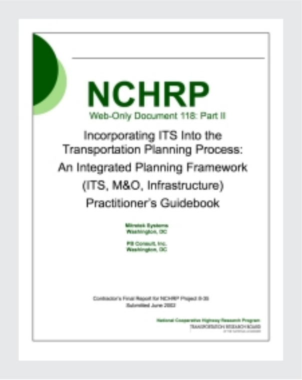

Incorporating ITS Into the Transportation Planning Process: An Integrated Planning Framework (ITS, M&O, Infrastructure) Practitioner's Guidebook

DETAILS

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Incorporating ITS Into the Transportation Planning Process:
An Integrated Planning Framework (ITS, M&O, Infrastructure) Practitioner's Guidebook

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Contractor's Final Report for NCHRP Project 8-35
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National Cooperative Highway Research Program
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I INTRODUCTION

The world and consequently, the issues that transportation decision making and planning must address is changing:

- Between 1990 and 1998 vehicle travel increased 72% while road miles increased only 1%. Congestion increased accordingly. Public transit is also growing at unprecedented levels causing overloading in many areas.
- Disruptions and incidents are causing more and more delay. Recently it was reported by TTI in the 2001 Urban Mobility report that in urban areas incident delay makes up 54% of all delay. In small areas the percentage is even greater at 60%.
- Events such as the tragedy that occurred on September 11th 2001 are causing a shift in priorities and new focus on such things as system management and operations, safety, and security, especially in response to unusual events.
- New Governmental requirements are emerging for conformity to the National ITS Architecture, and incorporating efficient management and operations of the system in planning.
- ITS systems because of their cost, their region-wide and system perspective and potential to provide improved performance and customer satisfaction are bridging the gap between planning and operations.
- Dedicated funding for ITS and/or modal systems is being phased out by the Federal government.

All of these point to the need to bring the ITS and operations and planning worlds together and integrate them into an overall transportation and decision making process. Recognizing this, a number of pioneering regions and planning organizations have begun to incorporate ITS into parts of their planning processes (See: Mitretek, 1999b; Deblasio, et.al., 1998; Siwek, 1998, AMPO, 1998). Some highlights are:

- **San Francisco:** The Metropolitan Transportation Commission (MTC), created a Systems Operations and Management Committee that developed a regional Management Strategy. It focuses on management of the transportation system operations and uses ITS as a key component. System management is reflected in the region's overall goals and throughout its planning process (Dahms, L. & Klein, L., 1999).
- **Chicago:** The Chicago Area Transportation Study (CATS) established the Advanced Technology Task Force to facilitate and coordinate between its myriad of operating agencies as well as the private sector. It's mission statement includes, " … to prepare a long-range vision and medium and short-range plans … for the development and integration of ITS in the transportation system serving Northeastern Illinois". The task force was responsible for the regions strategic early deployment plan for ITS. (Zavattero, D. & Smoliak, A., 1996).
- **Hampton Roads/Norfolk Virginia:** Planners and operators have combined to form a joint committee chaired equally by the State and MPO. They developed the region's ITS strategic plan that includes ITS strategies for both the short and long-term time frames, and are using ITS data collection and system performance to update plans on a regular basis.
- **Washington D.C.:** The Metropolitan Washington Council Of Governments (MWCOG), has developed a new vision, goals, and objectives to " use the best available technology to maximize system effectiveness" (Meese, A.1998).
- **Phoenix:** Maricopa County Arizona, has developed a multi-layer approach to incorporate ITS into its programming and budgeting process for development of the Transportation Improvement Program (TIP). This process includes development of Candidate Assessment Reports, Design Concept Reports, and TIP Design Projects. (Fowler, T. 2000.).

In spite of these pioneering efforts and the potential of ITS to address the new issues and concerns that have emerged from our changing world, considerable challenges to incorporating ITS into the transportation planning process still remain. Primary among these are the continuing gaps in perspective, institutions, and funding between those that operate and maintain our transportation system from day to day (e.g. traffic and transit operations, maintenance) and those that plan, design, and construct our transportation facilities and infrastructure (the focus of conventional planning). Technical hurdles also exist on how to estimate benefits and costs of conceptual and how to compare and evaluate decisions that trade off or combine system management and operation and new or expanded facilities and infrastructure. However, if the new concerns of the changing world are to be met our decisions must combine **what the system will be** (facilities and infrastructure) with **how it will operate**, and most important **how it will be managed**. Existing and emerging ITS technologies and services are providing new capabilities to manage our transportation system and respond to events as they happen instead of simply operating to meet normal conditions. There is consequently a need to build upon the experience of the above pioneers and others to strengthen the ties between ITS, management and operations, and the transportation planning process.

This Guidebook is the main product of the NCHRP Project 8-35: Incorporating ITS into the Transportation Planning Process which was initiated to develop guidance on integrating ITS (and operations) into overall transportation planning and decision making. The purpose of the Guidebook is to provide up to date information on: the need to integrate ITS and transportation planning; Federal and other regulations, processes, and reporting requirements, to do so, and recommendations on how to move from today's practice to an integrated approach. This version is targeted towards the "practitioners" that are responsible for supporting the decision process and "working out the details" to make sure that both decisions are made and the transportation system continues to move forward on a day-to-day basis. These include professionals and others in charge of planning and programming transportation projects, and operating and maintaining traffic, transit, and ITS systems. The companion, Executive Guidebook, provides a summary of the details provided here aimed at senior managers and public policy makers responsible setting overall transportation policy, allocating resources, and making the major decisions on the direction our transportation system will take.

The Guidebook is built upon four major perspectives, which are:

- **Incorporating ITS into transportation planning is virtually equivalent to incorporating management and operations:** ITS is aimed at responding to current conditions to manage the transportation system. While management and operations may expand beyond ITS, implementing and operating ITS provides the capability to manage the transportation system in many ways previously impossible.
- **Transportation planning goes beyond the Federal process:** ITS and other operational strategies often have not been Federally funded, or part of the traditional, infrastructure oriented, transportation planning process. However, they are now beginning to have long-range and system-wide impacts at a level similar to significant infrastructure improvements. The overall decision process must therefore go beyond current Federal requirements and consider all components and strategies that are part of the transportation system and its operations.
- **There is no one solution:** Different contexts require different approaches to integrating ITS and Planning, not simply different ITS deployments. These include both different organizational/institutional and technical/analytic ways to responding to the problems, issues, resources, and authorizing environments that practitioners face in developing solutions to their region's transportation problems. The Guidebook is designed to help discern what approach may be appropriate and where.
- **Both ITS (operations) and planning must evolve:** Integrating ITS (and management and operations) with transportation planning cannot be done simply by making ITS strategies fit within current planning practices. It requires that the decision-making process for both planning and operations change in significant ways.

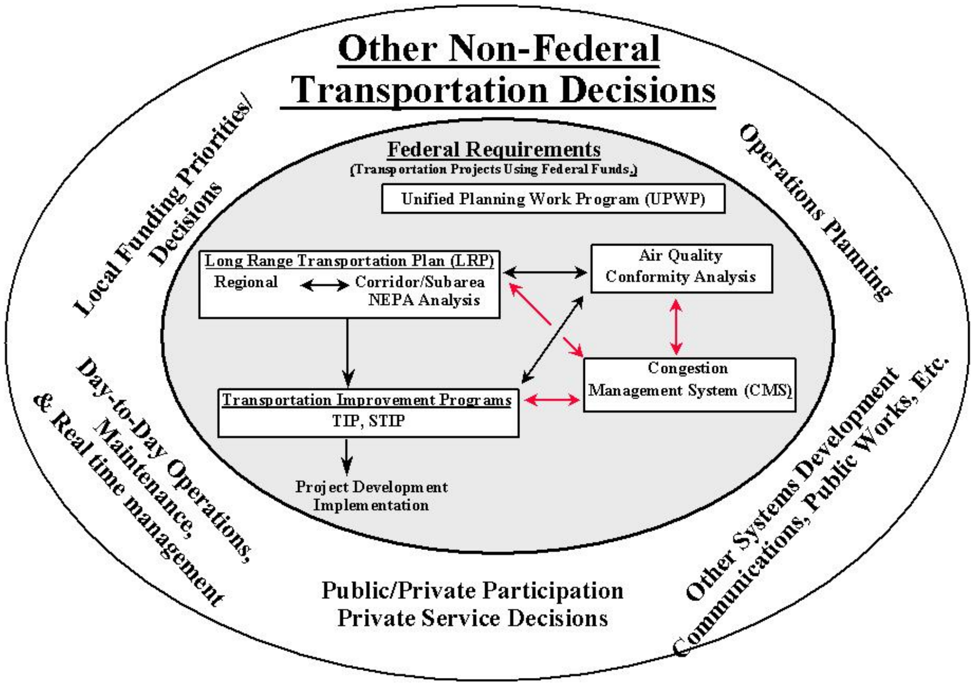
The principles and concepts underlying the Guidebook are described further next. An overview of the organization of the Guidebook is then provided. This includes a brief summary of how to use the Guidebook and the topics covered in each of its sections.

I.A SCOPE OF GUIDEBOOK: TRANSPORTATION PLANNING AND DECISION- MAKING

Broadly defined, transportation planning needs to involve all the components of the transportation system – facility and infrastructure expansion, operational planning, public/private participation, communications systems, day-to-day operations, maintenance, and system management decisions and their impacts. It no longer can focus on capital and infrastructure projects only, but also should address operating strategies and how they change the performance relationships of the transportation system itself. Consequently, the Guidebook extends "Transportation Planning" to encompass all transportation-related decisions that determine what the transportation system will be how it will operate. This is far broader than the usual definition of planning – i.e., the development of long-range plans. Under the definition used here: **planning means not only comparing alternative futures and deciding which future is best, but also it means comparing alternative "paths" to reach toward the desired future. It encompasses short-range decisions that may have long-term implications for the system and how it will function, plus short-range decisions that affect how the system functions in the immediate future.**

As shown in Figure I-1 transportation planning goes beyond the Federally defined transportation planning processes and its associated documentation requirements. Many if not most, ITS projects emerge from locally funded decisions and systems and are not part of the Federal process or the MPO and State planning to support it. Other ITS projects may be advanced as short-term operational improvements and are perceived to be the prerogative of the owner/operator of the system. Increasingly, the private sector is also involved in providing ITS and other services critical to the performance of the transportation system.

Figure I-1 Transportation Planning and Decision Making



Also, as ITS systems are implemented and integrated into the transportation system, the decisions made today affect the decisions that can be made tomorrow. The operational strategies and ITS that have been deployed enable new systems that may be built on top of them. More importantly, they also change the operational relationships (e.g. capacity and delay associated with a specific traffic volume) and travel behavior, which then changes what infrastructure and other systems that may be needed in the future. Consequently, planning and programming can no longer focus primarily on the long-range system and how it performs, assuming today's operating characteristics and relationships. Planning requires a new emphasis on determining the best development/operation paths for the future system.

I.B NEW PROBLEMS – NEW SOLUTIONS

The growing interest in ITS and its ability to help manage and improve the operation of the transportation system is not as some planners have stated "a solution looking for a problem". New goals and measures should not be added to the transportation planning process simply to justify ITS. Rather, problems, issues, constraints, and requirements (and continue to do so) that need to be reflected in today's goals and measures. Increasing congestion, inability to expand, impacts of accidents and other events, and demands for information all lead to a new reality that is increasing the interest managing and operating the system more efficiently and consequently ITS.

The policy environment and issues external to surface transportation has changed radically over the last two decades while the conventions of transportation network services have hardly changed at all. Issues and factors that have emerged include:

- **Growing and Changing Demands and Increasing Congestion:** – Urban areas are facing a substantial growth in travel and changing patterns of demand. It will be difficult to meet this demand with infrastructure and capital expansion alone, leading to a fragile system with limited ability to absorb disruptions.
- **Growing Impacts of Disruptions:** – The "unpredictable" disruption caused by the high frequency of crashes, breakdowns or weather-related incidents are now routine – causing over fifty percent of urban travel delay. Added to this is the continuing reconstruction and maintenance activities associated with the aging infrastructure.
- **Changing Demands and Concerns of Decision-Makers and the Public:** – Decision-makers and planners are faced with a growing list of transportation needs, above and beyond responding to congestion. Today's planners must also address goals associated with safety, reliability, meeting the needs of an aging society, environmental justice and welfare-to-work, air quality, and other factors.
- **New Service Attributes Required:** – The service orientation of the US economy is generating customer expectations – both passenger and freight – for on a broader range of performance and service options. As society moves further into the information age just in time delivery and instant knowledge of the system and feedback on conditions is becoming expected.

New issues and forces are also being confronted within the transportation sector itself and the institutions that build, operate, and maintain the transportation system. These include:

- **Constraints on Traditional Approaches:** The impacts of new facility construction – both high fiscal and environmental costs – often set practical limits on additions of new capacity. ITS provides a key component in managing existing resources.
- **Pressure on Government for Improved Effectiveness:** The continued pressures of deficits, downsizing, devolution, deregulation have encouraged state and local governments through major strategic planning efforts to "reinvent" themselves and find ways for more effective service delivery focusing more on outcomes and less on inputs and outputs.
- **Private sector entry into the transportation services arena:** There appears to be an emerging private industry initiative to provide transportation-related products and services associated with emerging in-vehicle systems, such as safety and information. These services and their impact on the system need to be incorporated into transportation decision making

Both ITS services and management and operation of the system respond to these emerging factors while at the same time contributing to meeting many traditional goals and objectives including travel time savings, reliability improvement, and emissions reduction.

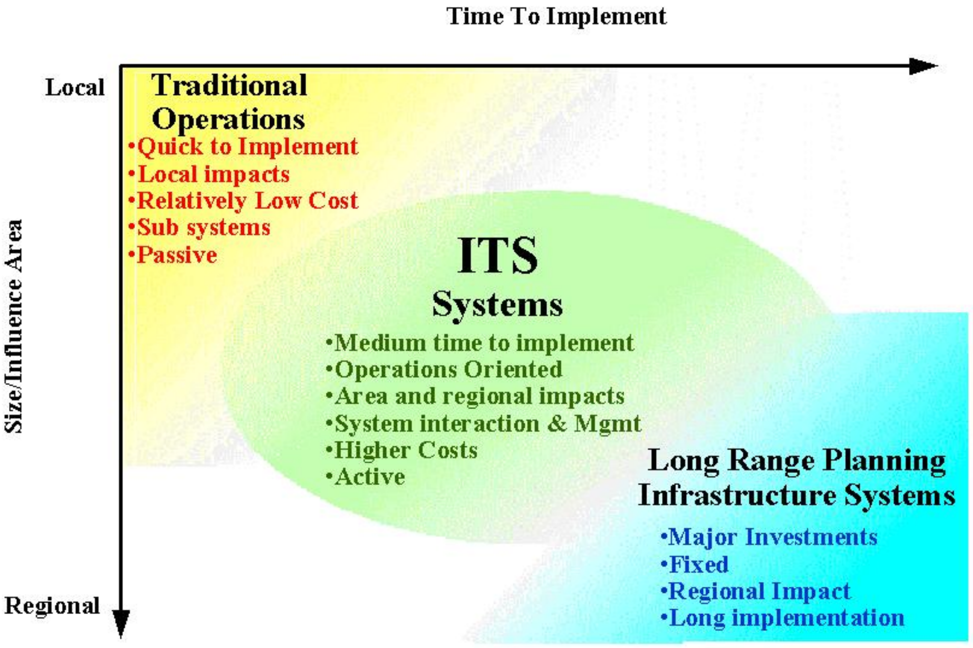
I.C ITS BRIDGES THE GAP BETWEEN OPERATIONS AND PLANNING

In integrating ITS into planning the conceptual and historic differences in operations and planning must also be overcome. Operating and maintaining the transportation system, and planning to meet future infrastructure and service needs have been carried out in their own worlds with different perspectives, measures, staff, policy makers, support organizations, funding support, and time horizons:

- **Operations:** Decisions for operating and maintaining the system have traditionally focused on short-term day-to-day issues on how to operate and manage the existing transportation network as efficiently as possible. They historically have been separable, short-term, localized, and responsive to conditions.
- **Planning:** In contrast, transportation planning has focused on expanding and modifying the facilities and services to meet long-term system performance under average conditions. Regional system performance is assessed against the overall goals of the region and fiscal/environmental requirements.

ITS bridges the gap between operations and planning. The deployment of ITS begins to alter the characteristics of “operations” decisions. ITS is operations oriented and provides information and communications to those operating and using the transportation system. Yet ITS components, especially as integration occurs, begin to have noticeable system-wide impacts and have elements (communications, traffic operations centers) that serve the overall system. In addition, ITS components also to have a much longer planning cycle, larger budget, and higher O&M costs than traditional operational improvements that require shared resources, scheduling, and budget coordination: i.e. “planning”. To reach their full potential ITS systems and components must also be integrated and coordinated to work together. ITS decisions, therefore, must be “planned” with others through collaboration, coordination, and cooperation and depend on the creation of a longer-term vision of the entire system (called system architecture).

Figure I-2 Traditional Operations and Planning versus ITS



While ITS has characteristics of both operations and planning, it also changes the nature of the transportation system and its decision making in at least two ways. First, ITS depends upon successful communications and protocols to function, meaning that the different elements of the system must be coordinated to work. Thus, implementation of ITS causes the various elements of the transportation system to become more inter-dependent. Second, ITS provides the ability to respond to changing conditions in order to **manage** the transportation system and its performance

I.D DESIRED FEATURES OF AN INTEGRATED DECISION PROCESS

A goal of this project is to define and develop an integrated decision process that embraces ITS. An integrated process is one where ITS (and management and operations) strategies are considered on an equal basis with traditional elements of the transportation system. As seen from the above discussion, however, developing an integrated process is much more than simply merging operations, ITS systems engineering and deployment planning and traditional infrastructure planning. It is evolutionary – to some, perhaps, it is revolutionary – and implicitly involves addressing regional goals and objectives that include both operational and system components. It requires both developing projects at a local level, and ensuring that they work with the system at a regional level.

> When creating any ITS plan, developers are encouraged to "**think regionally and act locally**." "Regionally can mean area wide, statewide, multi-state areas or even, and most importantly, nationwide. Local areas will know best what types of strategies will be successful, both in terms of solving the problem and of being accepted by the public, but it should be kept in mind that every individual project and activity needs to be compatible with a larger "system" if the goals of ITS are to be achieved.
>
> Virginia's Intelligent Transportation System (ITS) Interim Tactical Plan (August 1996)

An integrated process should therefore:

- Include ITS, management and operations, system preservation, and infrastructure / capital expansion tradeoffs in a single process.
- Incorporate the performance of the system in both average and unusual conditions in the decision process, and include the continual performance feedback and re-alignment of the system as time moves forward.
- Balance the near term management of the system to meet ongoing operational issues/concerns with long-term regional objectives.
- Account for the system orientation and inter-connectivity of ITS and other operational strategies as well as localized impacts.
- Be incremental and address the path of development, life cycle, and development cycles of both operations and ITS (primarily) near-term to mid-term, and long-term system expansion and needs.
- Account for rapid technological development and penetration.
- Address the impact of private sector provision of ITS services.

I.E ORGANIZATION OF THE GUIDEBOOK

The remainder of the Guidebook describes the forces that are pushing toward the need for integrated planning which considers ITS, operations, and traditional transportation solutions on an equal basis and presents an Integrated Framework for planning that is based on the ongoing evolution of current practice. The Guidebook is designed to allow different users to explore the information provided in chapter at the level that meets their needs. Accordingly, each chapter/section provides four views of its information at different summary levels. These and their intended audiences are shown in Table I-1. Each chapter/section is also written to stand alone as much as possible allowing readers to read only the sections of interest to them. Please recognize that the summary level presentations and this independence cause some repetition of the material presented.

Table I-1 Levels of Information And Their Intended Audiences

Level	Audience	Description
Key Point Outline	All	Callout box at the beginning of each chapter/section. This provides a quick snapshot of the material. It should be used to help assess whether further exploration is warranted or as a reference and memory tickler.
Introduction	Policy Makers Managers Senior Staff	Summarizes the chapter/section's material and provides a high level overview of the information contained within. It can be used by policy makers and/or senior managers may want quickly understand the main concepts and guidance contained within the section without going into the details of process.
Main Body	Technical Staff	This is designed to provide details to technical staff and others that are responsible for carrying out the activities and functions associated with the planning and decision making for both ITS and operations and traditional planning.
Review and Transition Self-Assessment	All	This is a summary of the key points and set of self-assessment questions. This is designed as a refresher for those that already know the material to help them determine where their area is in the transition from current practice to implementing truly integrated planning.

Readers may also be interested in different topics. To help determine what may address their interests each chapter is briefly summarized below.

Chapter II: The Changing Context of Planning and Decision Making: Forces Leading To Integrated Planning.

Chapter II describes the emerging concerns and governmental trends that are pushing towards integrated planning. This includes increasing congestion and the impact of disruptions, the inability to "build our way out", changing expectations of the public, and new priorities such as safety and security. On the governmental side, the historic shift towards efficient management of the transportation system is explained and the TEA-21 requirements for Conformity to the National ITS Architecture, and the Management and Operations Planning Factor are described. The strength of these forces depends largely on an area's local situation and conditions which are summarized as World I (low congestion, stable, still primarily expansion oriented), and World II (congestion, disruptions, inability to build new capacity, becoming management oriented).

Chapter III: An Integrated Decision-Making Framework.

Chapter III explains a new integrated planning/decision-making framework. It is derived from the natural evolution of the processes used by current pioneers in integrating ITS and planning and designed to meet the desired characteristics of an integrated process. Its main features include:

- New focus on near-term problems and systems management
  - A path of development is created through incremental cycles of planning (short, mid, long)
  - Both operational and long-range goals, objectives, and concepts/principles included in all time frames
  - System performance is continually assessed through feedback.
- New elements for an integrated alternative
  - ITS infrastructure and services
  - Regional ITS Architecture
  - Concept of Operations
  - Operating principals/concepts/ and characteristics
- Integrated functions and activities that merge operations and planning
  - Institutional/organizational change captured in "Concept of Planning"

  - There is no one-way to organize.
  - Must include new stakeholders and relationships including the public sector.
  - Technical activities are similar to traditional planning but now include operational characteristics

The ability to use the new integrated process to meet current Federal and other governmental planning requirements is also described.

Chapter IV: Institutional Relationships, Activities, And Functions.

One of the most significant challenges associated with making the transition to integrated planning is overcoming the institutional and organizational challenges associated with bring the planning and ITS/operations worlds together. This chapter, consequently, focuses on the changes in the institutional/organizational relationships, activities and functions in order to make this happen. In order to set the context the institutional/organizational gap is first explained. The activities and functions are then explored. These include:

- Redefining institutional/organizational relationships through enabling a new authorizing environment, and providing for within and between agency coordination.
- Expanding stakeholders to both the planning and operational worlds
- Determining public-private sector roles

This is followed by an explanation of different ways to organize identified to support ITS and operations within an integrated process which include:

- Do it alone,
- MPO Centric
- State Centric
- Ad Hoc or New Organizations.

Which to choose depends upon many factors including the willingness and ability of an institution to take the lead, the overlap of agency boundaries with ITS systems and their influence areas, transportation and environmental issues, other agency skills and resources, legal and other restrictions, and historical relationships. No matter what is chosen, the traditional planning agencies must be key participants for the results to be incorporated into the area’s formal planning documents (Transportation Plans, TIP, etc.). The ability to assemble resources to carry out the new activities and expand staff skills also plays an important role.

Last, the “Concept of Planning” is described. It captures how to organize, the roles and responsibilities for planning and decision-making, and how they will evolve to match the changing system and or conditions.

