, fuel consumption and total link counts. Other reports include a convergence monitor report, a detailed link-by-link report (which includes information on queues, delay, signal efficiency, capacity, etc.), a point to point speed report, and a turning movement report. Based on ITS-UC Berkeley experience, CONTRAM modeling requires a significant level of effort.

ROADSIM

The ROADSIM model performs a microscopic simulation of traffic flow along a single two-way, two-lane rural road. Like the NETSIM model, the ROADSIM logic calculates the trajectories of individual vehicles using an interval scanning methodology. ROADSIM's methodology and logic is based on a model called TWOWAY. TWOWAY was restructured and reprogrammed to be compatible with and meet the specifications of the other TRAF models while incorporating logic from two other microscopic simulation models.

Because ITS research and applications is currently focused at urban areas, ROADSIM is not likely to be an element of an integrated ITS modeling framework. Potential areas of model application are assessment of congestion and safety impacts of implementing ITS on at rural roads.

The statistics gathered by the model describe traffic operations in great detail. Many vehicle-type-specific, link-specific, direction-specific and overall measures of effectiveness are provided, consistent with output of other TRAF models. In addition, data specific to the rural road environment are presented. These include a breakdown of travel time and delay according to source (i.e., due to geometric features and to impedance by other elements of the traffic stream) and passing statistics (passes attempted, aborted, completed). Other statistics include distributions of speed, headways and platoon sizes at locations specified by the user. As a result of ROADSIM's small application size, the modeling effort is not as intensive as that required other microscopic simulation models.

APPENDIX E. PROCEDURES FOR EVALUATION OF SELECTED ITS STRATEGIES

Appendix E provides specific procedures for the evaluation of the potential benefits of selected ITS strategies. The purpose of this appendix is to supplement Chapter 6 of the ITS Planning Handbook with steps that analysts can use to derive reasonable estimates of the potential impact of ITS strategies on travel and congestion. The procedures are intended to be applied in the planning stage so that better decisions can be made on the benefits of ITS in comparison with other types of transportation improvements. The procedures do not include a treatment of each ITS market package. However, they address a cross-section of multimodal ITS strategies, which may, in turn, provide ideas for how other ITS market packages might also be analyzed. The emphasis of most of these procedures is on calculating changes in delay or vehicle hours of travel (VHT). However, other measures of performance (e.g. vehicle miles of travel) can also be generated as a byproduct of these procedures. It is important to note that the measures of performance calculated using these procedures are not the only benefits that can be realized for the ITS strategies being discussed. Other quantitative or qualitative benefits may also be realized. See Chapters 2 and 5 of the Handbook for information on other types of benefits.

Strategy evaluation can take place in a variety of areas in the planning process: in the formulation of the transportation plan, in corridor or subarea studies, in development of the ITS strategic deployment plan, or in other analyses not connected to a particular type of study. The procedures discussed in this appendix may be applicable in any of these contexts. Some of the information from Chapter 6 is repeated in this appendix as background information.

ITS STRATEGY EVALUATION

Analytical tools that can adequately examine the benefits of ITS strategies are still in the formative stages. Appendix E provides an extended discussion of the evaluation of ITS strategies using tools that are typically available to the transportation planning and engineering community. The basic approach taken in this appendix is to provide insights into how the most reasonable estimates of ITS benefits can be derived for specific applications using existing, available tools and without an inordinate investment in evaluation. It is recognized that agency budgets for studies and evaluation are limited. It is important to understand that reasonable estimates of benefit can often be obtained without a large, costly undertaking. As more sophisticated tools are introduced, more refined answers can be obtained. But even if more sophisticated tools are available, many agencies will either not have the expertise to use them, or their use will not be possible within the time and cost constraints of the agencies conducting the studies.

There are three generic approaches to ITS evaluation that are currently available: sketch planning analysis, travel demand modeling, and traffic simulation. These are related to analysis contexts in Exhibit E-1. An overview of the three approaches is provided below, followed by information on the evaluation of specific ITS strategies using each approach.

Exhibit E-1. Applicable Analysis Tools for Evaluating ITS Strategies

	Travel Demand Model	Traffic Simulation	Sketch Planning	Emissions Inventory	CO Hot Spot
Transportation Plan	U		U	U	
Plan and TIP Conformity	U			U	
ITS Strategic Deployment Plan	U		U	U	
Corridor/Subarea Study	U	U	U	U	U
Isolated location		U	U		U

Overview of ITS Evaluation Using Travel Demand Models

It is recognized that travel demand models are not as sophisticated in treating even the more traditional strategies as many planners would like. Procedures for evaluating ITS within travel demand models are included to provide agencies with at least some guidance, while recognizing the limitations of the tools. Where a region has a more sophisticated approach, they are encouraged to use it.

One of the advantages of using a travel demand model to estimate ITS benefits is that it expresses ITS effectiveness in the same terms as for other strategies evaluated with the model. Typically, these include vehicle miles of travel and vehicle hours of travel as the primary measures. There are significant weaknesses in the approaches prescribed, but they represent the best available techniques for using traditional travel demand models as ITS evaluation tools. Realistic alternatives to traditional travel demand modeling are likely a number of years away.

Travel demand forecasting models estimate highway volumes and transit ridership through a four-step process that includes: trip generation, trip distribution, mode choice, and assignment. In most regional travel demand models, trip generation is a function of socio-economic characteristics such as the number of households, employment, income, household size, and/or auto ownership. The trip distribution model converts the trips created by the trip generation model to a matrix of trips to and from specific areas of the region based on the travel characteristics of the transportation network. The mode choice model splits the trip table into travel modes based on the relative travel characteristics of each mode. The assignment procedures load the trip tables to the corresponding network, resulting in estimated traffic volumes and other travel-related variables.

The majority of models consider travel for the entire day, almost always a weekday. Some models simulate mode choice based on peak and off-peak conditions and assign trips to peak hour or peak period networks. The model will be more useful in ITS planning if it simulates peak period conditions. The impacts of ITS strategies on a daily model will be more difficult to quantify. To test ITS strategies with a travel demand forecasting model, the strategy must be characterized according to the parameters used in one or more of the modeling steps. Exhibit E-2 provides a list of the parameters within a typical travel demand model that ITS strategies could potentially influence. The order of magnitude of the likely impact of each change is also noted (negligible, low, moderate, and high influence). The ratings are made within each category and between categories. Recommended model implementations of various ITS strategies are described below.