Chapter V: Technical Activities and Functions

This chapter explores the technical functions and activities that need to be carried out within each cycle of the integrated planning process. It starts with an examination of the issues and concerns that cut across all areas including: the need for ITS architectures, the benefits of standards, geographic and time scale, how to treat uncertainty, and the perceived lack of ITS benefits and cost information. Each activity/function is then fully explored in its own section. The sections are:

V.A Crosscutting Technical Issues
V.B Vision Goals and Objectives
V.C Initial Conditions Analysis (problem identification)
V.D Identifying Integrated Alternatives
V.E Estimating Costs, Benefits, and Impacts
V.F Evaluation of Alternatives
V.G Planning to Programming
V.H Performance Feedback: ITS Data and Planning Decision Making.

Note, that each of these sections is also provided with its own summary and transition assessment, and can be read somewhat independently.

Chapter VI: Continuing Challenges and Sources For Staying Current

Planning and decision-making will continue to change after this Guidebook has been released. The Final Rule For Metropolitan And Statewide Planning incorporating the changes introduced by TEA-21 is yet to be issued. Re-authorization that is bound to introduce new changes is also drawing closer and closer. Events and our changing environment are also raising new priorities and concerns that must be addressed. This section briefly outlines continuing challenges, and then provides a series of websites where information on the policies, processes, and requirements are likely to be found as they evolve.

Appendixes:

Appendixes are also provided. One of the major needs identified in the research is the lack of a common language that bridges the gap between Transportation Engineers, ITS specialists and Planners. A Glossary is therefore provided in Appendix A that identifies the terms used in the Guidebook and their usage. Hopefully, this will help reduce the lack of communication between practitioners from different disciplines. It provides common planning and evaluation process terms first. These are followed by terms used in the ITS community and brief descriptions of the ITS User Services, and National ITS Architecture Market Packages. Appendix B provides the relationship between the ITS User Services and ITS Market Packages. Appendix C provides the self-assessment questions from each chapter as a package.

In conclusion, the reader should use this Guidebook as a resource based upon their needs and concerns. It is designed to be selectively read depending upon the need for depth and information that is needed.

II THE CHANGING CONTEXT OF PLANNING AND DECISION MAKING: FORCES LEADING TO INTEGRATED PLANNING

Key Points of Chapter II

- Emerging forces and issues are pushing public decision making and planning beyond the traditional focus of capital investments and towards integrated planning (build, maintain, operate, and manage).
    - Congestion & inability to expand capacity.
    - Increasing disruptions.
    - Changing public concerns and wants.
    - Private sector provision of services.
- Relevant Concerns and the approach to take depend on the local context.
    - World I: Available capacity, unconnected, low density, stable.
    - World II: Congested, connected, built/dense, unstable.
- New governmental requirements must also be met
    - ISTEA and ITS Program.
    - TEA –21 M&O Planning Factor.
    - TEA – 21 National ITS Architecture Conformity.
- ITS is bridging the gap between operations and planning. It is fundamentally different from alternatives typically considered in traditional planning, ITS has attributes of both operational and major infrastructure projects. ITS maybe the catalyst for integrated planning.
- **All lead towards the evolving framework for integrated planning.**

This chapter provides the background on why a new framework for integrated planning is evolving and most important, why it is needed.

Section II.A describes the many forces that are driving the mainstreaming of ITS and system management into transportation planning and decision making. These include new issues/concerns that have emerged as we enter the 21st century centered on increasing stress and demands on our transportation network, congestion and the growing impacts of disruptions. As new technologies are introduced throughout our world they are also shifting the wants and concerns of the public and its decision makers. People are demanding more reliable services, up to date information and rapid response in everything that effects their lives. New opportunities for private sector provision of transportation services and public-private partnerships must also be incorporated.

Section II.B examines the contexts and conditions for Integrated Planning. The forces and trends pushing towards integration are not taking place everywhere with the same intensity. It is useful to think of each area of the country as being part of two worlds. In **World I** congestion may not yet be at break down levels and conditions relatively stable. While growth may be occurring there is still room for capacity expansion. Continuing to "connect" and/or maintain the system are often key concerns. In **World II** the system is for the most part complete and "connected". When there are no breakdowns people can get where they want to go. However, there is little or no room for capacity expansion and the system is over congested at critical levels for large parts of the day. Small incidents or events can consequently cause major disruptions as their effects cascade through the network. The focus has, from necessity, become one of day-to-day management and operation of the transportation system. Each world has different demands for integrated planning and the mix of traditional and ITS M&O to solve its problems. Consequently, the approach a region or state may take depends on where it lies between the two.

Section II.C highlights the growing governmental emphasis and requirements towards better management of the transportation system and including ITS as a potential solution. This includes early efforts of transportation system management (TSM), through ISTEA's initiation of the ITS program and focus on efficient use of resources, to TEA-21's M&O Planning Factor, and requirements for conformity to the National ITS Architecture.

Section II.D examines why ITS is fundamentally different from traditional transportation solutions making it difficult to integrate into existing planning/decision making processes. ITS combines attributes of both traditional operations and major transportation investments that have been the focus of transportation planning. ITS is operations oriented, yet has system wide impacts, has significant costs, takes time to implement, and needs coordination. It also has attributes not addressed by traditional planning. Consequently, integration requires the decision processes for both ITS and operations and transportation planning to evolve.

This chapter ends with a review and transition assessment in Section II.E.

II.A RE-ORIENTATION TO MATCH 21ST CENTURY ISSUES

A principal reason that planning and ITS & M&O decision making need to come together is the environment and concerns within which transportation decisions are made have changed dramatically since the traditional planning process was developed 40 years ago. There is increasing recognition that “we cannot build our way out of congestion”. Revolutionary advances in communications and technology are having large impacts on how we live and travel from place to place. Our concept of a transportation agency’s role has changed – turning it from construction to service delivery. Both transportation planning and operations need to adapt accordingly to more effectively address the issues that transportation decision makers face today. Some of the more important issues are discussed below.

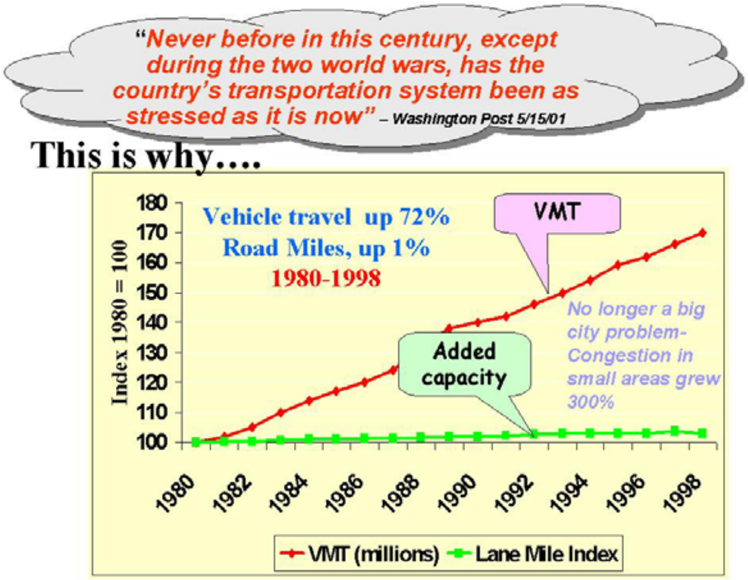
Growing and Changing Transportation Demands

Figure II-1 highlights that over the last 20 years capacity expansion has not kept up with growing demands leading to an overall stress of the system. The situation can only get worse. With growing economies, urban areas are facing continued rapid growth in travel over the next 20 or more years. Travel patterns are changing as well – suburb-to-suburb and off-peak travel are growing more rapidly than travel in general. It will be difficult to meet this demand with new infrastructure alone. Indeed, many transportation agencies acknowledge that there are limits to their ability to increase the capacity of the existing system because of:

- Limited funding for capacity expansion
- Lack of available rights-of-way, making capacity expansion more costly and disruptive
- Environmental concerns and public opposition to some projects

Those who recognize these constraints understand that transportation agencies must manage the existing system more effectively to squeeze as much mobility from it as possible. ITS provides some of the principal tools for this management through it’s ability to react to incidents and other events.

Figure II-1 Forces Towards Integrated Planning



Source: C. Johnson, 2001

Growing Impacts of Disruptions

As congestion grows, the system is likely to become ever more congested, fragile, and subject to break down as incidents and other inevitable disruptions occur. These disruptions are now almost routine causing The Texas Transportation Institute’s 2001 Urban Mobility Report to conclude “ *In general, more delay is caused by incidents than heavy traffic demand. The small and medium areas have a greater percentage of* *total delay due to incidents than larger areas"(Schrank & Lomax, 2001).* Based upon 68 urban areas across the country TTI reported that for 1999 incident delay made up 54% of all delay (52% in large urban regions and 60% in small areas). And this does not include the added disruptions caused by continuing reconstruction and maintenance activities associated with the aging infrastructure, severe weather, and/or special events. Another source estimated that up to 60% of congestion can be attributed to non-recurrent delays (Lindley 1986) and this percentage will grow as our transportation networks operate closer to break down conditions for longer periods of the day.

Changing Concerns of Decision-Makers and the Public

State and local governments are being charged with finding new ways to deliver services more efficiently, focusing more on outcomes and less on inputs and outputs. These efforts stem in part from the pressure of budget deficits, but more broadly from a desire to make government more effective. Meanwhile, with growing uncertainty about the future – in part a result of the technological revolution – there is a natural inclination to make small incremental changes to the existing system rather than massive, costly and disruptive investments in new infrastructure. Long-range plans become less relevant in this environment. Planners are charged with helping decision-makers reach informed short-term decisions while preserving options for the long-term.

There is also growing interest in ensuring the safety and security of the transportation system. While capacity expansion is often justified in terms of safety improvements, there is a more immediate desire to make the system safer today, not years in the future. Likewise, concerns over security while always important, have become critical since the events of September 11, 2001.

New Service Attributes Required

The service orientation of the U.S. economy is raising customer expectations – both passenger and freight – for a broader range of performance and service options. As society moves further into the information age, instant knowledge of the system and its conditions is becoming expected.

There is increasing evidence that travelers are willing to accept some level of congestion and delay, provided that this delay is reasonably predictable. This suggests the need to consider strategies that keep travelers informed, in real time, of how he system is performing at any given point in time. If such systems could be put in place, travelers will become less frustrated and more willing to accept the limits on the system.

Private Sector Entry into Transportation Services

Private industry is increasingly offering transportation-related products and services. These range from privately owned and operated facilities, to new technologies such as smart cards and in-vehicle information systems. These services and their impacts need to be incorporated into – and perhaps facilitated by – the transportation decision-making process.

All of these issues point to the need to broaden the focus of traditional planning to integrate ITS and the management and operation of the system under all conditions.

II.B CONTEXTS: CONDITIONS FOR INTEGRATED PLANNING

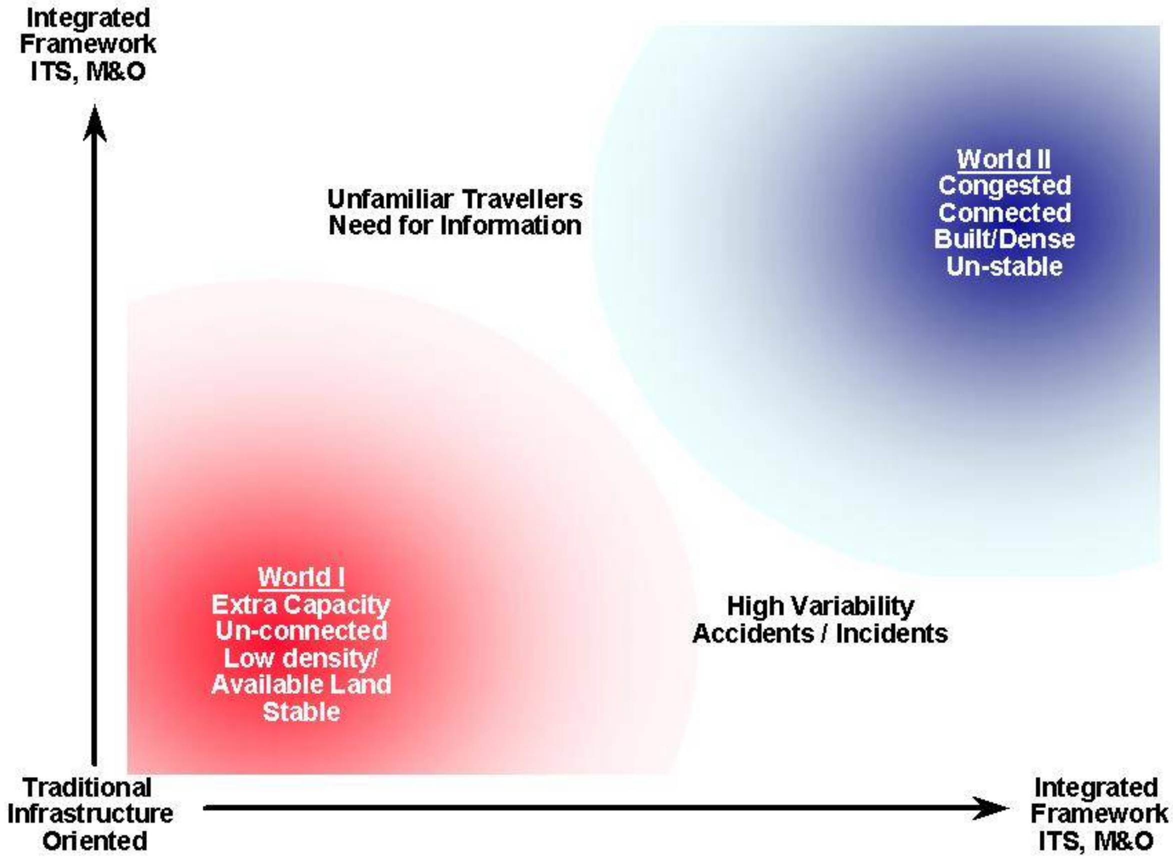
The traditional planning process and structure evolved to address specific needs and concerns faced by transportation decision makers in the expansion of the Federal Highway System and other modes since the 1940's:

- Connect the U.S. in a continuous highway network from coast to coast, and
- Meet the rapid growth and expansion of our cities since World War II.

Over time, new concerns like air quality and land use have been grafted onto the process, yet the main purpose and function of the traditional planning process remains the same – the identification and prioritization of capital projects. There is a growing need to expand these purposes and functions to include ITS and the operation and management of the transportation system. This expansion is most relevant to those parts of the country where demand continues to increase and the options for expansion are increasingly limited.

It may be useful to think of the country as being comprised of two very different sets of conditions, which might be called “World I” and “World II” (see Figure II-2). **World I** refers to those parts of the country that are relatively stable from day to day. Connecting the system to improve the ability to get from one place to another is often of prime importance. When system expansion is needed, the required land for future rights-of-way is often available, and conflicts between the transportation system expansion and other public objectives can often be resolved relatively easily. Small towns and rural areas with stable system needs and low congestion, where preservation and maintenance of the infrastructure has become the primary focus, are considered to be World I environments. Some growth areas in the South and Southwest still may have many World I characteristics.

Figure II-2: World 1 and World II Contexts



In contrast, for **World II** environments the thrust of the decisions facing the transportation community has shifted away from infrastructure expansion and toward preservation and management. The transportation network is for the most part complete and connected. When there are no disruptions or system failures travelers can reach their destinations. However, congestion exists and system performance becomes unstable as increased demand for travel exceeds the system’s ability to expand. Expansion is difficult due to conflicts with the built environment surrounding the transportation system and competing community interests. Land for expansion also is at a premium. Efficient management and use of the system therefore becomes more and more important. Responding to non-recurrent conditions and correcting for breakdowns in performance start to dominate the concerns of the transportation community. As a consequence, the focus of the decision process also shifts to the short and mid-term. Since ITS is aimed changing the system to respond to unusual conditions and providing information to travelers about the changing conditions, it becomes an important potential component of the World II transportation system.

On the path from World I to World II, systems start to experience periods of breakdown and increased variability. Other characteristics also may warrant movement towards the an integrated approach and the use of ITS and system management as an integral part of the area's transportation decisions. The need for information about the transportation system and its conditions may be high due to unfamiliar travelers, or vast distances within the network. High variability may also occur in the system due to incidents, accidents, and unusual weather. The impact of system variation is especially severe when the travel and routing options are limited.

Not surprisingly, areas with World II characteristics are some of the pioneers in ITS and in adopting transportation decision processes that are taking on many of the properties of the Integrated Framework. These include:

- Seattle and it's use of ITS
- Houston and it's balance of Mobility improvements and incident management with long range system developments
- Washington D.C.'s adoption of system management objectives in its vision planning;
- The Chicago region's inclusion of system operators in the MPO process.

The decision environment and context may influence an area's adoption of an integrated approach and transition from current practice. The transition should be an evolution of practice within each area to meet its needs.

II.C THE GROWING GOVERNMENTAL EMPHASIS TOWARDS BETTER MANAGEMENT AND USE OF ITS (ISTEA AND TEA-21)

Since the 1960s there has been a shifting Federal emphasis towards better management of the transportation system. It has grown from the early TOPICS (Traffic Operations Improvements to Increase Capacity and Safety) program in the 60's to requirements for Metropolitan Planning Organizations (MPOs) to develop a Transportation System Management (TSM) element as part of their regional transportation plans in the 70's (See Wiener, 1999). The trend continued through the Intermodal Surface Transportation Efficiency Act of 1991's (ISTEA) establishment of the ITS program, congestion management systems and new planning factors. It has culminated in the Transportation The Transportation Efficiency Act for the 21st Century (TEA-21) and its Management and Operations Planning Factor, and new requirements for conformity with the National ITS Architecture.

This shift in emphasis has also led to requirements for incorporating the issues ITS and system management address into all of planning. Highlights from ISTEA and TEA-21 are briefly explained below.

II.C.1 THE ISTEA ERA

The push towards integrated decision making accelerated greatly under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). ISTEA established a national program "***to research, develop, and operationally test intelligent vehicle-highway systems and promote implementation of such systems….***" The program ($659 Million over 6 years) is now called the Intelligent Transportation Systems program to stress its multi-modal nature. Some of ISTEA's other key features affecting planning and ITS – and the Federal response to those ISTEA provisions – include:

- Strengthened Planning and introduction of new planning factors stressing system management.
- Required Management Systems (later made voluntary) including a congestion management system (CMS).
- Major Investment Studies including and their required comparisons with TSM alternatives.
- Establishment of The US DOT ITS Joint Programs Office in 1994, to coordinate the ITS program within the different modes. The USDOT created the Joint Programs Office (JPO) to serve as the "principal architect and executor of ITS leadership".

- Definition of the National ITS Architecture, completed in 1996, that provides a master blueprint for the development of an integrated multi-modal ITS infrastructure. The architecture provides a framework and identifies information flows to be considered when planning and implementing ITS.
- Development of technical methods provided by significant research and development activities to produce the necessary tools for planning ITS including the ITS Evaluation Program, creation of the National ITS Cost & Benefit Database, and development of the ITS Deployment Analysis System (IDAS) ITS evaluation software.

During this time FHWA and FTA also provided grants to state and local governments for the development of early deployment plans (EDPs) to jump start ITS deployment and the initial planning of ITS systems. A five-step process tended to be followed for EDP development:

1) Data collection/survey
2) A User Services plan
3) ITS architecture
4) Strategic deployment plan
5) Recommendations

Due to the dedicated funding for ITS, EDPs were typically done outside of the traditional planning process. A review of the EDP planning process stated (Smith, 1995):

> “The Early Deployment Program is a first step in the necessary planning for a well-integrated regional ITS. …It is also clear that planning for ITS as a stand-alone effort is of limited effectiveness. ITS planning should be integrated within the traditional regional transportation planning framework”.

Consequently, as the ISTEA authorization period drew to a close, USDOT recommended that special funding for ITS be discontinued and that ITS be “mainstreamed” into the normal Federal aid program structure.

II.C.2 TEA – 21 AND THE MANAGEMENT & OPERATIONS (M&O) PLANNING FACTOR

The Transportation Efficiency Act for the 21st Century (TEA-21), enacted in 1998, continued and built upon the ITS programs from ISTEA while seeking to mainstream ITS into the normal Federal-aid programs. One of its most significant modifications is the stress it places on system management through the M&O Planning Factor.

TEA –21 consolidated the issues that must be considered in transportation planning for Federal funding into seven broad factors (previously there were 16 metropolitan and 23 statewide planning factors). More importantly, it added and emphasized the management and operations factor:

f) **Promote efficient system management and operation**

Work is currently under way to develop rules and/or guidance to appropriate build in an M&O orientation into both the planning and project development process with the appropriate documentation to accommodate Federal oversight. At a minimum this continued emphasis on M&O shifts the emphasis in the planning process from long-range needs to a more balanced approach incorporating short-term and mid-term needs, and their decisions and impacts.

Even as the guidance is being developed the US DOT is moving ahead in supporting the M&O planning factor. A new Operations Core Business Unit within FHWA was established in February 1999. The FHWA also established a dialog on operations and created a national steering committee to recommend actions needed for the new focus on operations to advance. In April 2000 the Institute of Transportation Engineers hosted the operations conference “Transportation Operations: Moving into the 21st Century” in Irvine California. The National Dialog for Operations Summit followed this in October 2001. More information on the M&O activities can be found at the FHWA Operations website (http://ops.fhwa.dot.gov) and at the Systems Management and Planning website (http://plan2op.fhwa.dot.gov).

Based upon these actions there is a growing understanding of what consideration of the M&O planning factor in transportation planning means. Consequently, while the details of the final M&O guidance are still being developed the characteristics of a process which considers M&O can be highlighted and are:

- Consideration of efficient operations and management of the transportation system in regional goals and objectives found at all levels of the process.
- Expansion of the participants in the process to include those that operate the system and others interested in/impacted by the management and operations of the transportation network. These include the traffic and transit system operators, Emergency Service, and Police / Fire, and communications representatives, as well as the private service providers of ITS and other services.
- Orientation towards service delivery and performance feedback as a central feature of the process.
- Explicit definition of how the system operates in the short, medium, and long-range including the relationships between congestion and system performance and response to non-recurrent “events” such as accidents, weather conditions, or service disruptions.
- Consideration of the full life cycle costs and benefits of each element of the transportation system including the costs of implementation, operations and maintenance/preservation.
- Balance the near term management of the system and time stream of operations improvements with longer term capital investments and system expansion.

ITS becomes a central element in the management and operation of the future transportation system since it provides for the identification of changing conditions (surveillance), communication (information), and response (control) as the conditions vary. The collection and analysis of ITS data also provides for the critical feedback from current operations to planning and the definition of the future system, its operations and performance.

II.C.3 TEA –21 AND CONFORMITY WITH THE NATIONAL ITS ARCHITECTURE

TEA-21 also requires ITS projects funded with Highway Trust Fund dollars to conform to the National ITS Architecture and standards. Section 5206(e) of TEA-21 states

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

As the ITS Program moves into the deployment phase, major steps are being taken to facilitate national compatibility and interoperability. As discussed in Chapter IV the National ITS Architecture is a common framework for the design and implementation of ITS. The Architecture Conformity Policy aims to integrate these systems engineering tools (architecture and standards) with the transportation planning and project development processes. To implement this requirement USDOT first developed Interim Guidance, which was followed at the project level by the FHWA final rule and FTA final policy.

II.C.3.1 Interim Guidance On Conformity to the National ITS Architecture

Shortly after TEA - 21 was enacted the USDOT issued Interim Guidance Conformity to the National ITS Architecture (October 2, 1998) that was to remain in effect while a comprehensive final policy was developed. It included recommended practices and "guidance" at both the planning and project level. While the Final FHWA Rule and FTA Policy for project level conformity has superseded the Interim Guidance at that level as of June 2002 release of the final policy at the planning level remains on hold. Consequently, the Interim Guidance recommendations and suggested approach are described below for the insights they provide in what is "good practice" and what may be incorporated into the final planning level policy when it is released.

The Interim Guidance Section IV.B concerning "ITS Considerations in Transportation Planning" stated:

> "Statewide and metropolitan planning activities should include consideration of the efficient management and operation of the transportation system. This should include the regional implementation and integration of ITS services and development of a regional ITS architecture(s), as appropriate. Regional consideration of ITS should address
> (a) the integration of ITS systems and components,
> (b) inclusion of a wide range of stakeholders,
> (c) flexibility in tailoring ITS deployment and operations to local needs
> (d) electronic information sharing between stakeholders, and
> (e) future ITS expansion."

A recommended approach that laid the groundwork for the Final Policy ITS and Planning considerations was also provided as part of the Interim Guidance. It listed the following suggested activities intended to *"encourage sound consideration of the operations and management of the transportation system, including the development of a regional ITS architecture and related efforts to advance ITS in a region"*:

- Engage a broad range of stakeholders
- Identify needs that can be addressed by ITS
- Describe existing and planned ITS enhancements
- Define a regional ITS architecture
- Define operating requirements
- Coordinate with planned improvements
- Develop phasing schedule
- Develop regional technology agreements
- Identify ITS projects for incorporation into transportation planning products

Note, that the above defined "ITS planning" activities presume ITS solutions are the outcome. It does not place ITS in the larger planning context to examine the tradeoffs between ITS and other strategies or the development of integrated alternatives.

II.C.3.2 Final Policy on Conformity to the National ITS Architecture

On January 8, 2001 the Federal Highway Administration published its Final Rule on "Intelligent Transportation System Architecture and Standards," in the Federal Register. The equivalent Federal Transit Administration (FTA) "National ITS Architecture Policy on Transit Projects" was also published. Both the Policy and Rule became effective on April 8, 2001.

The new Rule and Policy contain provisions that help to foster integrated ITS deployment locally by requiring the development of regional ITS architectures. During a regional architecture's development, agencies that own and operate transportation systems cooperatively consider current and future needs to ensure that today's processes and projects are compatible with one another and with future ITS projects. The new Policy and Rule also require the use of a systems engineering analysis for ITS projects.

The Policy directs that:

- Regions currently implementing/operating **ITS projects** must have a **regional ITS architecture** in place in four years. Regions not currently implementing ITS projects must develop a regional ITS architecture within four years from the date their first ITS project advances to final design.
- ITS projects funded by the Highway Trust Fund and the Mass Transit Account must conform to a regional ITS Architecture.
- Prior to the adoption of a regional ITS architecture "**Major ITS Projects**" not in Final Design by April 8, 2001 must include the development of a project level architecture that clearly reflects consistency with the National ITS Architecture.
- All ITS Projects not in Final Design by April 8, 2001 must be based upon a **Systems Engineering Analysis** on a scale commensurate with the project's scope and use USDOT adopted ITS

standards as appropriate (To date the U.S. DOT has not adopted any ITS standards. A formal rule making process will precede any such action.).
- No specific documentation is required. However, regions must be able to demonstrate compliance, account for Architecture maintenance and updating, and coordinate with Federal field offices.
- Monitoring compliance with the Policy will be in accordance with existing FHWA/FTA oversight procedures used for all projects**.**

Several important definitions and concepts (**bold above**) are also part of the Rule/Policy. Their definitions are provided below. They are (FHWA and FTA, January 2001):

ITS (Intelligent Transportation Systems): "*Electronics, communications or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system*".

ITS Project: "*Any project that in whole or in part funds the acquisition of technologies or systems of technologies that provide or significantly contribute to the provision of one or more ITS User Services as defined in the National ITS Architecture*".

Region: "*The geographical area that identifies the boundaries of the regional ITS architecture and is defined by and based on the needs of the participating agencies and other stakeholders. A region can be specified at a metropolitan, Statewide, or corridor level. In metropolitan areas, a region should be no less than the boundaries of the metropolitan planning area*".

Regional ITS Architecture: "*A regional framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects*". A regional ITS architecture shall include at a minimum:

- Description of the region
- Identification of the participating agencies and stakeholders
- An operational concept that identifies roles and responsibilities of stakeholders
- Any agreements required for operations
- System functional requirements (high level)
- Interface requirements and information exchanges with planned and existing systems and subsystems
- Identification of ITS standards supporting regional and national interoperability
- Sequence of projects required for implementation

A process and roles/responsibilities for maintaining the regional ITS architecture once it is developed must also be established.

Systems Engineering Analysis: **"***A structured process for arriving at a final design of a system*". It evaluates a number of alternatives to meet the design objectives considering total life-cycle costs, technical merit, and relative value of each. A systems engineering analysis for ITS shall be on a scale commensurate with the project scope and at minimum shall include:

- How the project fits into the regional ITS architecture (or applicable portions of the National ITS Architecture)
- Identification of roles and responsibilities of participating agencies
- Requirements definition
- Analysis of alternative system configurations and technology options
- Procurement options
- Identification of applicable ITS standards and testing procedures
- Procedures and resources necessary for operations and management of the system

Major ITS Project: "*Any ITS project that implements part of a regional ITS initiative that is multi-jurisdictional, multi-modal, or otherwise affects regional integration of ITS systems*". As stated above, prior to the adoption of a regional ITS architecture all Major ITS Projects must include a Project ITS Architecture.

Project ITS Architecture: "*A framework that identifies the institutional agreement and technical integration necessary to interface a major ITS project with other ITS projects and systems*". The project level ITS architecture needs to be based on results of the systems engineering analysis, and should include at a minimum:

- A description of the scope of the ITS project
- An operational concept that identifies the roles and responsibilities of participating agencies and stakeholders in the operation and implementation of the ITS project
- Functional requirements of the ITS project
- Interface requirements and information exchanges between the ITS project and other planned and existing systems and subsystems
- Identification of applicable ITS standards

The Rule/Policy also states "***Development of the regional ITS architecture should be consistent with the transportation planning process for Statewide and Metropolitan Transportation Planning*** (49 CFR Part 613 and 621)". Originally, as part of the proposed revisions to the Transportation Planning Regulations the USDOT proposed another requirement to implement ITS architecture conformity, the development of a planning level ITS Integration Strategy. The Planning rule is proceeding on a different schedule and the specifics of its requirements, including the development of an integration strategy, will be available when it is published. In any case all regional and project level ITS architectures must be consistent and included in the appropriate Transportation Plans, Transportation Improvement Programs, and Statewide Transportation Improvement Programs as is currently required under existing regulations. As stated the Interim Guidance provides valuable insights on what should be considered and what may be included in the final planning level policy once it is released.

Additional general information concerning the Policy/Rule can be found on the ITS Architecture Conformity website at: www.its.dot.gov/aconform/aconform.html.

II.D ITS IS BRIDGING THE GAP BETWEEN OPERATIONS AND PLANNING

Understandably, there has traditionally been a gap between the operations and planning worlds. Each focused on different decisions with different time frames, decision and funding processes, goals and criteria, and scale of impacts. ITS has attributes of both and consequently provides a bridge between the two. As a result, developing and implementing ITS can become the catalyst for integrated planning. However, ITS also has different features from transportation options considered in either traditional operations or traditional planning. Most important of these is the abilities that ITS enables to actively manage the transportation system in response to changing conditions. Consequently, integrating ITS cannot simply be done by connecting two parallel processes. **Each process must be redefined and evolve so that a merger can occur**.

The gap between operations and planning occurs along a number of dimensions including temporal, geographic scale, and budgeting/funding. Table II-1 and Figure II-3 highlight a number of these contrasts. Traditional Operations issues/decisions are quick to implement (within a budget cycle), relatively low cost (within annual operating and maintenance budgets), are usually independent with only localized impacts, passive (signage, fixed signal timing, printed transit schedules), and assume the transportation system infrastructure is constant. They have been **procedure oriented** aimed at operating the most efficient system in response to current conditions.

Figure II-3 Traditional Operations and Planning versus ITS and System Management

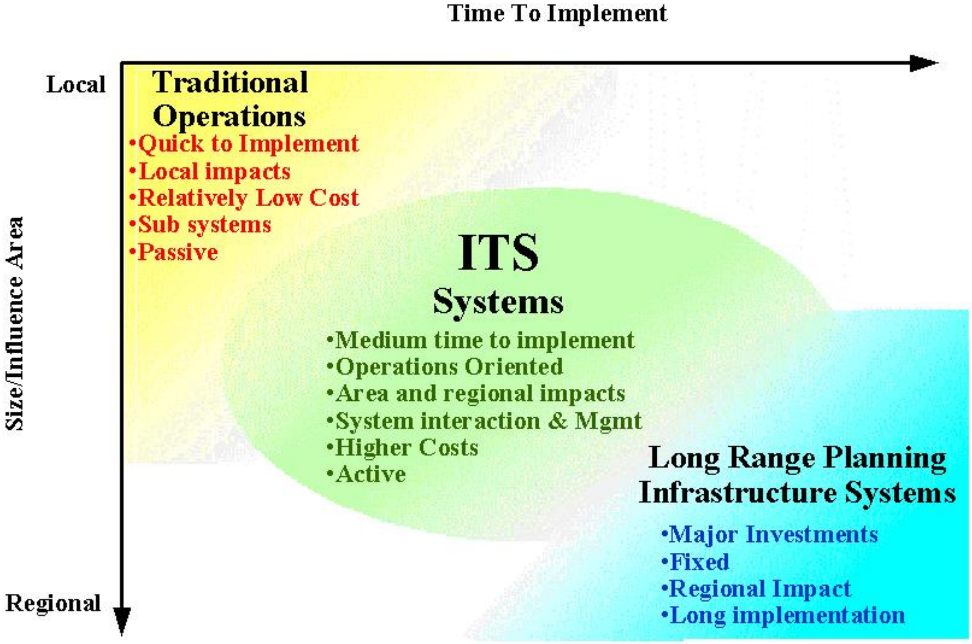


Table II-1 Contrasts between Traditional Planning and ITS and System Management

	Traditional Planning	ITS and Systems Management
Orientation	• Major capital facility – "build" • New capacity/service expansion • Addresses recurrent or average conditions • Focus on capacity, level of service, and safety	• Systems operation and service provision – "do" • Efficient management and operation • Response to variation in conditions • Focus on reliability, security, incident response
Temporal	• Problems of tomorrow • Forecast-driven • Long-term, multi-year implementation • One time decisions • Static once in place • Fixed, predictable technology and characteristics	• Problems of today • Response to current conditions • Short-term, immediate implementation • Continuous, incremental decisions • System evolves through feedback • Rapidly changing technology and characteristics
Costs/Funding	• Medium/high capital costs • Low/medium operating costs • Federal-aid context and requirements	• Low/medium capital costs • Major life-cycle operating costs • Often implemented with non-Federal funds
Providers	• Public agency • Construction industry	• Public and private partnerships • High tech. Industry
Other Attributes	• Stand alone projects • Separable • Facility based • Low/medium technology • Visible and permanent	• Piggy back on other projects • Connected through communications • System based • Advanced technology • Often hard to see

On the other hand, transportation planning decisions have been focused on expanding and modifying the facilities and services to meet long-term system performance/needs under average conditions and have been mostly **project oriented**. The resultant projects typically assume the system will continue to operate as it does currently, are very costly with regional impacts both geographically and to the transportation system's operations, and take years to plan and implement. The planning process traditionally has been focused on meeting Federal funding requirements and other regulations (CMS, TIP, LRP, NEPA, and air quality conformity). Consequently, planning and operations decisions have been carried out in their own worlds with different perspectives, staff, policy makers, support organizations and time horizons.

ITS has characteristics of both traditional roles (operations and planning). ITS is both operations oriented and aimed at managing the overall system. It usually takes several budget cycles to implement and may be too expensive to fund through traditional operating budgets. It requires coordination and is not independent or separable. It may need to cross political and other jurisdictional boundaries to be effective. It begins to have "regionally significant" impacts. Good system planning and coordination is therefore important to successful ITS implementation. ITS by its very nature is also active, with real-time feedback between performance measurement and operational/management decisions. Thus, planning for ITS impacts both operations and planning decisions and must be included in both.

ITS, however, is also very different from the options considered in traditional planning. Traditional solutions to transportation problems and the analyses that support them have tended to focus on long-term facility/service improvements to meet capacity constraints arising during a typical day. Because they focus on the peak congestion conditions and major infrastructure investments these solutions and analyses have typically minimized, or not addressed:

- The impact of operational strategies and improvements. **Current operations are usually assumed**.
- The impact of non-recurrent demands, incidents, or other unusual occurrences. Major facilities are usually not designed to accommodate unusual demands, or events. **Analyses focus on meeting average conditions.**
- Lack of information about the system, its current condition and the choices a traveler may have in making their trip. **Traditional analyses assume equilibrium conditions** where travelers fully know their choices, their travel times, costs, and other characteristics.

As already pointed out, non-recurrent accidents and other incidents are major contributors to urban congestion. Not including these effects in an analysis can consequently distort the impacts of traditional alternatives and overlook the benefits of ITS.

In contrast, ITS strategies use technology, communications, and a "systems" perspective to help adjust the system to conditions as they are realized on a day-to-day basis or evolve over a longer time frame. They focus on responding to changing conditions and thus become the "infrastructure" of the system management and operations. ITS Strategies are:

- **Operations Oriented**. ITS strategies such as coordinated signal systems, ramp meters, and automated toll readers directly impact the operation of the transportation system by reducing delays and **adjusting the performance of the system as conditions change**. They also provide the ability to manage the multi-modal components as a system instead of separate units. Traditional planning analysis efforts typically assume a steady state set of conditions over the analysis period and are consequently insensitive to changes in operations.

- **Aimed at Events and Unusual Conditions**. Non-recurrent incidents, special events, and weather conditions all add up to become significant factors in the delay and congestion found in our transportation systems. ITS strategies such as incident and emergency management systems, route guidance, highway advisory radio, and variable message signs, all help the system respond to these non-recurrent conditions. Yet, a typical analysis does not include incident occurrences in its validation of base conditions, and is based upon average, expected, conditions under "normal" conditions (i.e. no accidents, bad weather, or unusual conditions). It consequently cannot address the impact of incidents on the system or an alternative's ability to respond to them.

- **Information Oriented**. ITS strategies focus on reducing the difference between a traveler's expectations of the transportation network while they are traveling (congestion, delay, and cost along each route choice) and the actual conditions they will experience when they take their trip. As travelers and the system operators have better, more up-to-date information, significant improvements to an individual's choice can occur, especially under unusual circumstances. Typical analysis techniques presume that over the long run, travelers will "know" their options and make "informed" choices.

- **Connected Systems**. ITS services are a mixture of localized elements and area-wide systems/intelligence. As communications and system intelligence/response is introduced through ITS, individual ITS elements no longer function or can be analyzed independently. Thus, the metered rate (capacity) of a ramp meter may depend upon the traffic volumes at downstream locations along a freeway, sometimes miles away.

Each of these characteristics makes ITS strategies difficult to address using traditional transportation planning and programming processes and analysis methods. Because integrated ITS systems also depend upon communications and protocols to function the development of ITS must be closely coordinated if it is to work at all. Insuring that the components communicate with one another and function properly is the role of "systems engineering" and creates the need for a system "Architecture" when implementing ITS. Thus, ITS creates a need for integrated planning and at the same time cannot simply be incorporated into traditional approaches. Decision making for operations, ITS, and traditional planning all need to **evolve** to achieve an integrated approach.

II.E CHAPTER REVIEW AND TRANSITION ASSESSMENT

This chapter describes the forces that are leading towards mainstreaming ITS & M&O into transportation decision making or integrated planning. These include the emerging issues and trends of the 21st century that today's decision makers must contend and the parallel governmental emphasis on ITS & M&O in through changing policies and regulations. The principal forces are:

- Increasing and changing travel demand and the inability to expand capacity to meet it leading to severe congestion and increased failures with the transportation system.
- Increasing number and the resultant impacts of disruptions as the system operates on the verge of breakdown conditions for longer periods each day.
- Changing concerns of the public and its decision makers especially concerning safety, security and reliability.
- The introduction of new technologies in our society leading to new expectations for service delivery and it's options. People are starting to expect 24 hour up-to-date information, just in time delivery, and increased reliability in all areas of life.
- New opportunities for private sector provision and/or partnerships for transportation service and their associated risks.

The shift in governmental emphasis towards inclusion of ITS & M&O has been occurring since the early 1960's. Significant highlights include:

- The TOPICS program and TSM requirements of the 1960's and 1970's
- ISTEA's: strengthened planning requirements emphasizing efficient system management; Major Investment Study requirements to examine TSM options; and creation of the ITS Program and subsequent ITS Joint Program Office,
- The creation of new tools to assist in the deployment of ITS including the National ITS Architecture, the ITS cost and benefits database, and the IDAS sketch planning evaluation tool.
- The TEA-21 M&O Planning Factor
- The TEA-21 requirement for Conformity to the National ITS Architecture.

However, these forces are not occurring everywhere at the same rate or intensity. Consequently, the demand to re-orient completely towards system management and operations depends on the local situation and applicable governmental requirements. It is useful to recall two sets of conditions or "worlds":

- **World I**: Has available or extra capacity, available land for capacity expansion, low density, and is relatively stable from day to day. Much of the system is also unconnected and the focus of transportation decision-making is largely on building the missing segments. Rapid growth may also be occurring.
- **World II**: Already built environment with a connected transportation network. Inability to expand capacity due to lack of land, resources, or public resistance. Existing and increasing congestion throughout the day leading to system failures and increased disruptions (unstable conditions). Increasing needs for asset management and system replacement or maintenance.

As discussed throughout the rest of this Guidebook, where a region or state lies between these two worlds helps determine the most appropriate: concerns to address; participants in the process; institutional and organizational structures; and mix of ITS, M&O, and traditional transportation improvements to implement and operate. Consequently, Table II-2 provides questions for self-assessment to determine where your area is between the two worlds. Mark where you think your area's relative position is for each question.

Likewise, the need to meet the Federal requirements for Conformity with the National ITS Architecture may also play a significant role in how quickly ITS and M&O must be mainstreamed into the local planning and decision making and the organizations/institutions, stakeholders and process to do so. Therefore, a self-assessment for the National ITS Architecture Conformity requirements is provided in Table II-3.

How to meet the above requirements and integrate ITS & M&O into the overall planning and decision making of an area based on your answers to the questions in these tables is the subject of the rest of this Guidebook.

Table II-2 Context For Integrated Planning: World I/World II Self-Assessment

Question	World I World II
Are congestion and transit overloading a serious problem in your area causing extended peak periods, peak hour factors close to 1.0 and significant delays ?	NO - - - - - - - - - - YES
Do accidents and other incidents that cause cascading impacts over large portions of the transportation system occur frequently (daily)? Do the effects remain long after the incident is cleared?	NO - - - - - - - - - - YES
Do customers (travelers) complain frequently about unusual delays, or missed connections due to irregular service ?	NO - - - - - - - - - - YES
Is the area already built and densely populated with little or no room for additional road or transit right of way and expansion?	NO - - - - - - - - - - YES
Has there been significant opposition to transportation projects in the recent past?	NO - - - - - - - - - - YES
Is the transportation system complete and connected? Do the facilities exist for travelers to get to where they would like to go without significant diversion?	NO - - - - - - - - - - YES
Is the transportation system (roads, bridges, transit vehicles and facilities) in poor condition requiring an ever increasing portion of the transportation resources to maintain?	NO - - - - - - - - - - YES
Does the area have air quality or other environmental problems?	NO - - - - - - - - - - YES
Is the region experiencing rapid increases in travel (trips and VMT) due to population and employment growth and starting to experience congestion on some facilities?	NO - - - - - - - - - - YES

Table II-3 Applicability of National ITS Architecture Conformity Requirements Self-Assessment

Question	NO YES
Are the National ITS Architecture Conformity Requirements Applicable ?	
Is the area currently operating or planning to implement ITS?	NO - - - - - - - - YES
Were any of the existing ITS systems implemented after June 9, 1998?	NO - - - - - - - - YES
Do planned ITS projects use funds from the U.S. Highway Trust Fund?	NO - - - - - - - - YES
Are any "Major ITS" projects (multi-modal, multi-jurisdictional, multi-agency) planned for implementation?	NO - - - - - - - - YES
If The Requirements Are Applicable? (Yes to any of the above questions)	
Are the area's ITS systems included in and consistent with the appropriate Long-range Plan and Transportation Improvement Programs (both Metropolitan and Statewide)?	NO - - - - - - - - YES
Have a wide range of stakeholders including all ITS operators and major users participated in the development of the area's ITS plans?	NO - - - - - - - - YES
Have the major information sharing requirements between stakeholders been identified?	NO - - - - - - - - YES
Have the needs for future ITS expansion been identified?	NO - - - - - - - - YES
Does a Regional ITS Architecture exist, or is one being developed?	NO - - - - - - - - YES
Has a region for the regional ITS architecture been defined which encompasses the boundaries of it's major ITS systems?	NO - - - - - - - - YES
Does the development and continued maintenance of the regional ITS architecture include the required participating agencies and stakeholders?	NO - - - - - - - - YES
Has an operational concept been defined that identifies the roles and responsibilities of the stakeholders to implement, operate, and maintain the ITS system?	NO - - - - - - - - YES
Have the other required components of a regional ITS architecture been developed? (system functional and interface requirements, standards, phasing)	NO - - - - - - - - YES
Are agreements in place that ensure that the ITS system can be operated and maintained?	NO - - - - - - - - YES
Have the roles and responsibilities for maintaining and updating the regional ITS architecture been established?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

III AN INTEGRATED DECISION-MAKING FRAMEWORK

Key Points of Chapter III

- Desired properties of an Integrated system include:
  - Single process.
  - Balanced treatment of near and far term decisions.
  - Performance based feedback.
  - Account for system orientation of ITS.
  - Be incremental.
  - Include consideration of technological change and public-private roles.
- New focus on near-term problems and systems management
  - A path of development is created through incremental cycles of planning (short, mid, long).
  - Both operational and long-range goals, objectives, and concepts/principles included in all time frames.
  - System performance is continually assessed through feedback.
- New elements for an integrated alternative
  - ITS infrastructure and services.
  - Regional ITS Architecture.
  - Concept of Operations.
  - Operating principals/concepts/ and characteristics.
- Integrated functions and activities merge operations and planning.
  - Institutional/organizational change captured in “Concept of Planning”.
  - There is no one way to organize.
  - Must include new stakeholders and relationships including the public sector.
  - Technical activities are similar to traditional planning but now include operational characteristics.
- Can meet current Federal and other governmental planning requirements within the Integrated Framework.

Planning is a process that leads to decisions – decisions on what facilities to build, on what services to provide, and on how the facilities and services should be operated. This Chapter offers a new planning and decision-making framework that integrates decision-making for facilities and services with decision-making for ITS, system management, and operations.