Exhibit E-2. Ability of Travel Demand Models to Account for ITS Influences

Model Step and Parameter	Sample Related ITS Strategies	Potential of ITS to Influence Parameter
Trip Generation - Trip rates - Auto ownership	 Pre-trip travel info. Ridesharing & transit incentives	Low overall Low Negligible
Trip Distribution - Travel time - Travel Cost	 Ramp metering, signal systems Tolls, pricing	Moderate overall Low Moderate
Mode Choice - Travel time - Travel cost - Auto ownership	 Ramp metering, signal system Fares, tolls, pricing Ridesharing & transit incentives	Low overall Low Moderate Negligible
Assignment - Roadway capacities - Free flow speeds - Travel cost - Speed-flow relationships	 Ramp metering, incident mgmt, tolls Ramp metering, signal systems, info. Tolls, pricing Ramp metering, signal systems	Moderate overall Moderate Low High High

Overview of Sketch Planning Methods

Sketch planning refers to simplified techniques that can provide reasonable estimates of the benefit of various strategies. These methods will often be spreadsheet-based, using logical assumptions and estimates. However, substantial reliance is placed on experienced judgements by the analyst. To the extent possible, these judgements should be grounded in actual experience from similar situations and/or in research. Sketch planning methods have the advantage that they are normally relatively quick and inexpensive. With some ITS strategies, sketch planning may be as reliable as more sophisticated methods, given that travel demand models and simulation models have not been designed to address most of the ITS improvements. The additional cost of reflecting an ITS strategy in a simulation technique may not be warranted.

Overview of Traffic Simulation

Traffic simulation may provide a more sophisticated approach to some ITS evaluations. However, there are significant limitations. Most ITS strategies cannot be directly simulated with existing tools, but must be indirectly simulated through the adjustment of volume inputs and other parameters. Simulation provides a significant advantage over highway capacity analysis, as it tracks congestion from section to section and provides outputs in terms of speed and delay, the primary ways in which ITS affects travel.

An important step in the simulation process is model validation, in which the existing condition is simulated and compared against known data. It is similar to the validation process undertaken for travel demand models. For freeway simulation, a primary validation criterion involves matching the known speed profile with the simulated speed profile, an example of which was shown in

Chapter 6 of the body of the report. Simulation models can be highly sensitive to relatively small changes in volume, and it is important that the validated model reasonably reflect current speed profiles.

Short-term evaluations using simulation (e.g. 5 years into the future) can often be conducted using trend line traffic forecasts, unless a major transportation project could occur in the intervening years. Longer horizon years should consider factoring in results from forecasts using travel demand models. Normally, traffic volumes cannot be used directly from travel demand models; rather the travel demand model outputs need to be refined to account for the under prediction or over prediction of traffic. Typically, adjustments to future volumes are made based on the differences between the model validation year volumes and the actual counts for the same year. These adjustments are particularly important when forecasts are being input to simulation models because of the sensitivity of the simulation model results to traffic volume inputs.

Choosing the Analytical Approach

A variety of factors need to be considered in selecting the analytical approach to ITS. Chapter 6 in the body of the report described some of these factors. In some cases, the analysis could also be two-tiered: sketch planning might be used as a screening tool, with more in-depth analysis for selected strategies depending on the outcome. Sketch planning analysis may also be required to generate inputs for some of the more sophisticated tools.

Some of the basic rules in conducting ITS-related analyses include:

- Have key assumptions reviewed by multiple staff, not just a single individual.

- Sensitivity analysis may be warranted for conditions where the validity of key assumptions is highly uncertain. Sensitivity analysis shows how the outcome will change depending on changes in those assumptions.

- Ensure that staff have proper training in the use of travel demand models and simulation models, where used. Changes in model parameters can sometimes have unexpected effects that may not be readily apparent. The basic structure of the models must be understood to avoid problems.

- Maintain good records of assumptions used for each scenario analyzed. Variations may need to be tested later, or assumptions may be questioned. Good records will support the credibility of the process. The specifications for an alternative or strategy tested should be included in the computer-generated output, whether it be spreadsheet, simulation, or travel demand model.

- Expose the underlying assumptions so that decisions can be based on full knowledge.

- Ensure that the study area incorporates the full effects of the strategy being analyzed. Upstream and downstream congestion that may be influenced by a strategy should be included as part of the study area.

- Note any potential secondary effects that may not have been included in the analysis (e.g. diversions that were not accounted for, etc.).

- Make the results understandable to the intended audience. In many cases, the audience will be non-technical.

Approaches to Evaluation of Specific ITS Strategies in a Corridor/Subarea Context

Approaches to the transportation evaluation of individual ITS strategies are discussed below. Not all ITS strategies are provided with a methodology. However, the analyst will either be able to adapt the material here to the evaluation of other strategies or will be able to devise a similar methodology based on the principles described here. (Author's note: many of the approaches are newly devised for the ITS Planning Handbook. The procedures will be tested in the next project phase, and likely refined. Observations on these procedures should be directed to the FHWA contact manager listed in Chapter 1 of the Handbook.)

The discussion on simulation is based on three freeway models (FREFLO, FREQ, and FRESIM) and two surface street network (TRANSYT-7F and NETSIM). These represent the most available and used simulation models for most applications in the U.S. However, they are not the only simulation models available. The simulation approaches describe how to use the appropriate models in the analysis of the ITS strategies. Traffic volumes, VMT, and VHT are a standard output of both travel demand models and simulation models. Additional calculations are required to produce VMT and VHT estimates for sketch planning approaches.

Freeway management systems - ramp Metering Without HOV Bypass Lanes on Ramp

Ramp metering is designed to smooth traffic flow, provide priority to higher occupancy vehicles (in some cases), and influence path selection. It improves the speed on a limited access facility by controlling the processing rate of the access points. The increased delays at the access points (ramps) are generally compensated by higher speeds on the facility. If the trip is short, the benefits will not compensate for the delays, and the trip is likely to choose an alternative path.

Sketch Planning Approach: The following presents an analysis based on documented existing conditions. An analysis of future conditions would require additional estimation of speed in the future base (unmetered) condition. The analysis is conducted by individual ramp and segments between ramps. To help organize the data, a spreadsheet should be set up with columns for section length, volume, and speed for the freeway and arterial both with and without metering. Additional columns should be set up for ramp volume and ramp delay with and without metering. This will result in six columns for the freeway data, six columns for the arterial data, and four columns for the ramp data. The first column will define the sections being analyzed. Vehicle miles and vehicle hours can be calculated for each section in additional columns.

1. Estimate current freeway speeds for each hour for each freeway section in the peak period by direction, based on non-incident conditions.

2. Estimate the metering rate as a percentage of the on-ramp volume for each hour, depending on how strong the metering plan needs to be to maintain freeway flow. Typically, the metering rate will be no less than 80 percent of pre-metering volume. Use 300 vph per lane minimum metering rate and 900 vph per lane maximum.

3. Estimate peak hour ramp delay per vehicle at:
15 sec. + 5 min. x (demand vol./metering vol. - 1)
Minimum assumed to be 15 sec., maximum five minutes.