Section III.A provides desired characteristics for an integrated process. An integrated process should:

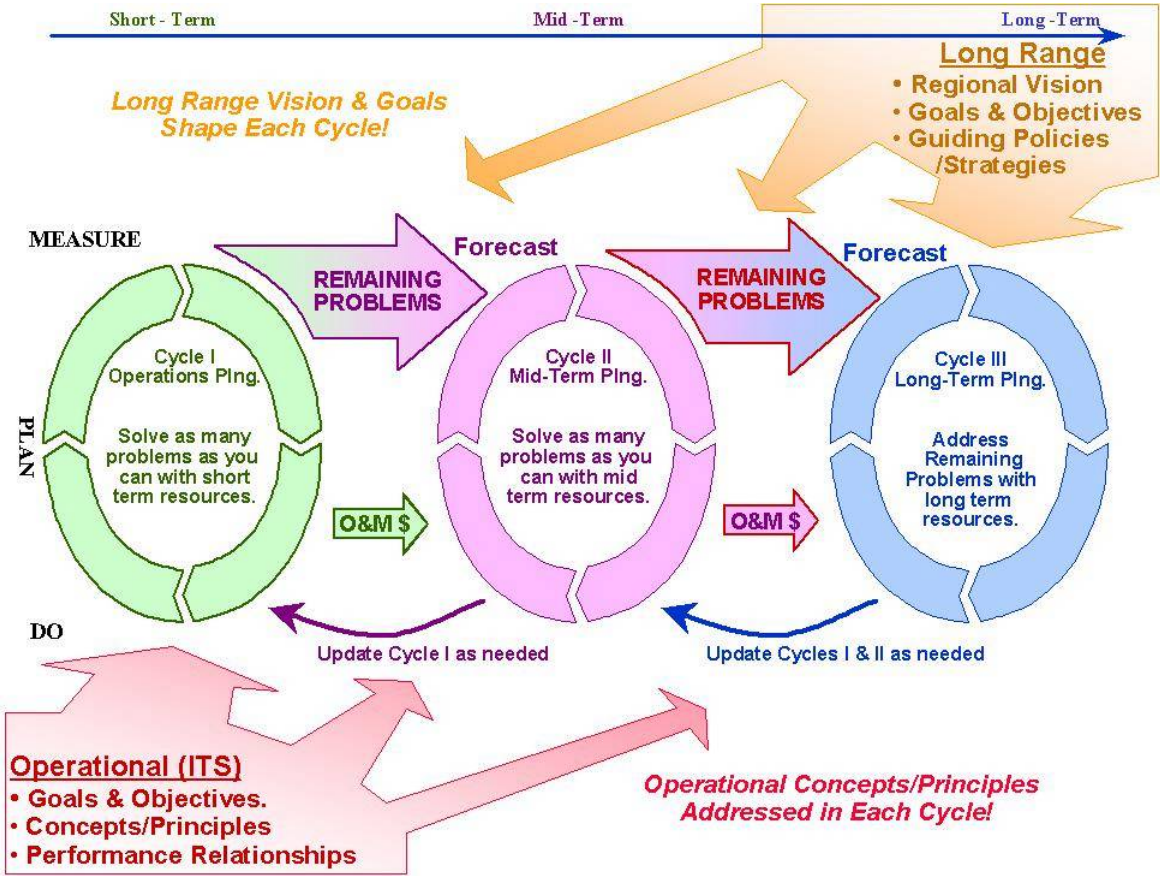
- Be a **single process** (ITS, M&O, System Preservation, and capital expansion)
- Be **Balanced** (near term management and long-term infrastructure needs and improvements)
- Be **performance based** (both average and unusual conditions)
- Account for continual **performance feedback**
- Account for the **system orientation** of ITS
- Be **incremental** (time stream of actions and their impacts, life cycle, and development cycles of all transportation decisions)
- Address **rapid technological development** and penetration
- Address the **public/private roles** in provision of ITS services
- Meet all **Federal and other governmental requirements**.

Section III.B describes a new Integrated Framework designed around the above characteristics. It provides a single process for determining current and future capital facility needs, ITS and system management solutions, operations, and maintenance. This contrasts with more traditional approaches that use separate processes because capital facilities, ITS, and/or operations each relied upon different funding different sources; or because they require planning for different time horizons. The Framework is a natural extension of current practice as it evolves to meet emerging concerns and include ITS, system management and operations in its decisions. It changes planning and decision-making in three key ways:

1. New orientation of planning/decision making on the management of the existing transportation system and its problems in the near-term using existing resources first, then on mid and long-term concerns. The new orientation results in a new incremental process and the "cycles of planning" shown in Figure III-1. Features of the iterative process shown include:

- The process focuses first on the problems of today and managing, preserving, and operating the existing system and its assets.
- System performance is continually assessed against goals objectives and criteria. How the system is operated and future plans are adjusted accordingly through "feedback".
- It is resource driven and aims at solving as many problems as possible based upon the resources available for each cycle (time frame). The costs associated with operating and maintaining the system and problems that can't be solved in one cycle are carried forward to the next time frame and set of decisions.
- It provides a bridge between operations and planning across all time frames. Long-range planning sets goals and objectives for the short and mid-range periods within which they operate and plan. Similarly, Operational goals and objectives are carried forward to the mid and long-range time frame and adjustments made to assumptions on how the system will be operated and how it will perform.
- It produces a "**path of development**", or the time stream of all actions needed to implement, operate, and maintain the transportation system from now and into the future for each alternative. The horizon year system is not only identified, but also shows how that system will evolve and function during the intervening years. It allows the costs and benefits of short and long-range options to be compared, and financial feasibility to be evaluated.

Figure III-1 Near to Far Focus and Cycles in the Integrated Framework



2. Incorporation of the new elements needed for integrated alternatives that Include capital facilities, traditional transportation services, ITS and system management, and operations.

ITS brings new system, infrastructure, and communication/info-structure requirements to decision making that must be included in the system inventory and definition of each alternative within the integrated process. Because ITS can also change how the system operates and functions, the operating assumptions and characteristics at each point in time must now be explicitly addressed. The new elements include:

- ITS and communications infrastructure (facilities, equipment, hardware, and software)
- ITS and operations services (information systems, fare cards, etc.)
- Regional ITS Architecture
- Concept Of Operations on how the system operates and who is responsible for what
- Operating principles and relationships (including predictions on how system performance will change due future technologies and their penetration)

3. Evolution of planning and operations decision making relationships, activities, and functions into to a single integrated process. Bringing planning, ITS and system management, and operations together will also cause institutions/organizations, their relationships, and the activities and functions they carry out to change and evolve. Pioneering areas around the country are already forging new lines of communication, partnership, and joint activities/functions between operations and planning. The activities and functions of the integrated approach that is emerging are:

- **Institutional/Organizational**
  - **Identify New Stakeholders.** Expand to include operating agencies and their customers (ITS, Transit, Public Safety).
  - **Redefine Institutional Relationships.** Overcome departmental, funding, and other barriers to implementing, operating, and maintaining an integrated system.
  - **Determine Public/Private Roles.** The type of service, and who will use it may vary greatly depending on who provides it. Consequently, the role the private sector should play in both planning and providing transportation services must be addressed.
  - **Determine How to Organize to Support ITS and M&O.** The appropriate way to organize to carry out the ITS and M&O functions within the Integrated Framework depends on the local context.
  - **Develop “Concept of Planning”.** The Concept of Planning describes how the roles and responsibilities for planning/decision making evolves along with changes in the system and other conditions.

- **Technical**
  - **Identification of Vision, Goals, Objectives, and Measures.** Expand to include emerging issues of congestion, reliability, safety, security, etc.
  - **Needs/Deficiency Analysis.** Include an extended inventory, operational issues, and causal analysis.
  - **Integrated Alternative Definition.** Include new components, and the path of development.
  - **Estimating Impacts (Benefits & Costs).** Must account for ITS and operational features and unusual conditions. Requires new methods.
  - **Evaluation of Alternatives.** Include the time stream of actions, impacts, and costs. Use life cycle costs. Account for system operations and asset management.
  - **Expansion of Programming /Resource Allocation.** Include ITS and M&O in programming criteria. Account for system focus of ITS. Fund integrated solutions based upon life-cycle costs and actions.
  - **Performance Measurement (ITS Data) and Feedback**. ITS data provides new opportunities for performance measurement and feedback including the monitoring of both recurrent and non-recurrent conditions

Each of these is carried out or reassessed within each cycle of the overall process.

Section III.C examines how Federal and other governmental planning requirements can still be met within the Integrated Framework. Since, the full development path for each alternative is defined, all governmental requirements for planning can be produced with the integrated process. These include producing Congestion Management System (CMS) Plans, Transportation Improvement Programs and Transportation Plans at both the regional and state levels. Requirements for Air Quality Conformity analysis and National ITS Architecture consistency can also be carried out.

Section III.D provides recommendations on making the transition from existing practice towards the Integrated Framework. Initial activities include:

- Expanding stakeholders
- Establishing advocacy and leadership for the new roles and responsibilities
- Defining new measures and starting data collection to support them
- Expanding the system inventory and definition of alternatives to include the new components and the path of development.
- Start to develop/implement new analysis methods
- Develop awareness, train staff, and gather other resources.

The chapter ends with a review and transition assessment in Section III.E.

III.A DESIRED CHARACTERISTICS OF INTEGRATED ITS, M&O, AND INFRASTRUCTURE PLANNING/DECISION MAKING

An integrated process is one where ITS and system management, and operations are considered on an equal basis with traditional elements of the transportation system. However, as seen from the discussion in Chapter II developing an integrated process is much more than simply including ITS options in the traditional planning process. It requires that both the traditional planning process, and the ITS deployment process evolve.

An integrated process should:

- Be a **single process** that includes operations, system management, maintenance, system preservation, and infrastructure/capital expansion decisions and tradeoffs for both ITS and traditional transportation improvements. An area’s transportation problems and deficiencies can often be addressed in many different ways: by new facilities; changes in/new transportation services (e.g. transit); changes in/new ITS and operations both alone or in combination. Mainstreaming, or integration, requires that these different options can be developed and compared, and that no particular type of solution is presumed over others.

- Be **balanced** giving proper consideration to the near term management of the system to meet ongoing operational issues/concerns while moving towards long-term regional objectives. It must also account for the changes that can be made in the near term that produce many years of benefits (and costs) versus changes that may have larger predicted impacts in a specific horizon year but take years to implement and have uncertain outcomes due to the nature of long-range forecasts.

- Be **Performance Based** and incorporate the emerging issues and concerns (e.g. reliability, disruptions, need for information, safety, security) discussed in Chapter II. This requires new performance measures to reflect these concerns and account for the performance of the system **under both recurrent (average) and non-recurrent conditions.** It is especially important since more than half of urban delay is due to incidents and other non-recurrent events now, and will continue to increase in the future.

- Include **continual performance feedback** and re-alignment of the system as time moves forward. A basic attribute of ITS and the management of the overall system that it enables is the ability to monitor how the system is functioning and make adjustments on a continual basis to account for problems. As the adjustment to the system are made they also impact the demand for current and future travel which may prompt additional adjustments. Consequently, an integrated process must account for this feedback in both how it develops alternatives and in its forecasts of future travel demand and system performance.

- Account for the **system orientation and inter-connectivity of ITS** and other operational strategies as well as localized impacts. Through surveillance communications and control, ITS allows changes to be made in the transportation system in one location to account for conditions in another that may be miles away. More importantly, ITS can be used to manage both the system and travel to optimize overall benefits rather than each individual's utility. These features must be incorporated into the analysis and evaluation of future decisions ITS is to be mainstreamed and its impacts fully captured.
- Be **incremental** and address the path of development, life cycle, and development cycles of both operations and ITS (primarily near term to mid-term), and long-term system expansion and needs. This is closely to the above incorporation of performance feedback. Chapter II also discusses the difference in time frames of different decisions: operational improvements are most often short-term; implementing ITS systems may occur in both the medium and short-term. Major infrastructure and system changes often require many year of planning and development. An integrated approach requires that the incremental nature of the short and mid-term decisions and their consequences (impacts, system adjustments) be captured. This allows the "balanced" tradeoffs of decisions made in different time frames to take place.
- Account for **rapid technological development** and penetration. ITS and other new technologies change the demand for travel and how the transportation system performs in response. Consequently, we can no longer implicitly assume that operating characteristics and services will remain the same as those that exist today. This requires predictions on the level of technological change that may occur in the future and it's impact on both travel patterns (behavior) and how the system performs. As the time frame moves further into the future it becomes more difficult to predict specific technologies, however, assumptions on changes to system performance should still be made. Sensitivity analysis should also be used to account for the inherent uncertainty associated with long-range changes in technology and ITS.
- Address the **public/private sector roles** in the provision of ITS and other services. In the past the desired attributes of a road or transit service could often be clearly defined. For the most part, it didn't matter who actually implemented or operated them. However, who provides different ITS services and if they are to be "market" based can profoundly impact their characteristics and who uses them and receives their benefits. For example, providing the a subscription service the "fastest " route to a driver on their way to work may actually cause delays to others and increase overall delay in the system. Consequently, the roles of both the public and private sectors in needs to be explicitly addressed as part of a integrated process. Equally important, is examining how the private sector can and should be included in the planning and decision making process as a partner and stakeholder.
- **Meet** Federal, state, and local **regulations and requirements**. Any process must be able to continually meet the regulations and requirements that exist at all levels of government for planning, programming, operating, and maintaining the transportation system.

The features of an integrated process that has the above characteristics are described next.

III.B A NEW INTEGRATED FRAMEWORK

Pioneering regions and states across the country are implementing planning/decision processes that meet many of the desired characteristics discussed above (see callout box). A new Integrated Framework that builds upon these efforts briefly outlined at the beginning of this Chapter. It represents the natural evolution of these pioneering efforts to overcome the remaining hurdles and gaps between traditional planning, ITS and system management, and operations It is defined by three key changes to planning and decision-making as it currently exists:

Examples of Pioneers In Integrated Planning/Decision-Making

San Francisco, CA. · San Francisco's MPO, The Metropolitan Transportation Commission (MTC), has developed a regional Management Strategy supported by the Systems Operations and Management Committee which focuses on management of the transportation system operations and uses ITS as a key component. The MTC also operates the region's traveler information system. System management is reflected in the region's overall goals and throughout its planning process (Dahms, L. & Klein, L., 1999). The MTC is now updating its regional ITS plan guided by a focus on customer needs and performance, and building from today.

Chicago, IL. · In Chicago the Chicago Area Transportation Study (CATS), has become a facilitator and coordinator between its myriad of operating agencies as well as the private sector. It established the Advanced Technology Task Force which includes in its mission statement, " to prepare a long range vision and medium and short range plans … for the development and integration of ITS in the transportation system serving Northeastern Illinois". The task force was responsible for the regions strategic early deployment plan for ITS. (Zavattero, D. & Smoliak, A., 1996). Chicago, also has created an Operations Task Force within the MPO and incorporated ITS and its evaluation into its CMS process. The region also coordinates its plans with the Gary Chicago Milwaukee Priority ITS Corridor, using a hierarchical/tiered ITS Architecture.

Hampton Roads, VA. The Hampton Roads Planning District Commission (HRPDC) commissioned one of the first early deployment plans (EDP) for ITS, the 1995 "COMPARE: ITS Strategic Deployment Plan for the Hampton Roads Region" (HRPDC, 1995). This early effort was updated in 2000. Since 1995, ITS and operations have become integral parts of the region's MPO planning process. One key feature is the region's ITS Committee that is jointly chaired by the MPO (planning) and VDOT-Smart Traffic Center (operations). The ITS Committee includes transit, the cities, and, military in the region. Both planners and operations staff from each organization participate. The ITS committee reports directly to the planning board and ITS is a central part of the region's Transportation Plan. An important innovation is the development of short-range, mid-range, and long-range ITS plans and the phasing strategy to implement them (path of development). The region is also currently using ITS data to evaluate performance of the system. The State's backbone communications system is also being shared by others and has become a catalyst in the region's coordination.

Other areas of note that are advancing towards integration include Seattle and Washington State, Washington D.C., Dallas/Fort Worth Texas, Florida DOT, and Minneapolis/St. Paul. Minnesota.

1. New orientation of planning/decision making on the path of development and management of the transportation system first to solve problems in the near-term and then in longer terms.
2. Incorporation of the new elements needed for integrated alternatives that include ITS and systems management.
3. Evolution of planning and operations decision-making, relationships, activities, and functions into a single process.

Each of these is described more fully below.

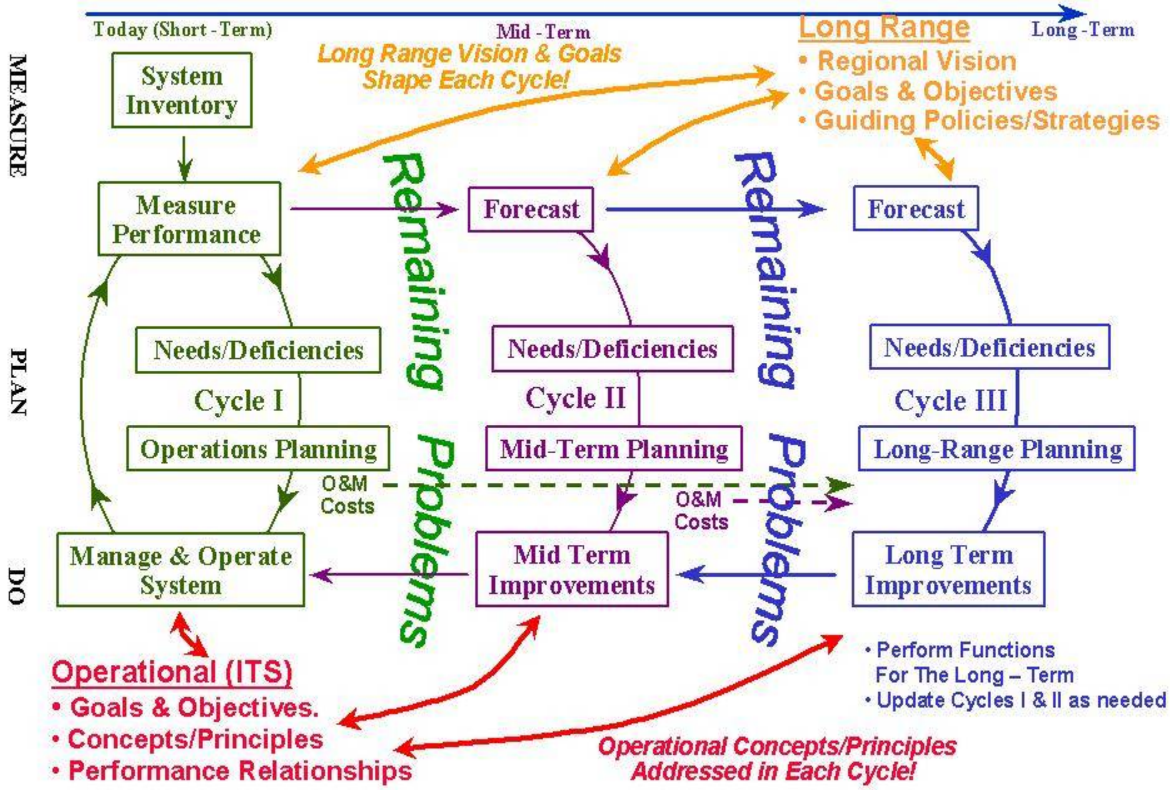
III.B.1 NEW ORIENTATION OF PLANNING/DECISION MAKING TO THE PATH OF DEVELOPMENT FROM THE NEAR-TERM TO THE LONG-TERM

Foremost in making the transition to a new integrated process is the need to bridge the gap between traditional operations and infrastructure oriented planning and their focus on different time frames, goals, objectives, and performance measures, and system feedback. In order to compare tradeoffs of near-term operational and other decisions with those that take years to develop and implement a full time stream of changes to the system and the impacts that result needs to be developed. Second, since continuous performance feedback can actually change what is feasible/possible in the future the process needs to be incremental. Third, the emerging issues described in Chapter II continue to shift the focus of decision making to balance near-term system management and ongoing operations with longer-term needs.

Figure III-2 provides a more detailed view of the cycles and feedback captured within the Integrated Framework that result. Three "cycles" of planning are shown:

- **Cycle I: Short-Term.** This cycle focuses on short-term needs and strategies. It starts with the measurement of current system performance, which leads to operations planning and decisions on the operational improvements to be made. These improvements are then made as a part of the owner's operation and management of the system. As the system is improved, its performance is continually monitored to assess the effectiveness of the changes that have been made and to identify the need for additional corrective actions.
- **Cycle II: Mid-Term**. Cycle II is the mid-range cycle, and considers needs and improvements with a planning horizon of perhaps 5 to 10 years. This cycle builds upon Cycle I by addressing performance deficiencies that cannot be overcome with short-term improvements alone. Deficiencies that do not exist today, but that are expected in the not too distant future, may also become apparent in this cycle. and Improvements that have a lead time of five years or more are considered. Cycle II has a short enough horizon that future travel demand can be forecast with some degree of confidence. Similarly, the evolution of technology and the availability of funding during a 5 to 10 year period are somewhat foreseeable. Thus, planning for the mid-range involves less uncertainty than exists for the long-range. Past ITS Early Deployment Plans, and Strategic Regional Architectures have typically focused on the 5-7 year Cycle II time-frame.

Figure III-2 Cycles and Feedback in the Integrated Framework



- **Cycle III: Long-Term.** Cycle III is the long-range planning cycle. It complements Cycles I and II by addressing those performance problems that are projected to occur in 20 or more years, and by evaluating strategies that have very long lead times. With the longer time horizon of Cycle III, there is more uncertainty about travel demand, and about the kinds of technology that will be available. However, baseline technology forecasts and sensitivity analyses can be used to account for potential future developments. At a minimum, the technology and systems forecast for Cycle II should be carried forward into this cycle.

Each of these cycles provide a performance focus and feedback through the same series of general steps:

1. **Measure** how well the system is performing
2. **Plan** what to do to overcome performance deficiencies
3. **Do** or carry out the plans while continuing to operate the system
4. **Measure** performance again to determine the effectiveness of the implemented actions and identify remaining deficiencies

Problems that can't be solved through management of the system are carried forward to the next time frame and set of decisions. If mid-term resources and management are not an answer, long-term solutions and infrastructure changes are examined. This leads to a fusion of long, mid and short-term decisions and a more balanced consideration of capital and operations. Compared with the traditional long-range planning process, far more emphasis is given to short-range operational improvements and system management. Note, that for simplicity three cycles are described. In actuality, though, the three cycles may be viewed as a simplification of a process that looks at a continuum of needs, which change continually over time, and a transportation system that evolves over time as well. Thus in practice there may be four, five, or more cycles.

Also shown is the integration of both short-range "operational" and long-range "planning" considerations throughout all the cycles of the Integrated Framework. Long-range planning determines the regional vision, goals and objectives and guiding policies and strategies that provide the context for the shorter time frame decisions. At the same time operational goals, objectives, and concepts and principals define how the transportation system is managed in the short-term and provide guidance for future changes. Both help establish the performance measures used for evaluation and identifying the remaining problems that are carried forward to the next cycle.

Following the process through the three cycles leads to a time stream of projects and activities, or "**path of development**" for each alternative. Short-term projects not only respond to short-term problems, but also lay the ground (such as the core ITS infrastructure) for subsequent mid-range and long-term projects. Major capital investments that have long lead times and require substantial funding may need to be built in stages. This may require adjustments to the previous cycles (backward pass) to account for their phasing and/or changes to the system needed for their implementation. Through the series of cycles, the planning process thus identifies the appropriate stages of the ultimate planned system and the timing of each improvement. Planning documents can then reflect how the system is expected to evolve throughout the planning period. Clearly, such documents would need to be living documents that are adjusted as conditions change.

As noted above, there is a tendency to see a natural progression from one cycle to the next. Cycle II, for example, looks to solve problems that are not satisfactorily addressed in Cycle I, and so on. Ideally, however, planning for the three cycles should take place concurrently and be seen as being mutually dependent. The "path of development" is developed by carrying out each of the cycles using the long-range and operational inputs (goals, objectives, etc.) as guides. If the long-range vision, or other requirements are not met (e.g. air quality conformity, fiscal feasibility) changes in guiding policies/strategies, operating concepts/principles, and actions can be made and the path of development adjusted. This can be repeated until a desired result, or vision of the future is reached.

It is useful to compare the above approach with traditional planning. The traditional planning process has typically focused on major investment decisions and the long-range "snapshot" of the infrastructure, transportation services (e.g. transit routes and frequencies), and policies for the horizon year. Typically, only a single horizon year forecasts and analysis are carried out, needs determined and a horizon year alternative chosen. Interim projects and activities simply reflect the phased implementation of the "snapshot" long-range alternative. Also, all operating characteristics and policies are implicitly assumed to remain constant.

In comparison, the Integrated Framework approach uses active management and performance measurement to adjust the system for efficiency and effectiveness at each point in time and account for changes in travel and other characteristics caused by previous decisions. As performance monitoring takes place incremental changes are made to the transportation system and its management and operations. This in turn alters the range of possible alternatives to consider, and may alter travel patterns, land use, and non-recurrent conditions which in turn alters the needs/deficiencies to address as time goes on. The result is likely to be a future system that is much different than one derived from the traditional planning process. These differences are explained more fully in Section V.D: Identifying Alternatives.