4. Assume diversion to parallel arterials is 50% of the difference between the demand volume and the metering rate. This assumption could be varied by the user. Assume these diverted vehicles travel for two interchanges on the arterial before taking another route. This is consistent with the logic that primarily short trips will be diverted.

5. For each ramp, calculate vehicle hours of delay under metering as delay per vehicle (step 3) times the new ramp volume with diversion (step 4). Assume no ramp delay for non-metering condition.

6. Estimate freeway speeds with ramp metering at a minimum of 40 miles per hour. This would apply to all non-diverted traffic.

7. Estimate the <u>change in speed</u> on the nearest parallel arterials by calculating the difference in speed (based on v/c ratio for the metered and unmetered conditions) from the BPR formula presented later in this appendix. The free-flow speed (T_o = free flow speed) should be set according to the characteristics of the specific arterial. A rule-of-thumb maximum capacity for an urban signalized arterial is 900 vph per lane.

8. Calculate vehicle miles and vehicle hours for freeway and arterial, including ramp delay. This should be done in a spreadsheet, calculating section-by-section volumes and speeds on both the freeway, arterial, and ramps. It is helpful to plot the non-metering and metering volumes and speeds on a simple sketch to keep all the information in order.

9. Estimate accident reductions based on evaluation data in Chapter 2. Accident frequency on arterials may need to be increased based on volume increase. Assume same arterial accident rate is applied to the higher arterial volume.

10. Estimate percentage of days that major incidents will disrupt metering effectiveness. Assume no benefit on these days. A typical value would range between 10 and 30 percent.

11. If estimating benefits on a regional basis, add individual corridor benefits together.

Travel Demand Model: Ramp metering can be approximated in the assignment model in one of two basic ways (or in a combination of both). It is important to note that none of the following procedures have been fully tested for these applications. A validation process, or at a minimum, a testing of scenarios for reasonableness, is needed for any individual application. At best, this will provide an order-of-magnitude estimate.

1. At on-ramps: restricting the capacity of the ramps to the maximum metering rate. This would not necessarily limit the assigned volume to the metering rate, but it would put downward pressure on the assigned ramp volumes. On the mainline: increasing capacity on the limited access facility in the sections metered. Evidence indicates that ramp metering could increase maximum mainline throughput (represented by capacity) at critical sections by three percent.

2. Modifying the speed-flow relationships on the ramps and limited access facilities to control the delays associated with near-capacity conditions. The objective is to significantly increase the delays on the ramps and slightly reduce the delays on the limited access facility. Speed-flow adjustments can be implemented in several ways. The most logical approach is to modify the speed-flow relationship on the facilities of interest based on traffic engineering principles. If a traditional BPR formula is used, this can be achieved by modifying the exponent value or adjusting the delay factor. Exhibit E-3 shows an example of changing the exponent from 4 to 7. This type of adjustment would improve the delay estimated on the metered ramps. The flow enhancements on the mainline could be implemented by reducing the delay factor from 0.15 to 0.12. This has the effect of stretching the curve to the right. Alternatively, other functional forms can be used. For example, Exhibit E-4 shows an exponential formula that simulates the impacts of ramp metering on mainline speeds more accurately than the traditional BPR formula.

If the available software does not permit the user to specify speed-flow relationships for specific links or facility types, a similar result can be achieved by changing peak hour percentages, free flow speeds, or link capacities. Link capacities are discussed above. The best way to implement the delay effects on the ramps is to reduce the free flow speed. This has the effect of giving some delay to all vehicles on the ramp regardless of the level of congestion. VMT, VHT, and traffic volumes are a product of the modeling analysis.

Simulation Approach Using Selected Models:

FREFLO: The model has no metering capability. Fixed-time metering can be approximated using ramp capacities equivalent to the metering rate. Ramp capacities may be varied by time period (also called time slice). No driver response is built into the model. Diversion would have to be calculated using a sketch planning approach. Linkages can be built to arterial simulation models for more advanced applications, but diversion adjustments will need to be made manually.

FREQ: In non-optimized mode, fixed metering rates can be established, with options for on-ramp motorists to divert to the arterial based on a user-specified set of decision criteria. Arterial simulation is relatively crude. Also has capability for ramp metering optimization based on a set of user-specified criteria. Considers metering only as aggregate demand reduction on freeway mainline. Does not consider effect of metering on merging operation. In optimized mode, uses linear programming to generate a corridor optimum. User can set maximum and minimum rates as well as decision criteria for drivers to divert from on-ramps to the arterial. Other constraints that can be entered include maximum v/c ratio at bottlenecks, maximum queue lengths at each ramp, and designation of ramps which are not to be controlled. By setting maximum and minimum metering rates for various ramps in various time slices both at the same value, the user can enter their own ramp metering plan.