III.B.2 INCORPORATION OF THE NEW ELEMENTS NEEDED FOR INTEGRATED ALTERNATIVES THAT INCLUDE ITS

New elements are required in order to include ITS within each alternative in the Integrated Framework. First, the infrastructure, equipment, communications/computer systems, software, and labor required to implement, operate, and maintain the systems must be included. Second, since with ITS, operating characteristics within the transportation system will change and regional "management" of the system becomes possible, operating assumptions and characteristics must now be explicitly addressed. The alternative must, therefore, encompass development of: a regional architecture; concept of operations; future operating principals/concepts and characteristics; and supporting operational policies and programs. A brief summary of these "new" elements is provided in Table III-1. They are examined further in Chapter V.

Table III-1 Summary Of New Elements For Integrated Alternatives

New Element	Description
ITS and communications infrastructure	ITS and communications facilities, equipment, hardware, and software used to implement the desired User Services. Examples include: transportation management centers, ramp meters, surveillance, variable message signs, toll and fare facilities, and communications systems. Supporting ITS infrastructure components such as a communications backbone and other equipment, and software also must be defined.
ITS and operations services	The ITS services that operate with/over the physical facilities and other infrastructure components must also be defined. These include the ITS User Services and market packages and the level at which they are expected to function. The costs of operating and maintaining these services must also be included.
Regional ITS Architecture	A regional architecture specifies the information flows, subsystems, and functions, necessary to implement the desired services (both traditional and ITS). As already stated it is now required for Federal funding.
Concept of Operations	The concept of operations addresses the roles and responsibilities of participating agencies in order to implement, operate, and maintain the desired transportation system (both ITS and traditional components). It includes the necessary agreements between parties as well as the allocation of resource and cost responsibilities. It also includes the roles of the public and private sector.
Operating principals /concepts, and characteristics	Explicit assumptions regarding the operating principals and characteristics of the system and how it will perform under different conditions. With ITS how the system is operated now directly impacts these performance characteristics. Note that this requires forecasts of the characteristics of future technologies and their

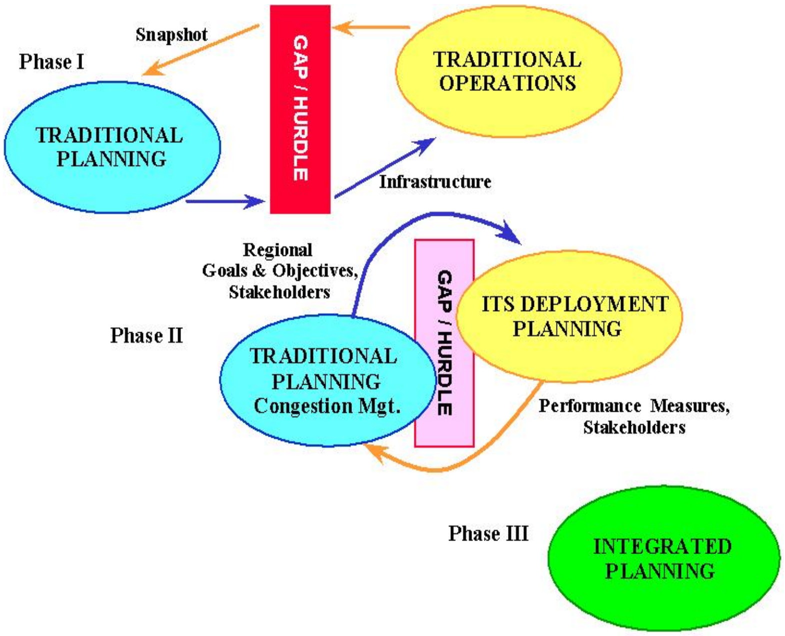
	penetration rates.

Again, each of these elements must be developed along with the infrastructure and services already included in the definition of traditional alternatives (e.g. roads, bridges, transit facilities, transit services, TDM measures). Both the traditional and new elements must also be defined at each point along the development path.

III.B.3 EVOLUTION OF PLANNING AND OPERATIONS DECISION-MAKING RELATIONSHIPS, ACTIVITIES, AND FUNCTIONS TO A SINGLE INTEGRATED PROCESS

Last, the decision-making relationships, activities, and functions of planning, ITS and system management, and operations in areas around the country are changing to meet the emerging challenges and concerns described in Chapter II. This is the result of traditional operations and planning evolving as they move towards integration. Figure III-3 shows this evolution. The current state-of-the-practice where planning and operations co-exist separately is represented by stage I. Pioneering regions and/or states have evolved to stage II. Here ITS has started to introduce system management and influence operations. Also, ITS deployment planning and regional ITS architecture development begin to take on some of the characteristics of traditional planning. However, at this stage many of the functions and decisions for infrastructure, operations, and ITS are still carried out separately. Stage III represents final integration where tradeoffs are considered and the best combined solution to an area’s transportation problems are determined. Each of these stages is examined more completely below.

Figure III-3 Evolution Toward the Integrated Framework



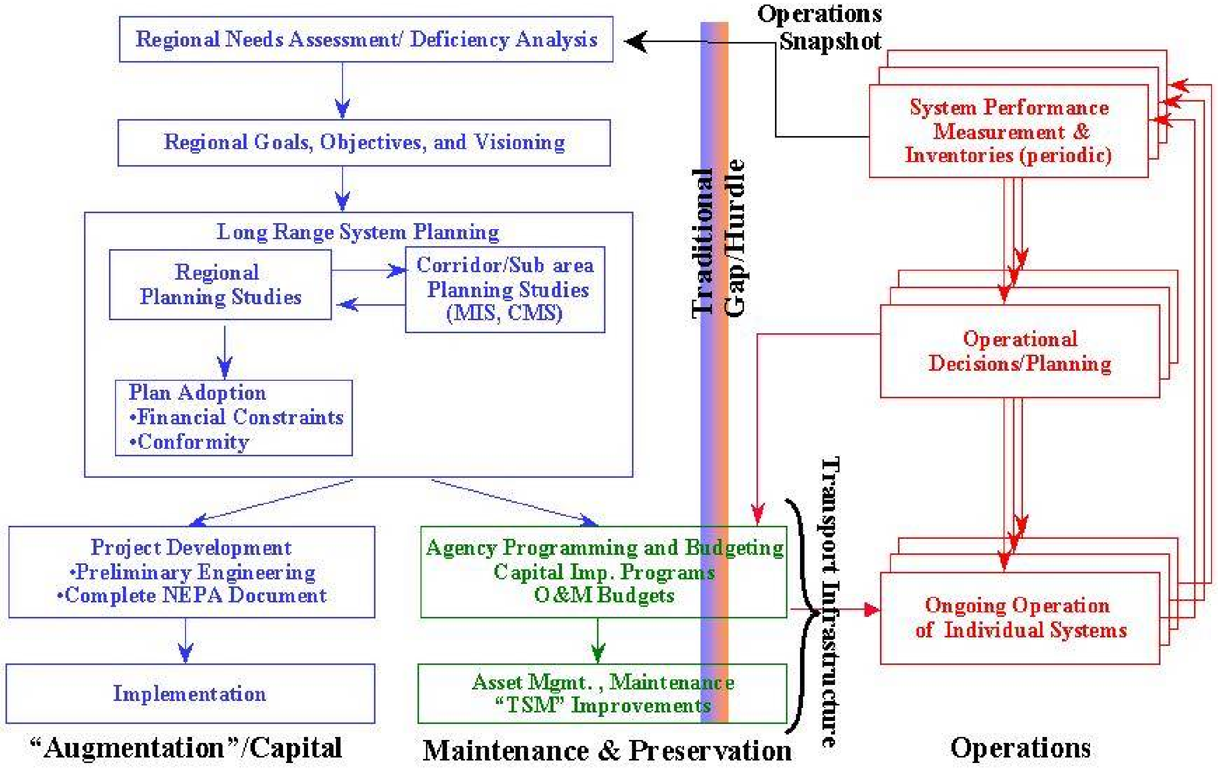
Stage I: Separate Parallel Decision Processes (State of the Practice)

The state-of-the-practice for transportation decision-making, Stage I, is depicted in Figure III-4. For all of the reasons described in Section II.D, “planning” and “operations” tend to be conducted as parallel processes with little or no interaction. Each involves separate institutions and actors, focuses on different time frames (horizons), and has differing goals and performance criteria. These factors create a rather firm “gap/hurdle” – in terms of communications, perspective, and cooperation – that makes the integration of traditional facility planning and ITS deployment planning very difficult, if not impossible. Consequently, no comparisons/tradeoffs are made of ITS and M&O with other types of improvements, or what the overall mix of services should be.

The traditional planning process is shown on the left hand side of the figure. As currently practiced in most states and metropolitan areas, transportation planning focuses on identifying the capital facilities and services that will be needed 20 or more years in the future to meet peak hour demand. There are several reasons for this focus including: Federal laws and regulations; the long lead-time and life and high cost of capital facilities; and the focus of Federal funding programs on capital improvements. Planners typically take a “snapshot” of existing operations and presume that the relationships found will remain the same in the future (efficiencies, capacities, costs per service unit, etc.). Planning is followed by project development and implementation and ultimately provides the infrastructure to the system operators.

Operations is shown on the right hand side of the figure. Typically, operators take the infrastructure as given. Each agency/function then tries to maximize the performance and efficiency of their system given their goals and perspectives. Operators typically have not looked at the transportation system as a whole and often compete for resources with one another in their decisions. System performance may also be measured infrequently, on an ad-hoc basis, and focused on specific problems or breakdowns.

Figure III-4 Stage I: Planning and Operations as Separate Processes



Often the only interchange between the planning and operations worlds is each one’s independent observation of the system. Planners collect data and validate their processes based upon their long-range goals and performance criteria. Operators take the infrastructure and services that result from the planning process that they are responsible for and operate them given their available resources. Under the “World I” fairly stable and predictable conditions where the primary focus of planning was (is) supporting major infrastructure investments and completion of the transportation system this arrangement tended to work fairly well. System performance was determined mostly by the infrastructure/service characteristics, and operators could incorporate new facilities into their activities as they were implemented.

Stage II: Performance Orientation and ITS Deployment Planning (State of the ART)

As areas begin to experience “World II” conditions (see Chapter II) attention on how the transportation system performs and its operation and management grows. Focus on “system performance” and how to improve current operations has increased. In response, pioneering regions and/or states have evolved to Stage II of integrated planning. In Stage II the right hand “operations” side of Figure III-4 is represented by the ITS deployment (planning) and operations process and more recently regional ITS architecture development. It has begun to take on many of the characteristics of traditional planning. However, at this stage many of the functions and decisions for infrastructure and ITS are still carried out separately. More important, tradeoffs between types of solutions (ITS and system management, operations, system enhancements), or the development of integrated solutions are not typically considered.

Steps in a typical ITS Deployment (Planning) process are shown on the right hand side of Figure III-5. and include (Lockwood, 1999):

- **Stakeholder Identification.** Include both users and providers of the potential ITS services.
- **Needs/Deficiencies Analysis.** ITS user needs and deficiencies. Focus on what can potentially be addressed by ITS. Presume that ITS is the solution.
- **Select User Services and Develop ITS Concepts Plan.** Creates an ITS (operations) plan to solve the identified needs and deficiencies. Again, the presumption is that ITS is the solution.
- **Define Concept of Operations.** Determines who will implement and operate the ITS system. The roles and responsibilities of each entity.
- **Identify Potential Projects.** Select and prioritize individual projects from the ITS User services.
- **Operations and Management Planning**. Plan and budget for how the systems will be operated.
- **Implement, Operate, Monitor, Evaluate.** Measures of effectiveness to evaluate the ITS services.
- **Feedback**.. ITS data provides for continuous feedback to operations to adjust service. It can also be used to modify/update the projects that follow.

This is very similar to Regional ITS Architecture Development Process suggested in Regional ITS Architecture Guidance. This process is described as (National ITS Architecture Team, 2001):

Step 1: Get Started. Identify need; Define region; Identify stakeholders; Identify champions.

Step 2: Gather Data. Inventory systems; Determine needs and services; Develop operational concept; Define functional requirements.

Step 3: Define Interfaces. Identify Interconnects; Define information flows.

Step 4: Implementation (of the architecture). Define project sequencing; Develop list of agency agreements; Identify ITS standards.

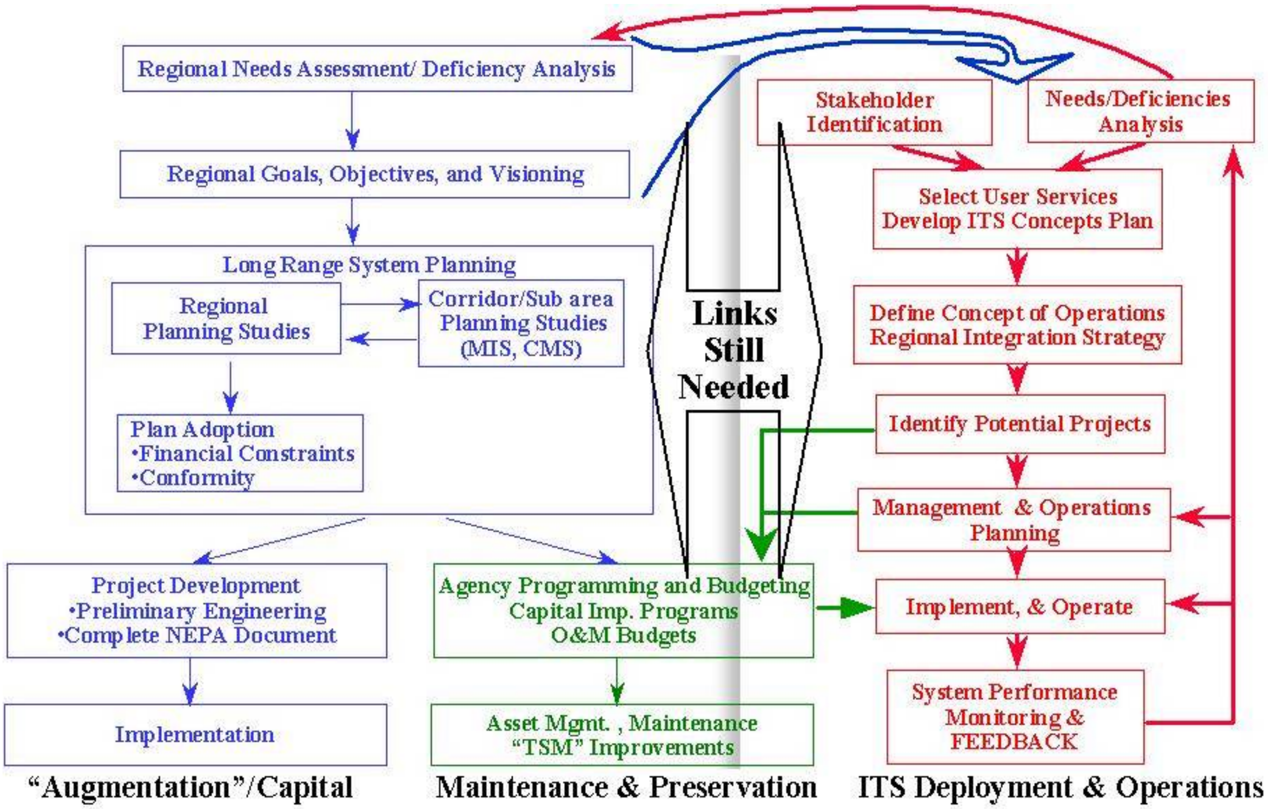
Step 5: Use the Architecture. Support project definition and implementation; Support Planning.

Step 6: Maintain the Architecture. Procedures, roles, and responsibilities for updating and maintaining the architecture.

Iterate through above steps as needed

ITS Deployment Planning and Regional Architecture Development due to the very nature of ITS have had to begin to address the issues raised by ITS's bridging the operations and planning worlds. Because of the time frame and budgets required to implement ITS a new emphasis on the mid-term system is generated. Because of the system-wide nature of ITS coordination begins to occur between operators and system performance is incorporated into the operations decisions (i.e. system wide management versus operating individual components). The ITS Deployment Process stresses this “coordination” and “integration” among ITS stakeholders and operators (see PCB course notes for Deploying Integrated ITS).

Figure III-5 Stage II: Performance Orientation and ITS Deployment Planning



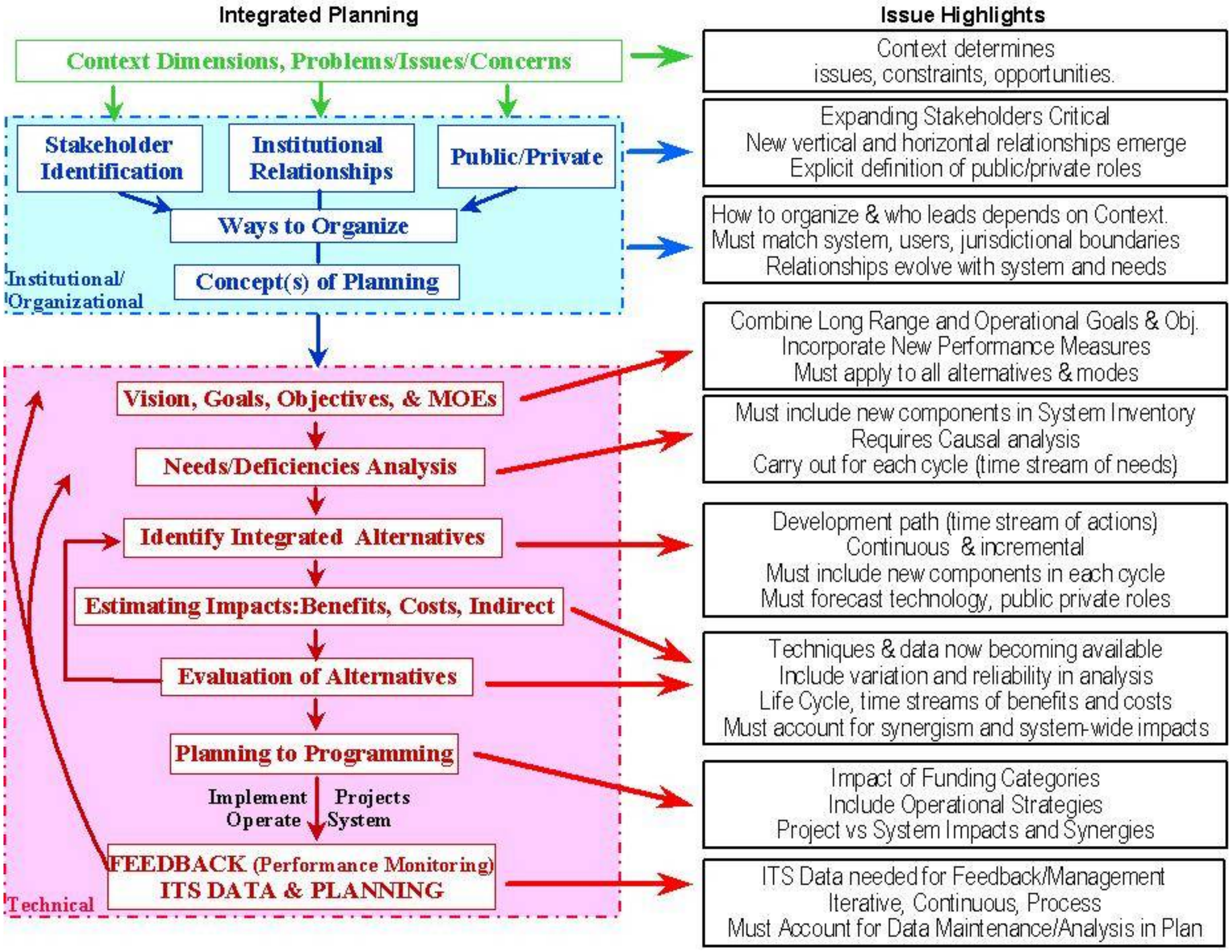
The importance of being consistent with the regional planning process goals and objectives is also recognized, and as shown in the figure these are incorporated into the analysis. However, this communication is often only one way. Regional goals and objectives are used to develop the ITS strategies for deployment and the needs addressed in the Regional ITS Architecture. However, both are most often carried out by stakeholders that are different from those for regional planning. Both also focus only on the ITS solutions to solve identified needs and meet regional goals and objectives. Management and operations goals are also rarely fed back into the overall planning process, nor are combined ITS, management, and infrastructure options and their tradeoffs examined. In addition as also shown in Figure III-5 links between the two processes are still needed for true integration.

Stage III: Integrated Planning (Relationships, Activities, Functions)

Last, in Phase III, the links are made between ITS and traditional planning and the activities and functions and the relationships that support them are integrated. At any point in time along the development path, the components of the transportation system (facilities, services, ITS, communications) and how they will be maintained, operated, and preserved is defined.

Figure III-6 offers a more detailed look at the integrated activities, functions, and shifts in relationships for the Integrated Framework. These are the result of completing the links between the ITS deployment and traditional planning processes discussed above and merging them into one. As illustrated on the left hand side the context first sets the range of transportation problems, concerns, opportunities, and constraints that are relevant to a particular state or region. The activities and functions can then be separated into 2 areas: institutional/organizational and technical. The institutional and organizational activities identify the stakeholders, define roles and responsibilities and establish the appropriate institutional and organizational relationships to carry out integrated planning. The technical activities and functions include: establishing the goals and objectives and their measures; identifying and evaluating alternatives; programming of the system enhancements, operation, and maintenance; and performance monitoring.

Figure III-6 Integrated Planning: Relationships, Activities, and Functions



The right side of the chart identifies some of the issues that are associated with each of the activities and functions shown on the left side. These activities and functions and some of their integration issues are briefly summarized below:

- **Institutional/Organizational**
  - **Identify New Stakeholders.** Expanding stakeholders is one of the key activities to successful integration. It must continue to combine the stakeholders from traditional planning with ITS and operations as well as users, communications providers, and non-transportation entities. Also it is a continuous process with stakeholders that should be included changing as the system changes.
  - **Redefine Institutional Relationships.** New institutional relationships must also be forged to merge traditional planning with ITS and operations. This includes overcoming departmental, funding, and other barriers to implementing, operating, and maintaining an integrated system both within an agency and across agencies
  - **Determine Public/Private Roles.** What should the public's position be on private sector provision of public services? The private sector must be included in the decision making process to develop lasting concepts of operations. Also, the type of service, and who will use it may vary greatly depending on who provides it. Consequently, the role the private sector should play in both planning and providing transportation services must be explicitly determined in order to understand how the overall system will function in the future.

  - **Determine How to Organize to Support ITS and M&O.** The appropriate way to organize to carry out the ITS and M&O functions within the Integrated Framework depends on the local context.
  - **Develop "Concept of Planning".** The Concept of Planning describes how the roles and responsibilities for planning/decision making will evolve along with changes in the system and other conditions. It includes memorandum of understanding and other agreements on both the decision-making implementing/operating responsibilities for the system. An incremental plan should be developed to match the these agreements and responsibilities with the system's development.