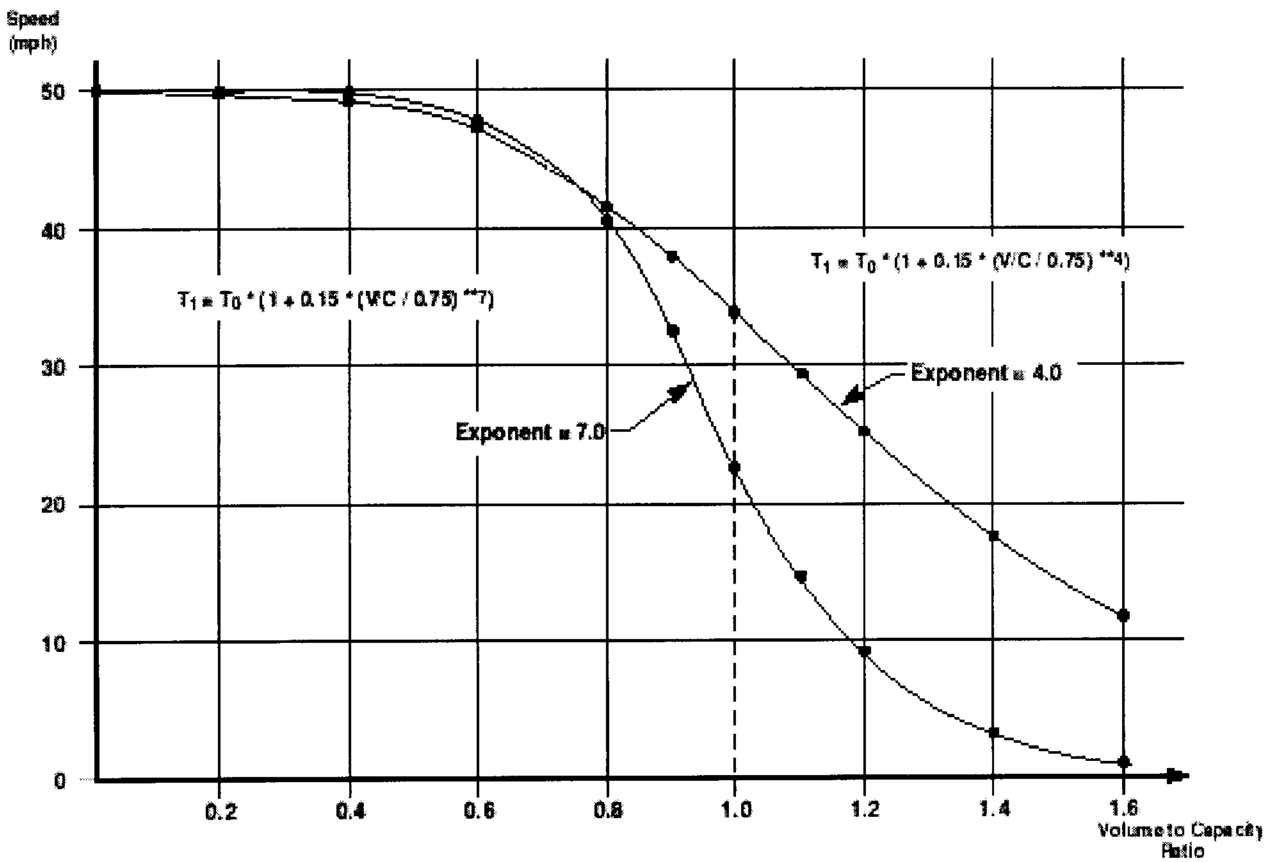


Exhibit E-3. Example effect of Adjusting Exponent in BPR Formula

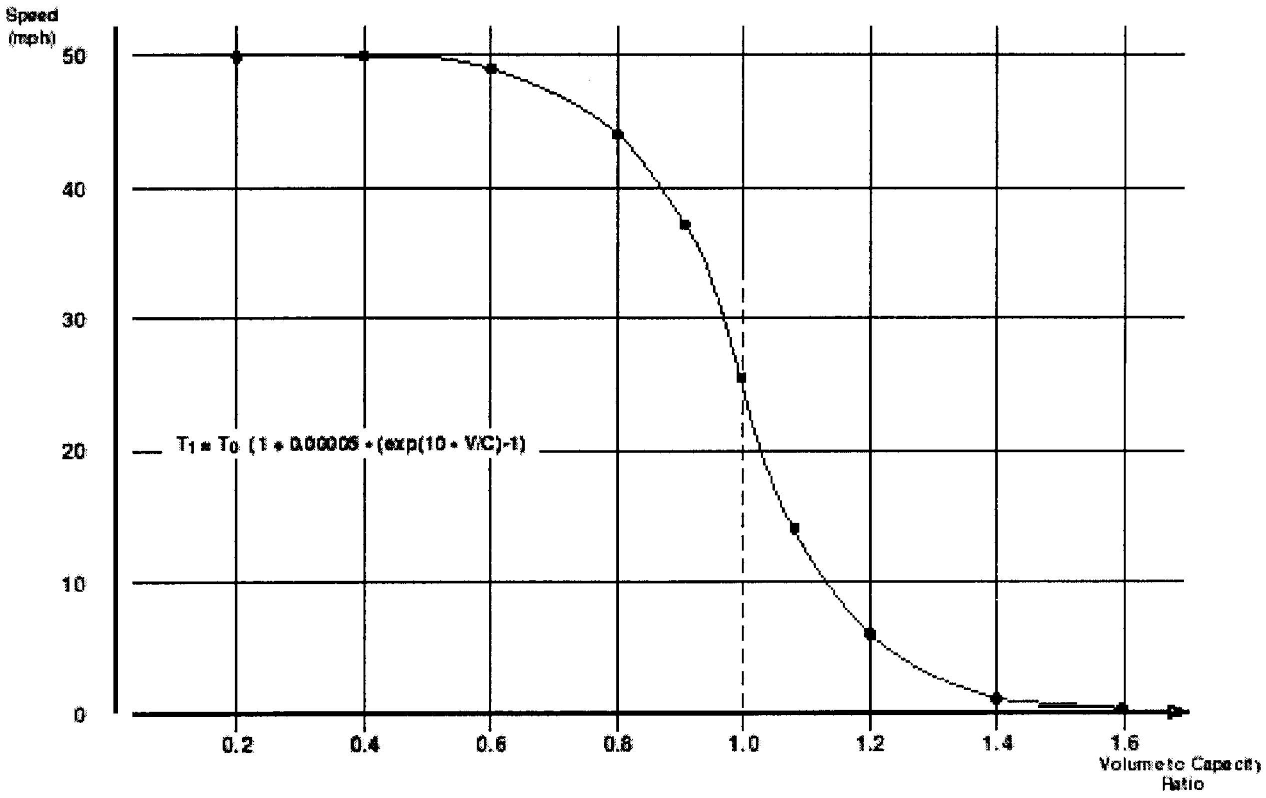


Exhibit E-4. Exponential Formula for Improved Simulation of Ramp Metering Condition

FRESIM: Several metering types can be selected, including fixed time. Considers both effect of limiting demand and on-ramp merging operations. As an optimization option, generates a local optimum based on mainline demand/capacity relationships or gap acceptance logic.

All of the above models will generate VMT and VHT statistics. For FREQ and FREFLO, the mainline capacity can be adjusted upward by a user-selected value to account for increase in throughput. Experience has shown that an increase in throughput of approximately three percent is possible through ramp metering. Steps 9 through 11 from the sketch planning approach may be applied to take individual corridor daily estimates to annual, regional estimates, if desired.

Freeway Management Systems: Ramp Metering with HOV Bypass

Sketch Planning Approach:

- Perform in same manner as without HOV bypass, but estimate vehicle occupancy distribution on each ramp, mainline and arterial. Calculate HOV volumes on ramp. Estimate savings in person hours of travel in addition to vehicle hours of travel (should be greater savings due to no delay for HOVs). Assume ramp metering for non-HOVs is more restrictive, keeping total on-ramp vehicle delay the same as for ramp metering without HOV bypass. Additional columns will be needed in the spreadsheet to handle HOV ramp volumes.

Travel Demand Modeling Approach:
If HOV bypass lanes are provided on the metered ramps, the mode choice and assignment models can be affected. The travel time advantage for HOV trips will have a slight impact on the number of HOV trips estimated by the mode choice model. Most mode choice models are not very sensitive to this change. The impact on the assignment of HOV trips can be significant. A possible procedure is as follows:

- Add a parallel ramp with HOV restrictions and increased capacity. Assign non-HOV and HOV trips to the highway network. Skim the HOV and non-HOV paths based on loaded speeds for use in the mode choice model. Rerun the assignment.

Simulation Approach:
FREFLO: Not treated.

FREQ: Incorporates a modal shift algorithm that generates additional HOV's in response to the delay saved by HOV's at the on-ramps. Algorithm calibrated for specific locations in California. Modal shift responsiveness may need to be modified depending on the nature of the urban area and orientation of the freeway. However, the effect of violation rates can be influenced by altering the percentages of HOV and non-HOV vehicles at the entry ramp.

FRESIM: No HOV priority capability.

Incident management and traffic surveillance

Incident management programs generally provide benefits in two ways: reducing delay directly through a reduction in incident duration, or reducing delay indirectly through the provision of information, which allows delay savings by individual drivers through alternate routing.

The time of incident duration is reduced by reducing the time for incident detection, verification, response, and clearance. Exhibit E-5 represents the type of assessment that needs to be conducted to estimate the effect of incident management strategies on incident duration. These data are from an incident management study conducted on the George Washington Bridge/Cross-Bronx Expressway in New York. Note that multiple ITS technologies are represented, both individually and in combination.

It is important to note that a variety of conditions on the highway system could change the distribution of time associated with detection, response, and clearance. For example, a lack of shoulders would ordinarily extend the response time (i.e., the amount of time required for emergency vehicles to arrive at the scene). To the extent possible, agencies should compile their own data on incident duration so that they will have a reasonable base from which to initiate an analysis.

Exhibit E-5. Sample Estimates of Incident Duration (Minutes) for Incident Management Strategies (Source: Case study on the Cross Bronx Expressway, New York)

Strategy	Detection	Verification	Response	Clearance	Total
For Accidents					
Current	8	6	10	20	44
Loops only	4	6	10	20	40
CCTV only	6	2	8	20	36
Loops & CCTV	4	2	8	20	34
Additional wreckers	6	4	6	15	31
Accident invest. sites	8	6	10	12	34
Access points	8	6	8	18	40
Lane control	8	6	6	20	40
Total program	4	2	6	10	22
For Other Incidents					
Current	10	6	10	15	41
Cellular call-in	5	6	10	15	36
Loops only	4	6	10	15	35
CCTV only	6	2	8	15	31
Loops & CCTV	4	2	8	15	29
Additional wreckers	8	6	6	10	30
Accident invest. sites	10	6	10	10	33
Lane control	10	6	6	15	37
Total program	4	2	5	8	19

Sketch planning approach:

1. Estimate the number of incidents by severity and duration within the study area for three time periods: A.M., off-peak, and P.M. peak periods. Severity means the number of lanes blocked.

2. Construct a set of incident duration curves by estimating the vehicle hours of travel incurred under existing conditions from each combination of severity (number of lanes blocked), direction, and time period. An example of an incident duration curve is shown in Exhibit E-6. The exhibit was based on incident duration in 15-minute increments (incidents of 15, 30, 45 minutes, etc.) These delay estimates could be provided in a sketch planning analysis using the QUEUES program available from FHWA (a spreadsheet-based analysis tool that can estimate delay for incidents and construction activities). The analysis will require traffic volume, number of lanes (or capacity), and number of lanes blocked (or capacity reduction). Exhibit E-7 shows typical reductions in throughput for each combination of number of lanes and lane blockage. Keep in mind that these delay estimates may be slightly high, as they assume no traffic diversion. This is the most time-consuming part of the process. To reduce the amount of effort,

the analyst may need to work with simplifying assumptions, such as using a single-lane incident at one or two representative locations during both a peak and an off-peak period.

3. Estimate the reduction in incident duration achievable through various incident management strategies, as illustrated in Exhibit E-5.

4. Estimate the delay savings for the new set of incident durations (compared to the unimproved condition) from the curves generated in step 2. The delay saving is the difference between the delay for the current and new durations attributed to the incident management strategies.

5. Sum the delay savings achieved for each set of strategies and representative sample of incidents. This will represent the savings in VHT. Changes in VMT are not assumed. The analyst would need to estimate diversions across given lengths of various facilities to estimate VMT. It is likely that diversion would increase VMT and that reduced incident duration would reduce the amount of diversion, resulting in a lower VMT for the incident management option than without incident management.

Travel Demand Modeling Approach:
The delay attributed to a specific incident scenario (similar to the sketch planning approach) would be implemented in the assignment model by modifying the time-based capacity of the roadway at the incident location. Since most models define capacity as an hourly value, the modeler will need to calculate the weighted average capacity of the roadway over the simulated period, and use this value in the modeling process. For example, if a peak hour model is used and the incident closes two lanes of a four-lane facility for 30 minutes, the resulting capacity is three fourths of the original value. The incident management strategies will modify the duration of incidents and thereby modify the capacity of the roadway. The following specific steps can be employed:

1. Construct an incident duration curve (or curves), as in the sketch planning approach, for defined sets of conditions using the capacity-reduction technique described above. The only difference is that the travel demand model will be used to estimate delays rather than the QUEUES program. Keep in mind that the travel demand model will assume diversion in the assignment program, which may or may not occur.

2. Follow steps 3 through 5 under the sketch planning procedure.

Simulation Model Approaches:
Simulation approaches will follow the same basic steps as in the sketch planning approach above, including construction of the incident duration curve. The primary difference is that the simulation models will be used to estimate delay rather than the QUEUES spreadsheet program. The simulation models (except for FRESIM) can be used to estimate incident delay by modifying their capacity

to correspond to the effect of the incident (see Exhibit E-7 for capacity-reducing values) for the prescribed time periods. Temporary capacity modifications in the simulation models can be treated as follows:

FREFLO: Specify the time slices during which the incident is to be active and code in the reduced capacity for those time slices.

FREQ: Specify the reduced capacity in the "reduced capacities" option for all time slices affected by the incident (e.g., a 45-min incident would affect three 15-min time slices).

FRESIM: Indicate the beginning and ending times for the incident and the lane or lanes blocked. In FRESIM, the beginning and ending times of the incident may be indicated to the minute and second and do not need to coincide with time slices, a limitation that exists in FREFLO and FREQ. FRESIM contains its own table of capacity-reducing effects of incidents. FRESIM also allows the simulation of an incident warning sign. This influences drivers to shift out of the incident lane earlier than they would otherwise.