- **Technical**
  - **Identification of Vision, Goals, Objectives, and Measures.** During the transition the vision, goals, and objectives of the region should be examined to reflect the operational concerns previously not part of the planning process. These include among others the emerging issues of congestion, reliability, safety, and security. New measures reflecting these goals and objectives that can be evaluated across ITS and traditional improvements, and are predictable must also be defined.
  - **Needs/Deficiency Analysis.** Inventories of the existing system and conditions must be expanded to include ITS and the other "operational" elements of the transportation system such as the communications system. Ways to conduct a causal analysis on why problems exist and whether they are recurrent/non-recurrent must be developed**.**
  - **Integrated Alternative Definition.** Definition of an alternative must be extended to include the phasing of all changes to the system during its implementation. An "alternative" is now the full development path or time stream of actions and activities concerning the transportation system to the horizon year. It must also include how the system will operate/perform at each stage in its development and who is responsible for what.
  - **Estimating Impacts (Benefits & Costs).** If an integrated process is to be truly implemented then the analysis techniques and methods used must capture the changes that ITS, operational, and system enhancement options alone and in combination cause in the system. Full (life cycle) time streams of the impacts and costs must also be estimated. During the transition these new techniques must be put in place.
  - **Evaluation of Alternatives.** During the transition the evaluation processes must be expanded to account for the new definition of alternatives (path versus horizon year), and tradeoffs in: operational versus system expansion improvements; time stream of benefits; system-wide synergies and the inter-dependence of project elements.
  - **Expansion of Programming /Resource Allocation.** Must extend the programming process beyond the TIP/STIP. Changes in operations and services must be included. Must develop ways to balance project versus system impacts and synergies and to look at alternatives that include both ITS and traditional improvements. Last, it is critical that the continued operation and maintenance of the systems be incorporated into the funding needs and programming.
  - **Performance Measurement (ITS Data) and Feedback**. ITS data provides new opportunities for performance measurement and feedback including the monitoring of both recurrent and non-recurrent conditions. It is important to develop continuous feedback loops to all cycles of the integrated process. Critical to this is implementing continuous data collection processes for the performance based measures previously defined, and planning for data cleaning, management, and maintenance costs.

These are more fully discussed in Chapter IV (institutional/organizational) and Chapter V (technical) of this Guidebook.

III.C MEETING FEDERAL AND OTHER GOVERNMENTAL PLANNING REQUIREMENTS

While the Integrated Framework re-orients the planning process and expands its focus to include ITS and management and operations, as shown above it is the result of an evolving process rather than a replacement of existing practice. Consequently, all Federal and other governmental planning and documentation requirements can be met within the Integrated Framework. This is explained below in a brief review of the typical process and products needed to meet current Federal planning regulations. It is followed by an explanation of how each of the Federal process products fits into the Integrated Framework.

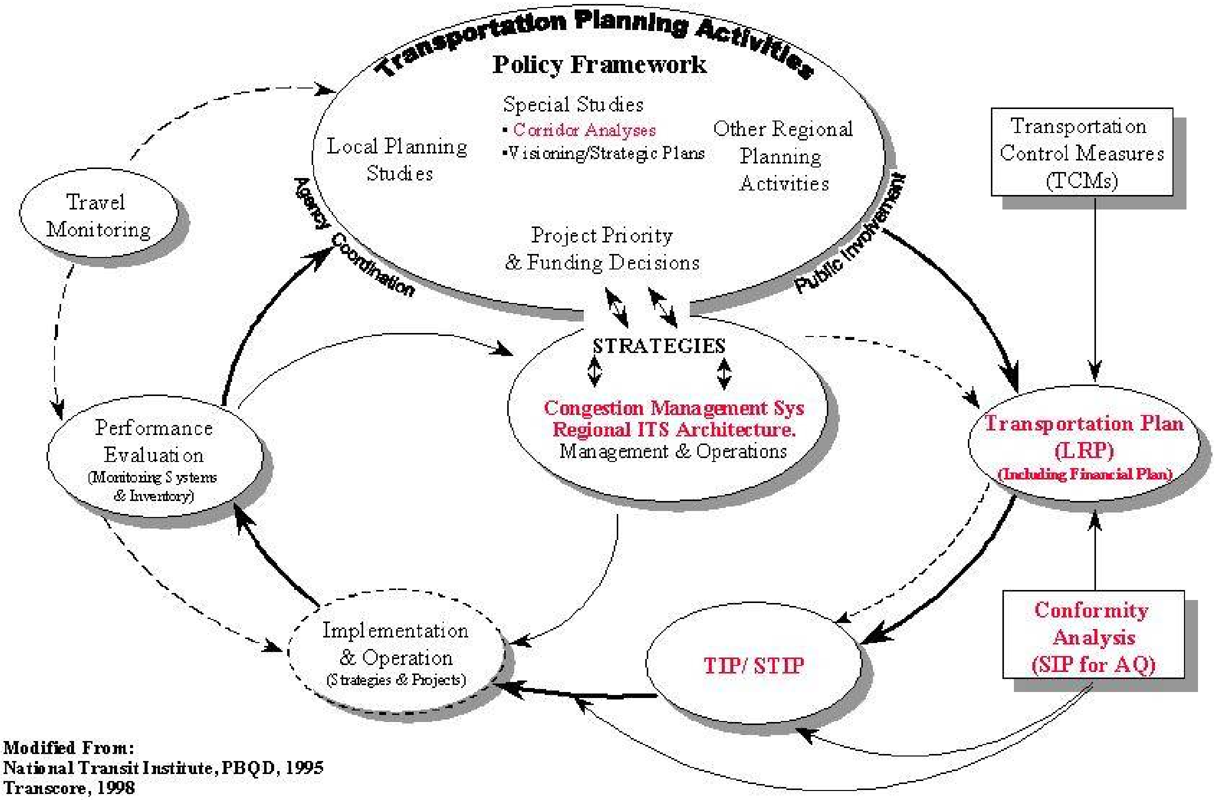
Figure III-7 provides one common depiction of the transportation planning process as envisioned in the FHWA/FTA regulations. The required products of this process are the metropolitan and statewide transportation plans (LRP) and the metropolitan and statewide transportation improvement programs (TIPs & STIPs). Other important products include the State Implementation Plan for Air Quality (SIP), Congestion Management System Plans (CMS), and special studies for major investments (e/g/ environmental impact assessments, FTA alternatives analyses). In the past, the activities carried out as part of the process typically had a long-range focus and are aimed at producing LRPs and TIPs. As discussed in Chapter II, TEA-21 also added a new requirement for National ITS Conformity that requires that a regional ITS architecture be developed that is consistent with both the LRP and TIP (See FHWA/FTA, 1993, Siwek, 1995; Siwek 1996; Weiner, 1997; Mickelson, 1998; Transcore 1998, and ITE 1999 for more on the history and details of the process).

A number of other requirements must also be considered in developing the LRP, TIP, STIP and other products of the traditional planning process. TEA-21, consolidated many of the considerations into seven planning “Focus Areas” including “Promote efficient system management and operation”, and “Emphasize the preservation of the existing transportation system”. Plans must be financially constrained to reflect funds reasonably expected to be available over the time period they cover. With ITS and active system management, the costs of continual operation of the system must also be included. Public participation, collaborative decision-making, and environmental justice have also become central elements required in developing the Federal products (NARC, 1995, Wiener, 1997).

Figure III-7 also highlights the similarities between the traditional Federally oriented process and the Integrated Framework described in this chapter. Most important, both are cyclic and continuous in nature. Conceptually, however, the traditional process starts with the establishment of the long-range needs, goals, objectives and LRP. Then TIP/STIP programs are derived and implemented. Performance evaluation is done for feedback into the planning activities but only periodically (This cycle is in Bold in Figure III-7). Also shown is a cycle to connect the short-range and mid-range development of CMS plans and congestion strategies with the LRP and TIP/STIP. This “strategy” cycle is also where regional ITS architectures should be developed. Last, there is the feedback of the travel monitoring programs to the planning process. Again, this process has traditionally been focused on the long-term, and the performance monitoring and travel monitoring feedback have been relatively infrequent due to data collection costs and processing requirements.

The Integrated Framework re-orients the elements of Figure III-7 focusing first on the short-term and then spiraling out to the mid and long-term issues and solutions. It shifts the emphasis and order of activities rather than creating new efforts. Thus, it is an evolution of the existing process rather than a replacement. Once the three cycles (short, mid, long-range) have been carried out, reconciled, and a full development path chosen the inputs exist to create each of the documents and products needed to meet Federal regulations.

Figure III-7 Transportation Planning Process and Federal Requirements



Modified From:
National Transit Institute, PBQD, 1995
Transcore, 1998

The rest of this section briefly looks at each of the Federally required products of the planning process and describes where they fit within the new Integrated Framework, and some of the issues that may arise as they are developed. The CMS, TIP, STIP, and Regional ITS Architecture are based primarily on results from the short-term and mid-term cycles. The Transportation Plans (LRPs), major investment alternatives and environmental analyses, and air quality conformity use the full development path that results after the long-term cycle is completed. The Federal products and documents are presented since they are the primary focus of many current practitioners and activities.

III.C.1 CONGESTION MANAGEMENT SYSTEMS

Congestion Management Systems (CMS) are one of six “Management Systems” (plus a traffic monitoring system) originally required by ISTEA. CMS and its development process is the conceptual forerunner of both the Integrated Planning Framework and the M&O Planning Factor of TEA-21. As stated in the final management system rule,

> “An effective CMS is a systematic process for managing congestion that provides information on transportation system performance and on alternative strategies for alleviating congestion and enhancing the mobility of persons and goods to levels that meet State and local needs” (FHWA & FTA, 1996).

Central to CMS is the use of “strategies” for managing the transportation system through continuous feedback and monitoring of the system’s performance. Suggested categories of strategies to be considered include: “Transportation demand management measures, including growth management and congestion pricing, traffic operational improvements, public transportation improvements; ITS technologies; and, where necessary, additional system capacity” (FHWA & FTA, 1996). ITS has always been seen as an integral part of the CMS strategies and their development (FHWA, 1998, ITE, 1997) because it provides. the opportunity to develop and apply **regional strategies** to manage the system.

The Final Rule defined the components required of a CMS. Table III-2 lists these and how they are addressed within the Integrated Framework.

Table III-2 CMS Components Within The Integrated Framework

CMS Components	Location in the Integrated Framework
Methods to monitor and evaluate multimodal system performance.	ITS Data & Planning New Performance Measures
Congestion performance measures and evaluation of the effectiveness of congestion reduction and mobility enhancement strategies	New Performance Measures Re-orientation towards near-term system management and performance feedback ITS Data & Planning
Data collection and system performance monitoring Program (congestion’s extent, duration, cause)	ITS Data & Planning New Performance Measures
Performance evaluation of appropriate traditional and non-traditional CMS strategies	Addition of ITS and operational components/strategies New Analysis Methods
Identification of an implementation schedule, implementation responsibilities, and possible funding sources	Development path definition Programming activities Regional ITS Architecture & Concept of Operations Concept of Planning
Implementation of a process for periodic assessment of the efficiency and effectiveness of implemented strategies.	ITS Data & Planning Feedback and incremental development path

CMS plans are also focused on the short and mid-range solutions to current and anticipated congestion and mobility needs. The CMS uses ongoing measures of system performance to identify short-term operational solutions and remaining problems within the system. Through operations planning in the short-term and mid-term planning cycles it then identifies the combination of management strategies to help reduce congestion and increase mobility for the area in question. Remaining problems are candidates for capacity expansion (infrastructure) and other longer-term solutions (e.g. land use). Note: that while the CMS is at the conceptual start of the Integrated Planning Framework it uses the regional vision, goals, and objectives from the current (longer-term) LRP to help define its measure of performance and direct its planning efforts.

Last, implementing CMS provides both institutional and organizational challenges (see FHWA’s Congestion Management System Interactive CD-ROM, FHWA, 1998). “A change in emphasis from new infrastructure development to operations and management is not easily achieved; it is likely to require the development of new patterns of organizational partnership and coordination” (FHWA, 1998). These challenges are the same that confront ITS and M&O in general and that the Integrated Framework is designed to overcome.

III.C.2 REGIONAL ITS ARCHITECTURE DEVELOPMENT

Chapter II described the new TEA-21 requirements for developing a Regional ITS Architecture that is consistent with the appropriate Transportation Plans, Transportation Improvement Programs and other planning documents required for Federal funding. Many pioneering areas have already begun developing or completed their regional architectures primarily through efforts separate from the planning process. Under the Integrated Framework the regional ITS architecture development becomes an integral part of the tradeoffs, activities and functions in the planning cycles that create an integrated alternative and its development path. The architecture simply reflects the ITS components of the overall alternative and its operation. Table III-3 summarizes where in the Framework the required ITS architecture components may be considered. This is explored more fully in Chapter V.

Table III-3 Regional ITS Architecture Components within the Integrated Framework

Regional ITS Architecture Components	Location in the Integrated Framework
Description of the region addressed in the architecture	Identified in the initial context assessment. May be updated in the inventory prepared as part of the Needs/Deficiency analysis.
Participating agencies and stakeholders	Identified in the initial context assessment and change in institutions and organizations. Reflected in the "Context of Planning". Continually reviewed and updated throughout the development path cycles.
Operational Concept (roles and responsibilities for implementing, operating, and maintaining ITS)	Defined as the part of Integrated Alternative Identification. Examined and updated in each development path cycle.
Agreements required for operations	Agreements must be tied to when the ITS and operations components will be implemented and operated. This should be reflected in the "Concept of Planning".
ITS system functional requirements (high level)	Defined as the part of Integrated Alternative Identification. Examined and updated in each development path cycle.
Information exchanges and interface requirements	Defined as the part of Integrated Alternative Identification. Examined and updated in each development path cycle.
Identification of ITS standards	Defined as the part of Integrated Alternative Identification. Examined and updated in each development path cycle.
Sequence of projects required for implementation	Explicit in the development path, once it has been defined. Addressed in "Planning to Programming".

III.C.3 TRANSPORTATION IMPROVEMENT PROGRAMS: METROPOLITAN AND STATEWIDE (TIP/STIP)

Transportation improvement programs are short-term documents that prioritize and program the list of Federally funded projects that are to be carried out for each year that they cover (FHWA & FTA, 1993). Both the Metropolitan and Statewide improvement programs must cover a minimum of three years, and be updated at least every two years. Both programs must be financially constrained by year to resources that are reasonably expected to be available during that period. They can cover more than three years (typically 5 to 6 year programs are developed), but must also extend the project prioritization and financial analysis to cover the additional years. The projects within the TIPs/STIPs must be consistent with the appropriate LRP. Metropolitan TIPs must also meet national air quality conformity requirements and be consistent with the State Implementation Plan (SIP) for air quality. The STIP includes without modification each of the MPO TIPs within its jurisdiction.

Once the "path of development" of system improvements, ITS, and operations is derived within the Integrated Framework, it is easy to see how the projects that use Federal Funding can be filtered out by year in order to produce the required TIPs and STIP. These documents are drawn from the short-term "manage and operate system decisions", and "mid-term projects" within the integrated process. There are still, however, a number of issues to be addressed regarding the TIP, ITS, and the Integrated Framework. These are discussed below.

Document precedence. The TIP serves as a strategic management tool that accomplishes the objectives of the LRP (Siwek, 1995). As such the current regulations assume that the long-range plan is developed/adopted prior to TIP development. In the Integrated Framework, the short and mid-range issues and concerns are examined and addressed prior to the long-range components. However, a forwards and backwards pass is always part each cycle. Also, the TIP and LRP may not be finalized until a full cycle (short, medium, long) of planning is complete and the "path of development" from today into the future defined.

TIP/STIP represent a subset of activities. The TIP is only required to include Federally funded projects and regionally significant projects (with respect to air quality). As the Integrated Framework is implemented and ITS and system management truly incorporated into the transportation decision process this will represent a smaller and smaller percentage of key elements in the process. Operational strategies, local-agency operations and project implementation, and private sector participation all fall outside the TIP requirements. Therefore, the TIP contents as currently defined cannot continue, to be the primary documentation of the short and mid-range transportation decisions of a region.

Programming and budgeting ITS. As ITS, system management, and operations are incorporated into the overall decision process a number of issues arise concerning projects vs. systems and how they should be integrated into the programming and budgeting process which is part of the TIP development. These issues include: funding eligibility, bundling projects, and capturing the tradeoffs between ITS, operations and system enhancements. They are more fully explored in Chapter V.

III.C.4 METROPOLITAN AND STATEWIDE TRANSPORTATION PLANS (LRP)

The Metropolitan and Statewide Transportation Plans (LRPs) are the main Federally required products documenting an area's transportation planning and decision process for Federal funding. They both must address at least a 20 year planning horizon. The Plans must incorporate consideration of the major elements of transportation planning as defined by ISTEA and TEA-21 including: the major planning factors, air quality conformity process, financial plans and constraints, public involvement, management systems input, project level corridor/subarea evaluations and NEPA analyses, and ITS Architecture Conformity (Siwek, 1995, FHWA and FTA, 1999). Metropolitan Transportation Plans 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" (FHWA & FTA, 1993). Definition and analysis of projected travel demand of people and goods, adopted CMS strategies, pedestrian and bicycle facilities, system preservation measures, interaction with Land use plans, transportation enhancement activities and major transportation investments must be included. Detail must be sufficient to provide for cost analysis, air quality conformity, and financial planning. They must be updated at least every three years in areas with air quality concerns, and every 5 years in attainment areas. Statewide transportation plans on the other hand must reflect the associated metropolitan plans, but can be developed at a higher "policy" level. Statewide plans are updated as appropriate.

Transportation Plans and air quality conformity are outputs of the final long-range cycle of the integrated process. These long-range products build upon the previous products and cycles (short and mid-range). They draw upon and reflect, the forecasts of conditions and remaining problems, the long and mid-range planning efforts and resultant long-term improvements. They also include the region's vision, goals and objectives and capture the work described previously for the TIP and CMS plan development. The Federal requirements focus on defining the transportation system in the horizon year.

As with the TIP/STIP the development of the LRP within the integrated planning process changes the LRP's content and raises a number of issues that are highlighted below.

Stakeholders. With the Integrated Framework the number and mix of stakeholders change dramatically. System operators (e.g. traffic operations, transit, ITS, communications providers) and users concerned with reliable performance (e.g. emergency services, police, fire) must now be included. This not only changes the discussion in creating the LRP but can alter its contents as well.

New goals/objectives/measures. Operational goals and objectives, performance and quality of service measures, and the needs/desires of the extended stakeholders must now be reflected in the LRP. Again, this alters the contents and outcome of the LRP.

Time streams vs. Horizon Year. Alternatives within the Integrated Process include the full "development path" of operational and system changes from today to tomorrow versus simple descriptions of the horizon year. The LRP now describes this path and uses the full time stream of costs and benefits in its analyses. Explicit assumptions regarding the performance relationships of the system over time must also be made rather than implicitly assuming that they remain constant.

New components introduced by the Integrated Framework. The new components of ITS and operations discussed previously must also be included in the LRP's descriptions/analysis of the existing and future systems.

III.C.5 CORRIDOR/SUBAREA ALTERNATIVE DEVELOPMENT (FORMERLY MIS) AND NEPA

TEA-21 eliminated the Major Investment Study requirement introduced by ISTEA for analysis of transportation improvements in corridors and sub-areas. Corridor alternatives analysis is now to be integrated into the planning and National Environmental Protection Act (NEPA) analyses. Options being considered by the U.S. DOT for this were presented in March 1999 (FHWA & FTA, March 1999) and are now being finalized. Despite the removal of a formal separate requirement, determining what is the best integrated transportation solution (ITS, system management, operations, and infrastructure) in a corridor is still an important element of the planning process. Corridor analysis often requires more detail and closer examination of options than the overall system analysis performed as part of the LRP. Issues associated with introducing ITS into corridor analyses have been examined elsewhere (Mitretek Systems, 1999, Rush & Penic, 1998, Transcore, 1998).

Carrying out corridor/subarea analysis within the Integrated Framework raises the same issues that have been presented in the TIP and LRP discussions above. The alternatives must now include development of the full evolution of improvements over time in the corridor. Operation of the system and changes in the performance relationships must be made explicit. Full life cycle costs and benefits and ways to tradeoff near and far term impacts/costs must be used.

III.C.6 AIR QUALITY CONFORMITY AND THE STATE IMPLEMENTATION PLAN FOR AIR QUALITY (SIP)

ISTEA linked transportation planning with meeting the requirements of the 1990 Clean Air Act Amendments. It requires that areas that do not meet the National Ambient Air Quality Standards (NAAQS) or are designated as "maintenance" areas must show that their LRPs and TIPs are in conformance with the Statewide Implementation Plan for Air Quality (SIP). The SIP establishes how the state will attain the NAAQS and includes the development of transportation control measures (TCMs) in ozone and CO non-attainment areas. The MPO must make the conformity determinations concerning the TIP and LRP (see Siwek, 1995, Transcore, 1998 for additional summaries of the AQ conformity requirements and transportation planning).

The Integrated Framework does not significantly alter how and when the air quality conformity determinations need to be made within the planning process. TIP conformity is carried out as part of the TIP development, and LRP conformity is carried out as part of the LRP development. Note however, that more information is available when using the Integrated Framework. The operations and performance characteristics are now explicitly determined for each time cycle. These can have a profound impact on the air quality determination. Also, the process of defining the full path of development and the feedback that occurs throughout may change the final system being analyzed. Two other points of note are:

- The order in which the analyses are carried out may change and/or become simultaneous. In the past, the LRP was found to be in conformance, and then the TIP was analyzed. With the Integrated Framework, the TIP (short and mid-range elements) maybe focused on and defined prior to the long-range planning cycle. An iterative process may be needed to finalize the development path and insure that it is continuous and consistent across time periods. Conformity analysis is then performed on the systems that exist at the different time points along the path.

- The Air Quality analysis procedures must be updated to account for the impacts of operations and ITS. This includes moving to modal emission models that capture the impact of high acceleration and deceleration by vehicles and network models that capture ITS and variation in the system (see Hagler Bailly, 1999 for further discussion).

III.D TRANSITIONING TO THE NEW FRAMEWORK

This section examines the transition from today's state of the practice to the Integrated Framework. Many regions are already part of "World II" described in Chapter II and are evolving towards the Integrated Framework and a reorientation of decision making to system management and near-term needs. Others still have many "World I" characteristics, and consequently have less pressure to make the transition. In both cases change does not occur overnight.

In the meantime there are a number of initial institutional and technical activities/strategies that can be started or encouraged to continue to assist in the transition. They are discussed in the subsection's that follow. Before determining what strategies to help in making the transition it is useful to determine where your area is in making the transition: Stage I, Stage II, or Stage III. Consequently, A transition assessment is provided at the end of this Chapter to help determine which may apply to an area's specific situation.

III.D.1 TRANSITION STRATEGIES (INSTITUTIONAL)

The changes in institutions, organizations, relationships, and agreements provide some of the most significant hurdles and gaps found in moving to an integrated approach to decision making. It requires changes both within and between agencies and organizations. It may also require some time to gain legislative and regulatory approvals, and to assemble resources to support the new relationships. At this time there is no clear direction on who or what entity is responsible for instituting this change. It could be the MPO, State, operating agency, or other organization with an interest in ITS or operations. It may also depend of finding the right individuals throughout the area that can come together to make it happen. As part of this some initial activities are:

Initial assessment of regional context (problems, issues, and concerns). Does the region have World I, or World II characteristics? Does it have relatively low congestion and stable conditions, or is it experiencing system failures due to congestion, an inability to expand capacity, and high variation in conditions? Are there other conditions and issues such as a high percentage of unfamiliar travelers (tourists) that need information on the system? This assessment will help establish who may need to be part of the process, what the focus of the transition may be, and when/how it may need to take place.

Establish advocacy and leadership. Several studies have found that "champions" are key to bringing ITS projects through the deployment process (Deblasio, et.al. 1998, ITS America, 1996). This follows also for incorporating ITS and management and operations in general into an Integrated Planning Framework. Also, crucial is tying the advocacy and ownership to where the problems and issues are within the area. As the new framework evolves the leaders must "own" both the solutions and the problems that they are aimed at overcoming.

Aim at crossing boundaries (communication/coordination across modal, geographic and institutional boundaries). A recent Volpe study (Deblasio, et.al. 1998) found that this improved communication across artificial barriers in the system is crucial for developing a system-wide operations perspective and bringing ITS into the planning process. System-wide committees and task forces might be established, for example, to bring together stakeholders from different jurisdictions as well as the new operations and ITS stakeholders.

Start developing operational agreements and opportunities for coordination/cooperation. It is a good idea to continue to encourage, or start to develop memorandum of understanding or other agreements that reflect how transportation is to be operated within a region. Equally important is the creation of task forces or other forums where operations and planning stakeholders can come together and begin to develop a joint understanding of each other. MPOs may be particularly helpful in this area, but others may also take the lead.