Exhibit E-6. Sample Incident Delay Curve Related to Incident Duration

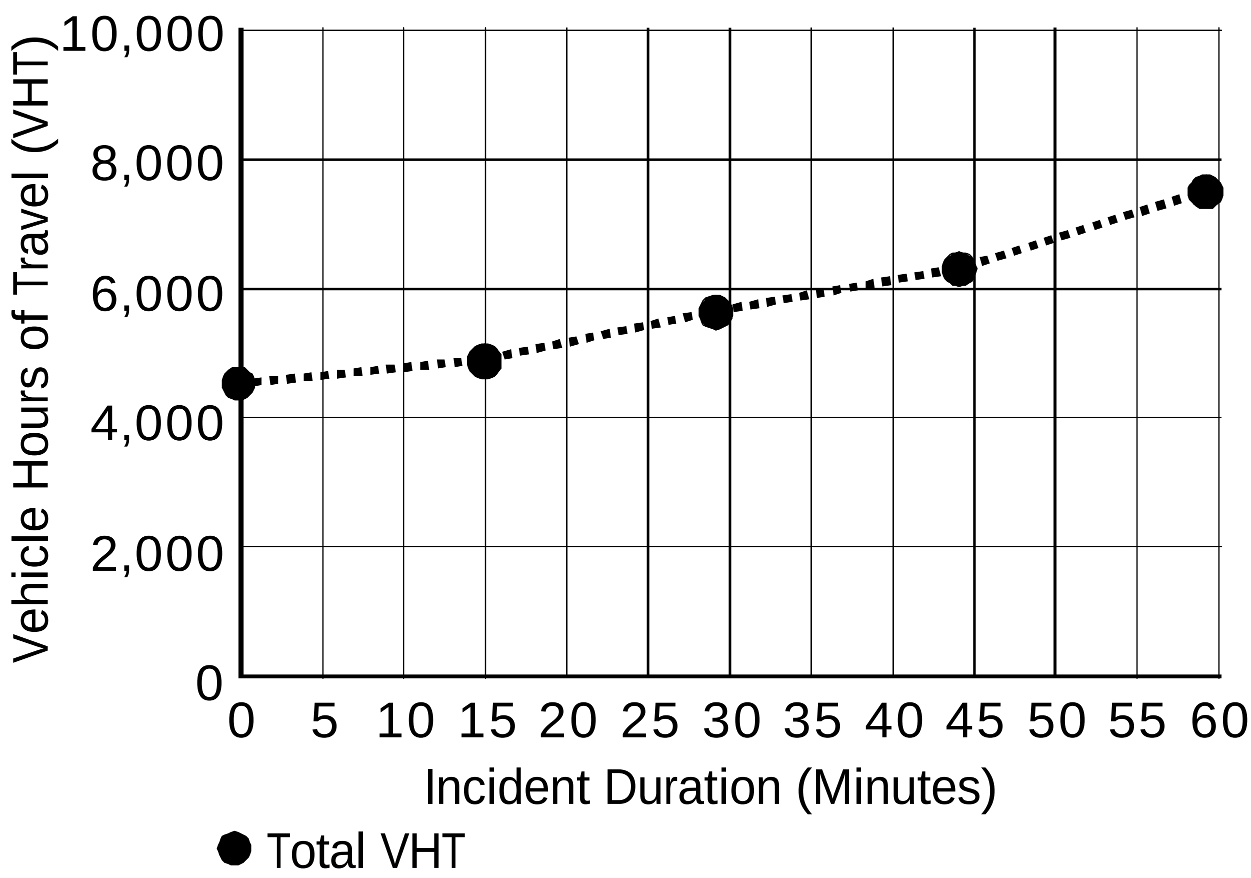


Exhibit E-7. Typical

Reductions in Throughput as a Result of Incidents

Total number of lanes	Incident on Shoulder only	Incident blocks one lane	Incident blocks two lanes	Incident blocks three lanes
Two lanes	25%	67%	-	-
Three lanes	20%	50%	80%	-
Four lanes	20%	40%	70%	85%
Five lanes	20%	35%	60%	75%

Variable Message Signs, Highway Advisory Radio and Other Forms of Motorist Information (diversion strategies)

Estimating the impact oftraveler information is perhaps the most difficult ITS strategy evaluation task for any of the analysis methods. Most traveler information systems focus on providing warnings about incidents. In general, one would expect most of the effect to be on path choice, resulting perhaps in slightly longer trips but shorter in time than compared with no information. Typically, a limited proportion of motorists on an affected route actually change their route (perhaps up to 30 percent in severe, non-closure instances). The travel time savings for these individuals varies widely by the nature and time of the incident and alternate routes available. Typically, though, the origin-to-destination trip time would not be reduced by more than 20 percent. These general parameters could be used to assess whether the model is within a reasonable range of the likely impact.

Sketch Planning Approaches:
It is assumed that motorist information will normally be in response to an incident and that it will involve diversion from a freeway to another freeway or from a freeway to an arterial. The approach will be to provide representative scenarios. There are two sketch planning approaches, one that is trip-based, and one that is based on the estimation of benefits for individual incidents.

Sketch planning approach (trip-based):

1. Within the region (or a smaller study corridor), estimate average trip distance and trip time for peak and off-peak periods. An estimate should be obtainable from regional planning data from the MPO.

2. Define the "trip markets" as the number of trips occurring in the region or corridor by time period (longer and shorter periods)

3. Estimate the incident-affected trip travel time for a typical incident situation. This data is typically unavailable, but a sensitivity analysis could be conducted using five-minute, ten-minute, and fifteen-minute increases in trip time.

4. Estimate the time savings potentially achievable through better information. This value will need to account for the availability of alternate routes (limited alternate routes will mean limited time savings) and the lack of congestion on

alternate routes (off-peak travel should have greater potential time savings for diversion). A value of 1 minute might be considered for a peak period, peak direction with poor alternate routing and up to 15 minutes for an off-peak or non-peak direction with good alternate routing.

5. Estimate the percentage of the trip market that will be able to take advantage of the information. This should account for locations to which the information is being delivered (e.g. if only on the freeway, only the share of trips using the freeways would benefit). The absorption capacity of alternate routes will also limit the trip market that can be affected. Typically, off-peak travel will have a higher percentage of the trip market affected than during the peak. It is expected that these numbers will be no greater than 30 percent of freeway traffic in the off-peak and 10 percent in the peak. Off-peak directions during the peak periods could be between these two values.

6. Estimate delay savings as the number of trips affected times the amount of time saved per trip. Handle each trip market separately. This will produce estimated savings in VHT. An estimate of change in VMT could be made by estimating the typical increase in trip length for diverted trips and multiplying by the number of trips assumed to be affected.

7. Estimate the frequency with which the travel information will be useful for each trip market, based on incident frequency and severity (probably no more than two days per week for each trip).

8. Multiply the time savings potential for each trip market by the percentage of trip market affected and by the percentage of days trips are likely to be affected to generate total time savings.

Sketch planning approach (based on individual freeway incident)

1. Document traffic volumes and speeds for the time period being analyzed.

2. Define the incident condition to be represented (location, duration and severity).

3. Estimate non-incident VHT using average speeds and volumes for the base condition. Estimate additional VHT under incident conditions (no information) using the QUEUES spreadsheet.