Develop awareness and train both staff and public officials. Before people will contemplate change they need to understand the issues and see the potential benefits of taking the risk of undertaking a new approach. At the same time planning staff need to understand ITS and operational issues, and ITS/operational staff need to understand planning. It is particularly important that public officials and policy makers (mayors, city council, state and Federal representatives, boards) understand the opportunities and advantages of integrating ITS and operations concerns in their decisions.

Assemble resources and assist others. Coordinated ITS and operations within an area requires that many different entities have the right resources at the right time. Because of the costs it may also be beyond key entities operating budgets and require additional revenues, bonds, or coordinated funding from many sources. Often, resources can be shared to assist those that may have resource limitations and yet are critical to the successful implementation of the overall system. It may also take targeted lobbying to change legislation and/or obtain funding streams that were not previously available.

Plan for incremental changes in the process as well as implementation of ITS systems. Organizations and decision processes do not change overnight. Change typically occurs incrementally. ITS services and systems can be implemented in modest stages and then extended geographically. Software and hardware are typically upgraded with improved technology in an evolutionary manner, retaining certain components and improving others. (This incremental improvement feature can pose special challenges for programming ITS. The benefits of “core” start-up ITS investments – such as communication backbones, traffic operations centers (TOCs), basic detection and surveillance – might be understated unless their potential to support multiple future additions of high marginal value is reflected.

Continually update and reestablish all of the above. This must be a continual process to overcome changes in policy makers or staff, new stakeholders, and new issues that may divert attention from making the transition to an integrated approach.

III.D.2 TRANSITION STRATEGIES (TECHNICAL)

Changes in the technical processes can also be instituted today to help make the transition. These may need to be carried out at many different levels and may include new data collection, new inventory items, or analysis techniques. Some of the most important are:

Begin to develop new performance-oriented measures and collect data to support them. Key to the Integrated Framework is the use of performance measures that reflect the user’s perspective on how well the system operates. A key step in this outcomes-driven approach is the use of deficiency analysis, with performance measured either against current conditions or against locally defined standards or benchmarks. Performance oriented measures do little unless the data exists to support them. Data collection should start now no matter what stage in the transition the area is in.

Expand the system inventory to include ITS and operational elements. Most areas do not include operational elements such as signals and their operation, communications systems, ITS, or system coverage in their current inventories of the transportation system. Without this information planning does not have the ability to even begin to develop integrated alternatives.

Move towards full definition of every project. The Integrated Framework hinges on including all aspects of a project in its analysis. Re-defining what is required in describing a project, or describing a future system alternative, can begin now. This should include not only the system infrastructure and associated costs, but also the ITS and management strategies, operations and maintenance costs, and the phasing and schedule of changes to the system as well. It is also important to look at the direct strategic connections and synergies that combined infrastructure, ITS and system management strategies offer. Major road and transit improvements can be specifically designed to capitalize on an aggressive systems management regime. At the same time significant savings can be realized though “building in” ITS improvements – piggybacking ITS onto major facility construction and improvement projects.

Move towards a system view of planning. ITS concepts, systems and technology are most effective when applied at the regional scale. The goal should be to achieve interoperability across jurisdictional boundaries, across modes, and among multiple vendor systems within a region. The regional ITS architecture can be an effective tool for coordinating the large number of technical decisions among the various institutional players who may be involved. Second, implementation plans are often useful for ensuring commitments to operation support from the necessary range of regional systems owners and operators. A systems perspective therefore becomes important in reflecting the true benefits and costs of ITS and management and operations.

Begin to develop new analysis methods. Existing planning analysis methods predict average conditions and the traveler response to infrastructure and capacity improvements. Planners should start developing new approaches that reflect variation in system performance. A special challenge in the long-term will be to understand how system capacity and improved real time systems information interact to influence travel behavior. Equally important is developing methods to account for the full life cycle of costs and benefits when comparing future system alternatives. Some attributes of the needed analysis techniques are:

- A focus on performance-based problems with strong feedback from existing operations
- Concern for average and non-standard conditions of incidents, weather, etc.
- Measures of effectiveness for new service attributes (including reliability, security, information)
- Data on ITS benefits relating to improved traveler information or variable prices
- Discounting for varying time flow of benefits to compare ITS with major capital investments

Start small (prototypes) and build from successes (feedback). One of the advantages of many ITS and operational solutions is that they can start small. Prototypes, such as instituting transit signal priority on a single corridor, or transit route, can be implemented and modified through feedback. The system can evolve. This allows building advocates based upon successful implementation and expansion.

Develop awareness and train staff. As the role of ITS and management and operations grows, the technical expertise of staffs involved in both planning and operations must increase as well. Training is available on a number ITS topics through the U.S. DOT Professional Capacity Building Program (PCB). Specific course details can found at the PCB web site: http://pcb.volpe.dot.gov/. Other training is also provided through state and local governments, universities and ITS Vendors (see the PCB web site for indexes of these courses in your area).

III.E CHAPTER REVIEW AND TRANSITION ASSESSMENT

This Chapter presented a new Integrated Framework for planning that addresses many of the desired characteristics of a process that places ITS operational and system enhancement options on an equal footing for evaluation in solving a region’s transportation problems. It is a performance based single process that balances both short-term and long-term improvements for consideration. It is incremental and includes feedback in the definition of alternatives. It includes examining the desired roles of both the public and private sector and the impacts of change in technology. It also can meet all Federal and other governmental requirements.

The Integrated Framework changes planning and decision making in three key ways:

1. New orientation of planning/decision making on the path of development and management of the transportation first to solve problems in the near-term and then in longer terms.
2. Incorporation of the new elements needed for integrated alternatives that include ITS and M&O

3. Evolution of planning and operations decision-making, relationships, activities, and functions into a single process.

The new orientation of planning shifts the focus first to problems of today and managing /preserving/ operating the existing system and its assets. Longer term needs and resources are then used to solve problems/needs that couldn't be solved in previous time periods. Adjustments may also be made to earlier periods to reconcile the phasing of long-term decisions. The new orientation also integrated traditional long-term planning and operational considerations (goals, objectives, concepts/principles, and guiding policies/strategies) in a single process. Performance measures reflect both perspectives. The result is a path of development of projects and activities to implement, operate, and maintain the transportation system from today to the horizon year.

The new elements needed to define an integrated alternative include:

- ITS and communications infrastructure
- ITS and operations services
- Regional ITS Architecture
- Concept of Operations
- Operating principles and relationships

Three stages were identified in the evolution of planning relationships, activities and functions: Stage I: Operations and planning as separate processes; Stage II: ITS Deployment Planning and consideration of system performance; and Stage III: An integrated process. The integrated process includes:

- Institutional/Organizational
  - Identify New Stakeholders.
  - Redefine Institutional Relationships.
  - Determine Public/Private Roles.
  - Determine How to Organize to Support ITS and M&O.
  - Develop "Concept of Planning".

- Technical
  - Identification of Vision, Goals, Objectives, and Measures.
  - Needs/Deficiency Analysis.
  - Integrated Alternative Definition
  - Estimate Impacts
  - Evaluation of Alternatives.
  - Expansion of Programming /Resource Allocation.
  - Performance Measurement (ITS Data) and Feedback

The Chapter then showed how the Integrated Framework can be used to meet the Federal and other governmental requirements for planning. These Include:

- Congestion Management Systems and Plans
- Regional ITS Architectures
- Transportation Improvement Programs (metropolitan and statewide)
- Transportation Plans (metropolitan and statewide)
- Corridor and Sub area Alternative Development
- Air Quality Conformity.

Last, both institutional and technical transition strategies were provided. Key in making the transition is carrying out he self-assessment of the regional and its World I – World II characteristics provided at the end of Chapter II. As pointed out above different geographic areas face different circumstances that may be pushing some of these regions in the direction of an Integrated Framework much more quickly. Generally speaking, this Guidebook espouses the view that those areas with extra capacity, stable system conditions, and low congestion (World I) are less likely to perceive an immediate need for the Integrated Framework. Alternatively, those areas with limited capacity, that are constrained in their ability to build more, that face unstable system conditions and higher congestion (World II) are likely to be moving in the direction of the Integrated Framework more quickly.

Table III-4 provides some questions that might provide some insight into where your region stands regarding its positions and development towards an Integrated Planning Framework. Mark where you think your area’s relative position is for each question. In any case, the movement towards an Integrated Framework tends to be evolutionary in nature and heavily dependent on regional characteristics.

Table III-4 Questions on Region's Progress Towards An Integrated Framework

Question	NO YES
Does your planning process extend beyond current Federal requirements and consider all components and strategies that are part of the transportation system and operations?	NO - - - - - - - - YES
As part of the planning process, does the region include consideration of ITS, management and operations, system preservation, and traditional infrastructure capacity improvements in an integrated process?	NO - - - - - - - - YES
As part of the planning process, has the region set short and mid-term goals focused on operations and system performance in addition to the 20-year horizon of the typical long-range plan?	NO - - - - - - - - YES
Does the region's plan accommodate short and mid-term initiatives that focus on other than traditional infrastructure capacity?	NO - - - - - - - - YES
Do plans for all time frames define operational strategies and concepts?	NO - - - - - - - - YES
Is there a process whereby short-term planning results can be fed into mid-term planning results, mid-term results into long-term results, and back to short-term? In other words, is there a "cycling" process whereby planning occurs along a continuum and is not only directed at a 20-year horizon?	NO - - - - - - - - YES
Have elected and senior officials enunciated their support and interest in short and mid-term operations and system performance as well as in capacity improvements?	NO - - - - - - - - YES
Are stakeholders from both the planning and management and operations communities represented in the regional planning process?	NO - - - - - - - - YES
Have most key transportation and related organizations in your region developed internal structures that enable cooperation between planning and operations elements?	NO - - - - - - - - YES
Have key transportation and related organizations in your region collectively developed a structure(s) that enables cooperation between the several agencies, and specifically cooperation between planning and operations staffs in the different agencies?	NO - - - - - - - - YES
Is the region able to effectively measure and make tradeoffs between ITS, management and operations, and traditional infrastructure-type improvements or expansions?	NO - - - - - - - - YES
Has the planning process expanded its view of system performance to include other than average or peak-hour conditions? Is the region effectively able to measure system performance? Are performance measures used to evaluate progress towards goals, and to make changes in current plans and programs when warranted?	NO - - - - - - - - YES
Does the inventory of transportation facilities and services include the ITS and communications components and operating rules/strategies that are part of an integrated alternative ?	NO - - - - - - - - YES
Does the region have a data collection and analysis program that includes varying system performance from throughout the day, between days, and under unusual events?	NO - - - - - - - - YES
Has the region completed an ITS architecture?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

IV INSTITUTIONAL RELATIONSHIPS, ACTIVITIES, AND FUNCTIONS

Key Points of Chapter IV

- Activities and Functions needed to bridge the gap/hurdle between planning and operations.
  - Redefine institutional/organizational relationships through:
    - + Enabling a new authorizing environment.
    - + Within agency coordination.
    - + Between agency coordination.
  - Expand stakeholder involvement.
    - + Planning, operations, and users.
    - + Match to services.
  - Determine Public-Private Sector Roles.
    - + Who provides ITS can change its characteristics and who uses it. Therefore, need to set policy on respective roles.
    - + Create positive environment.
    - + Develop common understanding of tasks, roles, and expectations.
    - + Both public and private must benefit!
- The best way to organize to support ITS and operations within the integrated framework depends upon the local situation and issues. It may change and evolve over time as the situation changes.
  - Options include:
    - + Do it alone.
    - + MPO Centric.
    - + Sate Centric.
    - + Ad Hoc or new organization.
  - Factors important to the choice:
    - + Willingness and ability to lead.
    - + Geographic overlap of agencies, ITS services, and influence areas.
    - + Legacy institutions and relationships.
    - + Transportation and Environmental concerns such air quality non-attainment, and major incidents.
    - + Other agency skills and resources
    - + Authorizing environment (legal and other issues).
  - Assembling new resources to carry out the activities and functions and expand skills is also critical.
- A “Concept of Planning” captures the approach to take and how it should change over time. It defines responsibilities.

Institutional and organizational challenges hinder the integration of ITS, system management, and operations with the planning process. These challenges range from a lack of coordination within and among specific agencies, to the broad context of professional traditions and organizational missions.

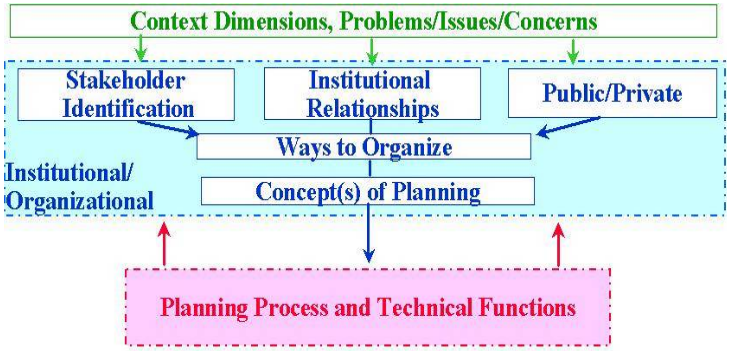
This Chapter deals with the institutional and organization relationships, activities, and functions needed to address the challenges in implementing the Integrated Framework. These are highlighted in Figure IV-1 and include: gathering stakeholders, forging new institutional relationships, determining public/private roles, deciding how to organize, and capturing the relationships and how they change (evolve) over time in the Concept of Planning.

Section IV.A examines how to overcome the institutional and organizational gap between planning and operations while implementing the Integrated Framework. There are many cultural, professional, and institutional differences that may be more difficult to resolve than the technical challenges. A key component in overcoming the hurdles is working to change the context by educating policy makers and the public on the basic concepts and benefits of ITS. Finding champions and redefining agency missions towards performance also help set the stage.

The institutional and organizational activities and functions of the Integrated Framework must also be carried out, including:

- **Expand Stakeholders.** Expanding stakeholders is one of the key activities to successful integration. The process must continue to combine the stakeholders from traditional planning, ITS, and operations as well as users, communications providers, and non-transportation entities. Note also that expanding stakeholders it is a continuous process. The stakeholders must change to match the transportation system as it evolves and changes over time.

Figure IV-1 Institutional/Organizational Activities and Functions in the Integrated Framework



Institutions and Organizations Provide the Environment for Planning As ITS and M&O Are Integrated They Will Evolve

- **Redefine Institutional Relationships.** New institutional relationships must also be forged to merge traditional planning with ITS and operations. This includes overcoming departmental, funding, and other barriers to implementing, operating, and maintaining an integrated system both within an agency and across agencies
- **Determine Public/Private Roles.** What should the public's position be on private sector provision of public services? The private sector must be included in the decision making process to develop lasting concepts of operations. Also, the type of service, and who will use it may vary greatly depending on who provides it. Consequently, the role the private sector should play must be explicitly determined in order to understand how the overall system will function in the future.

Section IV.B explores choosing what is the best way to organize to represent ITS and systems management within the Integrated Framework for a given context. Four approaches are identified including:

- **Do IT Alone.** If an agency is the only entity carrying out or contemplating development of significant ITS services in an area it may be appropriate for it to develop and plan for ITS primarily on its own. This could include some transit authorities, or ITS services along rural interstates. Stakeholders would still need to be included and others consulted.
- **MPO Centric.** MPOs are providing the lead for ITS and operations planning in several pioneering areas around the country. AMPO has identified 5 levels of increasing MPO participation (Traditional, Convener, Champion, Developer, and Operator). Which is appropriate depends upon among other things MPO boundaries, skills and resources.
- **State Centric.** Likewise States have become the primary movers and developers of ITS in many areas.
- **Ad Hoc or New Organizations.** In many areas new "regional operating organizations" are also developing to address needs for operations and coordination across jurisdictional, modal, or agency boundaries that have not been met under existing relationships.

Which to choose depends upon many factors including the willingness and ability of an institution to take the lead, the overlap of agency boundaries with ITS systems and their influence areas, transportation and environmental issues, other agency skills and resources, legal and other restrictions, and historical relationships. No matter what is chosen, the traditional planning agencies must be key participants for the results to be incorporated into the area's formal planning documents (Transportation Plans, TIP, etc.). The ability to assemble resources to carry out the new activities and expand staff skills also plays an important role.

Section IV.C explains the "**Concept of Planning.**" A concept of planning describes how the roles and responsibilities for planning and decision making will evolve along with changes in the system and other conditions. It includes memorandum of understanding and other agreements on the decision-making , implementing, operating, and maintenance responsibilities for the system. An incremental plan should be developed to match these agreements and responsibilities with the system as it develops over time.

This chapter ends with a review and transition assessment in Section IV.D.

IV.A BRIDGING THE GAP BETWEEN PLANNING AND OPERATIONS

As previously discussed the "Gap" between the operations and planning worlds is largely institutional/organizational and may prove more difficult to overcome than the technical challenges. Therefore, this section first provides a closer look at the differences between operations and planning institutions and issues they raise. Activities and functions to help bridge the gap are then discussed including: redefining institutional/organizational relationships; expanding stakeholder involvement; and determining private-public sector roles.

Note, that merging consideration ITS, systems management, and operations into planning and programming must take place at an area or regional scale – the logical scale of many operations improvements and ITS User Services. It is at this scale that cooperative multi-jurisdictional mechanisms are needed for defining and deploying a high tech "ITS regional infrastructure." The regional scale is also appropriate for the development of: operating concepts and regimes; protocols and performance measures; and real-time implementation responsibilities. As congestion increases the spillover effects of one jurisdiction's/agency's operational decisions to others are becoming more significant. Taken together, these imply significant changes in not just *what* services are delivered – but also *how, when* and by *whom*.

IV.A.1 THE GAP BETWEEN THE PLANNING AND OPERATIONS WORLDS

Currently, planning and operations largely continue to take place within different institutional and organizational worlds. A sizable number of institutions and organizations populate each. Those populating the transportation-planning world include:

- State DOTs – who own and plan for the State's highway system and may also own and plan for ports, airports, transit and other facilities.
- Metropolitan Planning Organizations – who are responsible, in metropolitan areas, for adopting regional transportation plans and programs.
- Transit Agencies – who own and plan for transit facilities and services. Some metropolitan areas are served by a number of transit agencies.
- Local Governments – who plan for and control land use, and who often own and plan for the local street system and local transit.

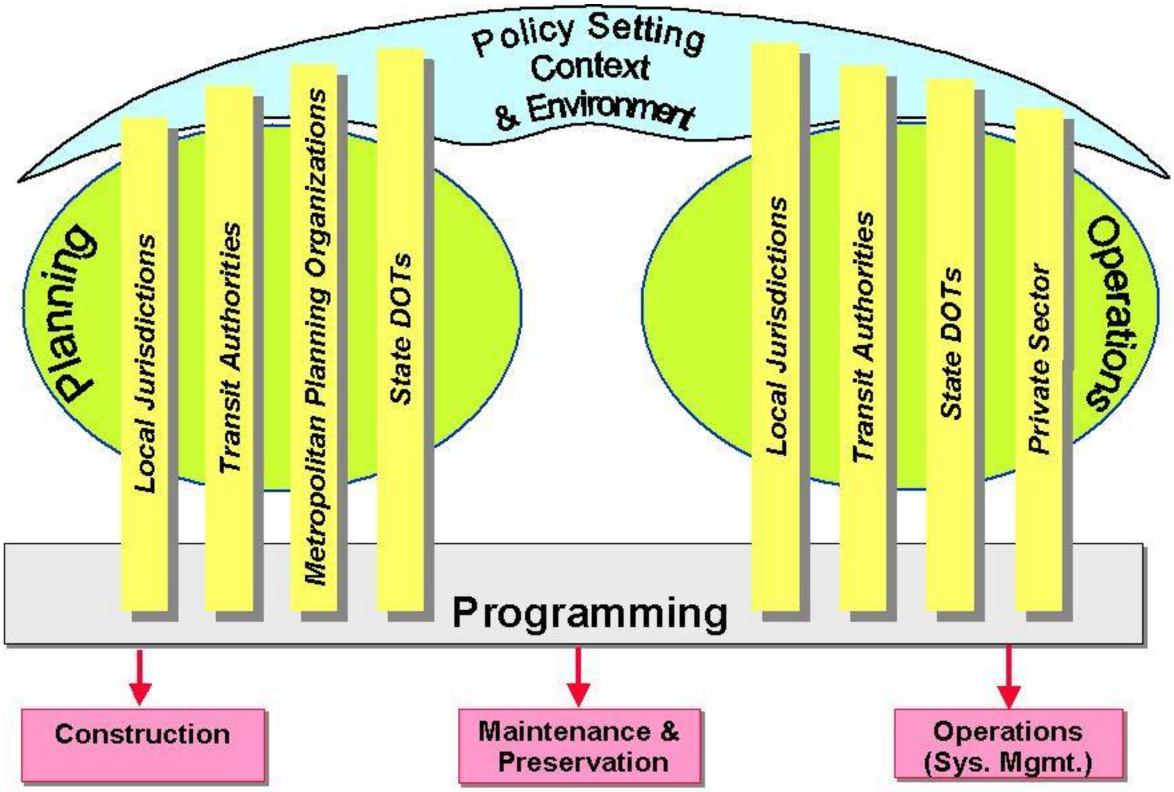
Each of the institutions engaged in planning also establishes the goals and policies that act as guides for planning, and is involved in the programming of capital projects. Each has its own planning, programming and budgeting priorities, and its own procedures and traditions.

To a large degree, these same institutions inhabit the operations world, but there are important differences:

- State DOTs – who maintain the systems they own and set operating policies
- State Police – who enforce highway-driving laws and respond to incidents.
- Transit Agencies – who operate and maintain the transit systems they own
- Local governments – who operate and maintain the roadway and transit systems they own, and who provide police and emergency response services
- Private Sector – who operate vehicles that utilize the transportation system, and who may operate and maintain elements of the highway infrastructure as well.

Figure IV-2 illustrates the institutional relationships described above. The institutions involved in planning and operations act as loosely coordinated "stovepipes" that develop policies, physical and operating plans, and programs of priority projects. As shown, however, the planning and operations worlds do not overlap. In most parts of the U.S., there is little to no coordination between planning and operations.

Figure IV-2 Institutional Relationships



This gap between planning and operations is found in many ways. First, there is a general lack of coordination within the institutions that perform both planning and operations. More broadly, there is a gap in coordination across institutions. Also, planning and operations each involves their own set of activities, relationships, and traditions. These differences hinder integration.

The Gap in Coordination Within Organizations

As described above, there are a number of institutions (e.g., State DOTs, transit agencies, local governments) that carry out both planning and operations. Normally, however, the planning and operations functions are performed in very different parts of the organization. While governed by the same body or leader, and subject to the same agency goals and policies, the planning and operating units may have different interpretations of the directions they receive. The individuals in each unit have different professional traditions, and tend to see their missions in very different terms. They may also utilize different funding – the capital budget, or the operating budget. Coordination within agencies is consequently often loose, informal, and sporadic.

The Gap in Coordination Across Agencies

In metropolitan areas, the MPOs are called upon to coordinate the transportation planning activities of the various institutions and organizations involved in planning. Nevertheless, decision-making is complicated as the various players (different levels of government, different modes, and different jurisdictions) all jockey for position and advantage. Some (but not all) rural parts of the country have established similar coordinating bodies for planning. There, coordination occurs on an informal basis, and tends to be dominated by the State DOT.

With some notable exceptions, most parts of the country have not established formal mechanisms for coordinating operations, especially those funded from local sources. The owner of each system tends to decide for themselves how they will apply the resources they have for operations, system management, and maintenance. Consequently, there are often disconnects at jurisdictional and system boundaries and between modes. The potential efficiencies and synergies of integration are lost.

The Gap Due To Institutional Differences

The integration of planning, ITS and system management, and operations is also hindered by a number of other institutional differences between the planning and operation worlds. These include the kinds of decisions that planners and operations people are involved with, the kinds of activities they perform in order to support these decisions, and their professional traditions, skills, authorities, technical jargon, stakeholders, and funding. These differences are summarized in Table IV-1.