4. Estimate diversion of vehicles that would occur with additional information. Experience has indicated that this amount can range from several percent for "weak" messages to 30 percent for strong messages.

5. Recalculate freeway VHT in QUEUES spreadsheet assuming diversion.

6. Calculate increase in arterial VHT using existing speeds and changes in speed estimated from BPR equation or from other preferred capacity/delay calculations. Additional trip length of diverted vehicles must also be accounted for.

7. Sum all component VHTs to provide comparison between the with-information and without-information conditions. VMT would need to be calculated by estimating a change in volume over the segments affected and summing the change in VMT by segment.

Travel Demand Modeling Approach:
Since travel models do not directly consider incidents, only indirect modeling can be performed. This modeling could take the form of a general reduction of non-work travel during the peak period based on more reliable information about travel conditions (i.e. trips would not be made or would be deferred - these would need to be accounted for elsewhere). Traveler information could also affect the in-route path selection of travelers. Travel demand models were not designed to evaluate any of these effects, and models would need to be "fooled" into providing ballpark estimates. Substantial trial and error would be required. Use of travel demand models for this activity is not recommended.

Simulation approach:
In a simulation-based approach, the diversion amount will typically need to be reflected manually in the model input volumes. The diverted amount will need to be reflected in either another freeway or arterial simulation model (as an increased volume), in a network integrated with the primary freeway being analyzed, or reflected in a sketch planning analysis.

FREFLO: Motorist response to variable message signs, highway advisory radio, and other information/diversion strategies would need to be reflected in manual volume adjustments to on-ramps and off-ramps in the simulation model. Little basis exists for estimating diversion percentages other than the general rules described above, and separate estimates would need to be made for the effect on the arterial.

FREQ: Same as for FREFLO.

FRESIM: Same as for FREFLO for route diversion. FRESIM simulates incident warning signs and lane diversion, as discussed above.

TRANSYT7F: Traffic volume adjustments would need to be made to the input volumes to reflect diversion from the freeway to the arterial. The model can be run with either the same timing plans or be allowed to optimize, if that capability is presumed to exist in real-time on the arterial.

NETSIM: Traffic volume adjustments would need to be made, as with TRANSYT-7F.

Computerized Traffic Signal System

Sketch planning approach:

- Sufficient field evaluation data exist that could be assumed for comparable conditions. See Chapter 2. No further sketch planning is suggested.

Travel Demand Model: The primary modeling impact is in path selection. The generalized benefits of improved speeds will have little impact on the other components of the modeling process. These strategies can be implemented in the assignment model by:

- Modifying the speeds and capacities of the roadways included in the signal system. If this adjustment is to be applied accurately, the increases should be somewhat proportional to the percentage change in speed expected for the level of improvement implemented (changes in free flow speed are the preference). Increases in capacity of 50 to 100 vehicles per hour per lane and in free flow speed of 2 or 3 mph are typical for significant improvements.

- Modifying the speed-flow relationships to reflect higher speeds at near-capacity conditions.

Evaluation of the benefits of signal system improvements indicate that upgrading to computer-controlled signal systems can increase speeds from eight percent (compared to a reasonably well managed pretimed interconnected system) to 25 percent (compared to a non-interconnected system). The results of the travel demand model should be calibrated to or gauged against these general parameters.

Simulation approach:

- The benefits would need to be represented by signal timing changes within TRANSYT-7F, NETSIM, or comparable network/arterial simulation model. The ability to accomplish this depends on the ability of the analyst to replicate signal timing patterns and algorithms. Each case needs to be handled individually, using the guidelines for model operation provided for each model.

Electronic Toll Collection and Other Toll Processing Time Improvements

The analysis of ITS electronic toll collection technologies deals with the efficiency improvement of electronic toll collection, not the imposition of tolls itself. Conversion to electronic technologies yields substantial cost savings over manned toll booths, in addition to the delay-reduction potential. The analysis procedures below deal with estimating delay reduction.

Sketch planning approach:

1. Document traffic volumes through toll plaza by hour and the distribution by type of toll payment (exact change lanes, other lanes, and existing passes, if any).

2. Document average service time per vehicle for each type of toll payment, including electronic toll payment (may be slightly reduced speed at toll plaza).

3. Estimate capture rate for electronic toll collection from each payment type.

4. Estimate processing time saved for the diversion from each payment type.

5. Multiply the processing time saved for each payment type by the number of vehicles for the corresponding payment types. Sum the total processing times and take the difference between the times with and without electronic toll collection. This difference represents the savings in VHT.

6. If existing queuing delays at the toll plaza are long, an additional assessment can be made of total vehicle delay saved brought about by higher toll facility capacity. The QUEUES model can be used, inputting a weighted average processing for the total toll facility (by direction) for conditions with and without electronic toll collection. The volume inputs will need to be demand volume, not processed volume. Demand volume is typically more peaked than processed volume.

Travel Demand Modeling Approach:
Travel demand modeling approaches assume that a toll facility is included in the modeling process. Electronic toll collection mainly affects the processing rate. The strategy can be implemented in the assignment model by:

C Modifying the capacity and free flow speed of the toll plaza area(s). If the toll plaza includes a mix of electronic and manual toll collection, a weighted average processing rate and speed should be used.

C If the user wishes to simulate an exclusive electronic toll lane, a separate network would need to be established for the toll lane (similar to the coding of an HOV lane). If it were assumed that an ample percentage of drivers had AVI tags, the assignment of trips to the toll lanes would be an outcome of the assignment model balancing the impedance added by the toll versus the impedance attributed to congestion. During non-congested periods, few drivers would likely use the toll lanes.

C If the user wished to simulate a shared HOV and electronic toll lane or lanes, two separate networks would need to be established, one for the electronic toll lane and one for the HOV lane. Because of the sharing, a proportion of capacity would need to be allocated to each (e.g. one third of the capacity to HOVs and two thirds to tolls, based on the expected proportion of traffic for each).

Simulation approaches:
FREFLO: Toll plazas could be specified as a block of capacity on the mainline based on the maximum toll processing rate for all the

booths. The effect of changes in toll operations (e.g., increasing toll processing rate through electronic toll collection) could be estimated by changing the capacity in vehicles per hour based on the type of weighted average calculation used under the sketch planning approach.

FREQ: Same as FREFLO.

FRESIM: FRESIM could simulate toll operations through its mainline metering capability. However, there may be limitations to this capability, depending on toll plaza configuration. A weighted average processing rate would need to be used, similar to the sketch planning example.

Bus Pre-emption

The capability for bus pre-emption of traffic signals has existed for many years. However, it is not widely practiced due to practical problems associated with operation. Under the right conditions, bus pre-emption can provide noticeable time savings. The analytical approaches below assume that no crossing bus routes are pre-empted.

Sketch planning approach:

1. Identify the routes and signals to be pre-empted

2. Estimate average delay per vehicle (for peak hour, or for additional hours, if desired) for the pre-empted approaches, through the Highway Capacity Manual procedures or other technique. A simplified approach to estimating delay/vehicle would be to take the difference between free flow speed and average operating speed, divide this into section length, and divide the resulting value by the number of signals.

3. Assuming random bus arrivals (unless otherwise known), estimate the proportion of buses undelayed is equal to the proportion of green time on the approach. The delay per bus without pre-emption for the remaining buses would be equal to the average delay per vehicle for the delayed vehicles. This would be calculated as the average delay per vehicle, divided by the proportion of vehicles delayed (assumed as the proportion of red time to total cycle time, if there is no signal coordination; if there is coordination, the proportion will be lower, but the operating speed should also be higher than the uncoordinated condition).

4. Calculate the amount of peak hour (or additional hours) bus delay that can be saved through pre-emption. Assume 50 percent of the average delay per delayed bus can be saved through pre-emption. Limitations in how quickly signals can change and the presence of queued traffic in front of the bus will not allow full elimination of signal delay. Multiply the average delay per delayed bus by the number of delayed buses expected during the peak hour (or additional hours). Assume 50 percent reduced delay to one signal cycle worth of other traffic on the bus approach for each pre-empting bus (not all buses need pre-emption). Conduct the analysis for both directions of travel.

5. Calculate the delay increase on the side street approaches. Assume increased delay of 50 percent times the average green time for the non-preempted approaches for cross street traffic times the number of signal cycles likely to be preempted.

6. Calculate person delays for each component of the signal cycle assuming appropriate vehicle occupancies. Tabulate total person hours of delay and vehicle hours of delay.

7. If it is desired to estimate the potential effect of faster transit travel times on transit ridership, an elasticity value could be applied. The elasticity of transit ridership with respect to transit trip time is typically in the range of -0.4 to -0.5 (i.e. a one percent reduction in travel time produces a .4 to .5 percent increase in transit ridership. This information could be used to estimate a change in VMT.

Travel Demand Modeling Approach:
The effect of a bus pre-emption system can be estimated using a travel demand modeling system, but all except the last two steps of the sketch planning approach need to be undertaken to derive an estimate of change in transit speeds. The approach assumes the availability of a mode choice model. Once an estimate of the change in transit speeds is provided, the following steps can be undertaken:

C Increase transit speeds on transit network for those paths affected.

C Increase hourly capacity on pre-empted route proportional to the ratio of green time with pre-emption vs. without pre-emption. Decrease hourly capacity on the side streets, also based on the ratio of pre-empted vs. non-preempted green time.

C The mode choice model will account for any mode shifts. But any shifts in mode in the equipped corridor are likely to be very small.

Simulation approach:
NETSIM: Can simulate buses explicitly in the model, but no provision is made for bus pre-emption. An approximation could be made by reducing average bus dwell times (a model input for each bus stop) in proportion to the amount of delay per bus estimated to be saved through pre-emption as per sketch planning guidelines above. An alternative approach is to modify the signal timings to favor person trips (additional green time would be assigned to approaches servicing pre-empting buses). The change in green time would be increased by 25 percent of the existing green time (average time assumed saved by a passing bus) multiplied by the percentage of cycles that encounter a bus. Thus, 10 percent of the cycles with buses would mean a 2.5 percent increase in green time on that approach.

TRANSYT-7F: Take weighted average of additional green time provided to pre-empted approach and assign it to the bus route approach (same method as above). Calculate person delay savings by multiplying (post-model) the vehicle delays by the appropriate transit and auto vehicle occupancies.

Electronic Fare Collection for Bus Transit

Aside from the management and administrative benefits, electronic fare collection may provide time savings to the traveler through reduced bus dwell times. The benefits can be estimated as follows:

Sketch planning approach:

1. Estimate the number of fares being paid (by route or by system) through passes, transfers, cash, or other method.

2. Estimate the transaction time for each

3. Estimate the capture rate of electronic fare cards from each current payment method

4. Estimate time savings for a transaction for conversion of each payment type to electronic means.

5. Multiply estimated time savings for each combination of fare conversion by the capture rate for each fare conversion type.

6. Estimate the change in average dwell times brought about by the fare conversion, based on the number of boardings per bus stop. Estimate the impact on change in average bus speed and in person-hours saved based on average bus occupancies.

7. If estimating benefits for individual bus stops, estimate the number of passengers by fare type and the proportion being converted to electronic payment. Perform same operation as above.

8. If it is desired to estimate the potential effect of faster transit travel times on transit ridership, an elasticity value could be applied. The elasticity of transit ridership with respect to transit trip time is typically in the range of -0.4 to -0.5 (i.e. a one percent reduction in travel time produces a .4 to .5 percent increase in transit ridership. This information could be used to estimate a change in VMT.

Travel Demand Modeling Approach:

The effect of an automated fare collection system can be estimated using a travel demand modeling system, but the sketch planning approach needs to be applied to generate the inputs to the mode choice model. Once an estimate of the change in transit speeds is provided, those speed improvements can be coded into the transit network. Shifts in mode will be evaluated within the mode choice modeling step.

Simulation:

NETSIM: Average dwell times can be modified in the model based on the change in weighted average transaction time. This will account for benefits to bus operations as well as benefits to traffic (which are not accounted for in the sketch planning procedure).

TRANSYT-7F: No practical way to simulate.

Bus AVL and Passenger Information System

Bus automatic vehicle location and passenger information systems will allow passengers to time their trip to the bus stop more exactly and reduce the inconveniences of waiting in inclement weather or uncertainty concerning bus arrival time. There is no procedure for travel demand modeling or simulation.

Sketch Planning Approach:
The sketch planning approach calculates the reduction in the amount of time reduced in waiting for the bus.

- Estimate existing average wait time per passenger

- Estimate wait time with passenger information system to be three minutes.

- Wait time savings is the difference between the two amounts. Multiply this amount by the number of boarding passengers. Transferring passengers should not be counted, as they have no control over wait time.

Safety Evaluation

There are no models or sketch planning procedures readily available to assess the impacts of most ITS strategies on accidents. Some estimates can be derived based on documented evidence of accident reductions. These should be used, where possible. There is the potential for estimating the effect of diversion strategies on accidents by multiplying accident rates by volume. The shifting of volume from facility to facility would be accounted for in the calculation of total accidents. However, this does not account for the safety benefits of certain ITS strategies, such as advance warning systems, that also are realized when implementing traveler information systems.