Table IV-1 Institutional Differences between Planning and Operations

	Planning	Operations
Decisions	• Adoption of long-range plan • Adoption of short-range capital improvement programs	• Identification of short-range projects • Immediate response to incidents
Activities and Traditions	• Analysis of long-range problems and solutions • Emphasis on infrastructure-based solutions • System performance is measured in terms of level of service under typical conditions • Professional jargon includes acronyms like TIP, SIP, SIP, UPWP, MPO	• Analysis of existing and short-range problems and solutions • Consideration of low capital and system management solutions • System performance measurement considers level of service, reliability, customer service • Professional jargon includes terms like ITS architecture, protocols, deployment
Professional Skills	• Civil engineering • Forecasting • Impact assessment	• Traffic engineering • Systems engineering • Computer science
Authorizing Environment	• Planning programs and processes are in place and are closely linked to construction program delivery	• Few State DOTs or MPOs have established funding programs for operations • Transit agencies and local governments have operating programs and budgets
Stakeholders	• State DOTs, transit agencies, MPOs, local government planners • Future users of the system • Construction industry • Real estate industry • Those impacted by proposed projects	• State DOTs, transit agencies, local government traffic operations people • Current users of the system • Suppliers of systems and equipment • Traveler information providers • Incident response and management • Law enforcement
Funding	• Emphasis on capital funding	• Emphasis on both capital and operating budgets

The activities required to define, deploy and manage appropriate operational improvements are significantly different from those associated with traditional planning and programming that focuses on providing long-term capital facilities. The differences highlighted in Table IV-1 suggest the changes in the overall institutional setting needed for the Integrated Framework. They include: a new mission mix for transportation organizations; new functions (including some not currently defined as “transportation”); new roles and relationships; shifting boundaries in funding categories; a planning and programming process that includes both capital and operational projects; and new skills needed by the key players in transportation policy, planning, implementation, and operations.

IV.A.2 REDEFINE INSTITUTIONAL/ORGANIZATIONAL RELATIONSHIPS

Bridging the gap often requires new institutions and relationships to be defined.

The modest level of ITS implementation achieved to date has been accomplished without modifying the current state/local/regional institutional framework, including the planning process. An initial round of ITS planning and programming has taken place off-line, as special initiatives, without challenging existing priorities. In most cases, implementation has been dependent substantially on the creation of “virtual” organizations that either by-pass or supplement the institutional conventions. Budgets have depended heavily on earmarked discretionary funds. ITS elements have been buried in other projects, treated as special technology demonstrations, or handled outside the formal programming and planning process. Leadership has depended on personal relationships among stakeholders.

A number of new organizations have evolved in metropolitan areas to deal with the implementation and real time management of ITS and related operational programs. These entities have typically been fostered by special programs and dedicated, earmarked funding and have focused on implementing and operating a specific set of projects. While they share many of the features required of an institutional framework to integrate ITS and operations into the conventional planning and programming process (such as inter-jurisdictional membership, champions, regional vision, etc.), these new organizations have not been established for that purpose. Typically, they do not conduct broad comprehensive ITS programs, nor are they involved with non-operations matters.

Full integration of ITS and system management at the regional scale will involve significant changes to “business as usual “ – from high level policy to real time management in the field, including the planning and programming process. It implies a systems engineering initiative, multi-stakeholder coordination and commitment to real time operations. A program or budget line items called “ITS” may not be essential to a modest ITS program. Nevertheless, increasing levels of commitment to ITS and system management requires a formal program, organization and budget recognition that cannot be easily accommodated within the institutional status quo. Key transportation organization such as state DOTs, MPOs, local government DPW, law enforcement, and emergency response entities are, to varying degrees, at odds with this shift in focus, roles, and responsibilities.

It is important to note that these changes may take place at an evolutionary pace and that the changes do not imply displacement of existing institutional practices or organizations. They may be accommodated in a parallel set of institutional practices, or through minor changes in existing organizations – formal or informal – such as supplementary resources and program adjustments, or through new organizations.

Key changes that must take place include:

- The authorizing environment which sets the mission, policies and resource priorities,
- New coordination and relationships within agencies and organizations
- New coordination and relationships among service provider organization

IV.A.2.1 Enabling A New Authorizing Environment

With very few exceptions, systems management and the ITS that supports it is not a program within the funding and organization framework of state DOTs or MPOs. MPOs lack authority for involvement in day-to-day management and operation of the system. They do, however, offer a venue for operations committees and informal communication. No state DOT has a separate system management and operations unit. Some operations oriented ITS programs exist as special ad hoc programs – they are often based on federal discretionary funds, and are treated as demonstrations of new technology or as special treatments for unique problems. If a truly integrated process is to evolve, then all of the activities needed to build, maintain, and operate a sustainable transportation system need to be included in a balanced program driven by system performance.

Transit operators, by contrast, devote considerable attention to the day-to-day operations of their bus and other systems – trying to make sure that “the trains (buses) run on time”. They have separate operating budgets for this purpose, although limited resources and political realities often constrain their ability to make large scale operational improvements. Similarly, individual local governments typically have traffic operations as a separate budget and organizational element as well – often housed in a fund-starved subsidiary to public works.

Introducing and integrating system management and operations considerations into the formal processes by which resources are allocated and program activities are prioritized requires a series of changes within the authorizing environment:

Creating a Wider Understanding the Basic Concepts

Planners and operations people operate in their technical world, with its own technical jargon. Just as traditional planners may not comprehend such terms and acronyms as “ITS architecture” and “ATMS”, operations and ITS people may not understand the traditional planning process, the role of MPOs and acronyms like “TIP”, “STIP”, and “UPWP”. Better communication, cross-training, and personnel exchanges would help bring the two worlds together.

Real time, region-wide systems management as a public responsibility and professional priority is not widely appreciated in the transportation community. ”Operations” has typically been a secondary priority for state highway organizations. Local governments may control traffic signals, but rarely cooperate at the multi-jurisdictional scale. While ITS technology has a “high tech” appeal, the notion of systematic incremental applications of ITS application is not well understood by naturally conservative elected officials and agency management. Furthermore, there is a natural resistance to supporting major initiatives involving untried technology and limited precedents. Even less well understood is the potential of the relationship between public infrastructure, operations and emerging private traveler information and traveler assurance services. The perception that newly available ITS concepts, systems or technology merit a change in policy or program regarding the nature of agency responsibility is not widespread.

A key precondition to a greater operational focus is a more widespread understanding of “systems management” as a underlying principle that includes maximizing the efficiency of the existing infrastructure and providing a broad range of services. While the “Gee whiz” characteristics of ITS attract interest, the systematic nature of ITS, the multiple/synergistic nature of supply and demand-based services is more difficult to explain. A major professional effort is essential to educate the decision-making community on the value of the necessary institutional adjustments. It will be increasingly important to build on early successes by highlighting their virtues, gaining support for their extension, and generalizing from their success to the justification for additional investments.

Clarifying the Benefits

Traditional transportation projects that focus on adding new capacity introduce visible changes in local accessibility and level of service. The direct benefits of many operational improvements are much less apparent. Most published data regarding ITS benefits refer to a limited number of isolated projects or specific new installations. There is limited evidence from more integrated deployments where mutually supporting applications leverage each other. Important payoffs from ITS – the value of improved reliability, increased security, and improved traveler information – are not widely known. Other benefits, such as the reductions in delay from incident management, are hard to measure. Despite high cost -benefit ratios, data that are available also show that the impacts of ITS tend to be modest, widely distributed and focused on users. These features are less highly valued in the political decision arena. A key precondition to generating support for increased operations focus is a more widespread appreciation of the relatively high cost-effectiveness of most operations improvements.

Finding Champions

Champions are crucial in the absence of established programs with influential constituencies. On-going transportation programs with developed stakeholder constituencies generate institutional inertia. New programs with unfamiliar characteristics, that lack established support interests, depend on articulate, well-placed supporters to lobby for agency resources and to capture and maintain a position in the resource-competitive program arena. Leadership is also necessary to convene outside stakeholders and generate constituency support. Lead agencies and lead individuals are closely related, as the latter generally requires at least tacit support from the home agency. To date, champions from a variety of institutional staff positions within transportation agencies have been very influential in moving ITS programs to an initial plateau. In several states and regions, ITS is identified with key individuals.

A key precondition to establishing a context for the aggressive introduction of operations into the formal planning and programming process is the emergence of leadership. While some visible ITS advocates have arisen, they have typically been at the technical level – middle management in transportation organizations. These players are of critical importance in "rallying" their peers to the benefits of operations. However, they are not likely to have a significant impact on the overall institutional environment

Redefining the Agency Mission

The traditional mission of highway and transit agencies has been dominated by output – measures of facility improvement. The addition of new programs is constrained by the organizational and resource focus on competing traditional missions – access and system preservation – as well as the difficulty in reaching consensus among the larger number of stakeholders. A shift in mission priorities towards service provision will be paced by the ability to demonstrate payoffs compared to other uses of available funds, and the support of articulate stakeholders. Formal strategic planning processes that review customer needs may well reveal the relevance of a set of program strategies that focus attention on short-term actions and more politically realistic improvement approaches with strong operations orientation. Increasing the competitive value of time and reliability is stimulating a focus on performance in both logistics and travel service levels. At the program level, given the constraints on added capacity, system performance is increasingly being linked to improvements in operations and management of existing systems.

Accepting responsibility, however circumscribed, for real time systems operations introduces the risk that user-customers will begin to identify the agencies with the quality of service they are experiencing. At the same time, most systems operations involve multiple jurisdictions and multiple agencies. These arrangements can place transportation agencies in a position of apparent responsibility for aspects of ITS they do not control. (How will the police or EMS entities perform? Who will receive the blame for the hazmat spill that blocks traffic for hours?)

Strategies for shifting the authorizing environment may include:

- *Developing a mutual understanding of basic concepts by actors in both the planning and operations worlds.*
- *Emphasizing the basic principles of system management: maximizing the efficiency of the existing system and offering a broad range of services*
- *Explaining the benefits of operational improvements to policymakers, the public and others*
- *Widespread appreciation of the high cost-effectiveness of most operations improvements*
- *Emergence of leadership*
- *A formal reorientation of mission*

IV.A.2.2 Within Agency Coordination: Performance Based Organizations

As anyone that has worked within a large corporation or public agency knows: organizations are not single entities! Each department may have it's own professional perspective, performance measures, culture, and evaluation criteria. Maintenance, operations, planning, and construction often have very different views of the world and what is important. Managers may also not see the value of changing from the status quo, especially if it leads to uncertainty and reduced autonomy. This is especially true when dealing with large agencies such as State DOT's. Observations made during the Discussion Forums conducted during this Guidebook's development include:

- "Operations are dispersed throughout the organizations hampering their function. Benefit of ITS maybe to force cooperation between groups and data." (North Carolina DOT)

- The institutional barriers for implementing ITS are: " 1. Dysfunctional operations scattered throughout organizations, especially DOTs. 2. Attitude of locals that traffic monitoring and planning in general are more of a federal requirement than of vital interest to themselves." (James Porter, Louisiana DOT)
- "You must deal with internal coordination within your agency first, before you even attempt inter-agency coordination" (J.R. Robinson, Virginia DOT)

Substantial effort and internal communication is required to make everyone understand the new mission of system management and the value of cooperation. One example of internal coordination is now taking place at Hampton Roads Transit (HRT). HRT's Executive Director (Mike Townes) has established an internal ITS Project Team for the transit agency bringing operations and planning together. This team coordinates across departments and makes trade-offs between investing in capital and investing in ITS. Participants include the Director of Planning, Director of Operations, head of Service Planning, Director of Communications, Director of Human Resources, Database Administrator, head of IT. HRT was created through the merger of two transit agencies – Peninsula Transit and Tidewater Transit – and the unique circumstances of this merger and an environment of change may have been a catalyst for establishing new institutional relationships within the agency.

IV.A.2.3 Between Agency Coordination: Coordinated Service Provision

The regional scale and the activity focus of many ITS User Services require the involvement of agencies and jurisdictions beyond those in capital facilities planning and implementation. Several types of cooperation are involved:

Cooperative Regional Decision-Making

Conventional transportation programming has been evolving towards increased shared decision-making in resource allocation, especially in metropolitan areas where Federal funding programs and planning regulations encourages states and local governments towards an increasingly cooperative mode. ITS reinforces this trend. In some cases there are substantial differences in the relative priorities placed on operations improvements on behalf of agencies whose mission may not be operational – such as law enforcement or public safety. Even where objectives are shared, most state and local agencies jealously guard their prerogatives to control the realm of their authority in order to insure responsiveness to their own constituencies. Additionally, operations improvements often require a joint capital commitment – as well as a joint operating resource commitment. Since systems operations is not typically a line item in either state or regional programs, it is difficult for planning processes to determine resource reliability especially in out years. At the same time, there are a few mechanisms for coordinating funding across agency boundaries other than an item-by-item negotiation and trust built up with cooperation over a period of years.

Increased sharing of authority and resources depends principally on finding common objectives and demonstrating the advantages of cooperation from a cost and effective point of view. Within transportation organizations, the ability to pool funds, share federal aid on multiyear basis, and even bring regional politics to bear can have a major impact

Inter-Jurisdictional Cooperation

ITS operations (for example, incident response and traveler information) ideally involve User Services delivered at the scale of the user's trip regardless of jurisdictional boundaries. Projects developed for one mode or jurisdiction often fail to capitalize on the systems integration potential of ITS. The regional, multi-modal, capital and operational aspects of many ITS projects require cooperation and coordination at several stages in program development. Depending on the project characteristics, cooperation within the public sector occurs vertically between levels of government and horizontally within agencies or modes as well as among the same level of government.

Lack of a single program development entity for multi-jurisdictional ITS deployment creates the need for burdensome ad hoc arrangements on a project-by-project basis. Often, these arrangements are absent or not well executed. Defining and negotiating the approaches and arrangements is a substantial undertaking. As a result, ITS projects have been sub-optimized – shaped by a perception of the difficulty of achieving the necessary level of coordination in project development and the desirable level of coordination in operations. Relative resource availability, history of cooperation, and personalities all play a major role in such perceptions.

For integration to occur issues relating to unclear or overlapping authority to act, varied priorities among organizations, differing resource capabilities and conflicting cultures must be resolved. The lessons learned to date suggest that the agencies involved must:

- Accept the impacts of operational regimes, such as diversion, that may result in some loss of jurisdictional independence
- Agree on specific condition-based protocols for actions and roles that require a commitment of resources and operational responses
- Commit to some level of real time coordination that may involve some sharing of responsibility or even temporary ceding control to other entities

The creation of the National ITS Architecture and the TEA-21 requirements for development of regional ITS architectures based upon it may act as a catalyst in providing the coordination needed. Important components that must be included in a regional ITS architecture include (see Chapter II):

- The identification of participating agencies and stakeholders
- An operational concept describing the roles and responsibilities of the stakeholders in implementing and operating the ITS system
- Interface requirements and information flows between agencies and organizations
- Agreements required for operating the ITS system.

However, while a regional ITS architecture requires that these be put in place for the ITS system it describes, it does not require actual coordination and integration of the ITS elements within the overall transportation network. Participants can choose not to coordinate and integrate for efficient operations. If they do so, their regional architecture must simply reflect and highlight this lack. Also, it remains to be seen if the agreements and commitments reflected in any particular area's regional architecture will be honored. This depends upon the agency's themselves and the full commitment of the organizations and policy makers they represent to those agreements.

Strategies for bridging institutional disconnects include:

- *Analyzing agency formal and informal structures to determine whether traditional planning and operational functions communicate and work cooperatively*
- *Analyzing the roles of transportation and related agencies in a given region to determine where roles may overlap, where communication might be improved, and where interests may be shared*
- *Finding common objectives and demonstrating the advantages of cooperation*
- *Resolving issues relating to unclear or overlapping authority, varied priorities, differing resource capabilities, and conflicting cultures.*
- *Develop a Regional ITS Architecture that includes identification of interagency information flows, a concept of operations, and agreements necessary to implement and operate the systems it includes.*

IV.A.3 EXPAND STAKEHOLDER INVOLVEMENT

One of the key activities in making the transition to Integrated Planning is the expansion of Stakeholders. Stakeholders are interest groups who benefit from, or are otherwise impacted by, transportation improvements. This includes the various transportation "providers" (those concerned with building, maintaining and operating the system) and transportation "customers" (the public itself as travelers or shoppers, freight haulers, and other users of the transportation facilities and services).

ITS – with its regional focus, inter-modal potential, and operational scope – requires the involvement of a wider range of players from different modes, jurisdictions, and agencies than found in traditional planning. In fact, expanding stakeholders is required as part of any regional ITS architecture. In addition, many ITS User Services impact and involve stakeholders that have not been part of transportation in the past such as law enforcement and emergency medical services and the private sector (information service providers, Mayday services). An example of potential stakeholder groups is shown in Table IV-2.

Table IV-2 Potential Stakeholders in the ITS Planning Process

Stakeholders (Providers)	Stakeholders (Users)
▪ Federal Transportation Agencies (FHWA, FTA, etc.)	• Motorists (commuters, Tourists, other travelers)
• Federal and State Environmental Agencies (EPA, DOE)	• Transit Riders (commuters, tourists, other travelers)
• Florida Department of Transportation	• Bicyclist/Pedestrians
• Metropolitan Planning Organizations	• Private Paratransit and Taxi Services
• County and Local Transportation Agencies	• Commercial Vehicle Operators and Fleet Managers (trucks, intercity bus)
• County and Local Environmental Agencies	• Motorist Associations/Transit Rider Associations
• Transit Operators	• Commercial Vehicle Industry Groups
• State and Local Police Departments	• Traffic Reporting Services/Media
• Fire Departments/Ambulance Services	• Major Traffic Generators (airports, major employers, universities, ports)
• Emergency Management Agencies	• Private Industry (communications, automotive, electronics)
• Toll Agencies	
• Public Health Agencies	

Source: Cambridge Systematics, 1998

Transportation provider stakeholders in ITS and operations are typically the organizations, public or private, whose public responsibility or business relates to services or functions related to travelers or transportation – especially those that take place on the infrastructure. Most of these have nothing to do with the principal planning and programming focus on physical improvements. They include:

- **Freeway and traffic operations:** Infrastructure owner organizations: state DOTs, local government public works and traffic/transportation departments that deploy and manage freeway and arterial traffic operations systems
- **Incident response and management:** Infrastructure owner organization: state DOTs, Local government public works and traffic/transportation departments, state and local law enforcement, emergency response entities (fire and medical), hazmat–related entities who are involved in incident detection and response, weather and road works-related maintenance
- **Commercial vehicle operations (CVO) regulation and enforcement:** Motor vehicle administrations, CVO and law enforcement entities that manage and operate CVO programs including administration and roadside enforcement
- **Traveler information:** State and local traffic operations, private service provides who collect, process and disseminate information to agencies and consumers
- **Traveler security:** Incident response groups (as above) as well as Public Safety Answering Points (PSAP) agencies, private service providers that provide and manage Mayday and related services

- **Electronic payment:** Toll agency, transit, and parking personnel who deploy and operate these systems.
- **Transit operations and special preference services**: Transit agency and state and local traffic operations personnel, and law enforcement who are involved in transit fleet operations and management

The planning and programming process for ITS, system management, and operations must create a framework for cooperative actions among these “players” whose involvement is essential to the various operations activities ranging from the coordinated deployment of operations infrastructure to the cooperative delivery of real time services. Developing a motivation for cooperation is a key first step. This require identification of common objectives that can be shared widely across organizations that may have very different priority hierarchies, programming cycles, and experience with working outside their own “institutional” framework. Finding non-competitive objectives is crucial together with picking initial objectives with a high probability of producing early wins.

It is also important to identify new constituencies who benefit directly from ITS and operations. Key supporters of conventional transportation investments (larger long tern capital investment) are typically non-user interests who expect to benefit indirectly. These supporters may include major developers, employers, real estate business interests, and construction and labor interests. A major challenge to “institutionalizing” support for ITS at higher levels of implementation is the justification for resource diversion from a stakeholder perspective. Benefits to operations from this user perspective such as reduced delay, improved information, and increased security must be brought to the fore. The short-term tangibility of these benefits (compared to long-term facility improvements) are somewhat offset by their more widely dispersed nature.

At the same time, travelers are playing an increasingly important role in determining the availability and quality of ITS services. Market-based products and services – such as commercial traveler information, Mayday subscription services, users of toll and HOT lane tags – introduce a new relationship between travelers as customers and the service providers, public or private. The rate at which service can be improved now depends on the customer’s willingness to pay rather than on public policy. In addition, travelers are also becoming part of the service delivery chain. The effectiveness of publicly provided traveler information is directly related to consumer investment in mobile communications products and the quality of incident management is now substantially dependent on the traveler-as-informant though cell phone calls from passing or affected motorists. As more and better information on travel conditions is available and as premium services become available, travelers expectations will increasing include the notion that infrastructure should be operated and demand responsive.

A key precondition to institutionalizing ITS and operations within the state, regional and local decision-making processes is finding supporters who exercise their self–interest in the political, policy making and program development process. Thus it is important to identify stakeholders and update participation in the process based upon the ITS User Services that are contemplated, and when they are expected to be implemented and operated. Table IV-3 provides an initial screening of stakeholders by category of ITS User Service (See Ertico, 1998, Transcore, 1998 for additional stakeholder lists).

Strategies for expanding stakeholders may include:

- *Identifying and involving stakeholders and constituencies who can exercise their self –interest in the political, policy making and program development process*
- *Defining the benefits of ITS and operational improvements to policymakers, the public and others to engender a widespread appreciation of their cost-effectiveness. Identifying common objectives that can be shared widely across stakeholders*
- *Tying Stakeholder involvement to the User Services that impact them.*
- *Stimulating the emergence of leadership*

Table IV-3 Initial Identification of Stakeholders for Various ITS User Services

	ATMS	ATIS	APTS	EMC	AVC	EPS	CVO	RR
Federal Transportation Agencies	o	o	o	o	o	o	o	o
Federal Environmental Agencies	o	o			o			
FDOT	X	o	o	o	o	o	X	X
MPOs	X	X	X	o	o	o	o	X
Local Transportation Agencies	X	X	X	o	o	o	o	X
Transit Operators	o	o	X	o	o	X		o
Police Departments	o		o	X			X	o
Fire Departments	o			X			o	
Emergency Management	o			X				
Toll Agencies						X		
Public Health Agencies	o			o				
Motorists	X	o		o	X	X	o	X
Transit Riders	o	o	X	o		X		
Bicyclist/Pedestrians	o	o	o	o				o
Private Paratransit Services	o	o	X			o		
CVO	o					o	X	
Motorist/Transit Rider Assoc.	o	o	X	o	X	X	o	o
CVO Industry Groups	o					o	X	
Traffic Reporting Services	X		o					
Major Traffic Generators	o	X	o				o	
Private Industry	o	o	o	o	X	O	o	X

Key: X Primary Participant o Secondary Participant

Source: Cambridge Systematics, 1998

IV.A.4 DETERMINE PRIVATE-PUBLIC SECTOR ROLES AND RELATIONSHIPS

The public sector (Federal, State, Local) provides the legal framework and rules within which the private sector and “free enterprise” market system operates in any area. As new technologies advance there are increasing opportunities for the private sector to be providers or play a significant role in the provision and operation of ITS services. The private sector may be involved in ITS as (see Siwek, 1998):

- Users (commercial vehicle operators, private transit providers, taxis);
- Suppliers (ITS service integrators, automobile manufacturers, equipment suppliers);
- Franchisees (toll and fare collection, traveler information systems);
- Information service providers (real time traffic/transit information vendors –SmartRoute, Mapping services – Etak, MapQuest, News organizations).

However, the characteristics of the service, who will use it, and who is impacted or benefits vary can vary greatly depending on who provides it. Consequently, conscious decisions should be made on what the private and public sector roles should be, the rules within which the private sector will operate, and how the private sector will participate in the planning/decision making process. In any case it is important to identify and invite to the table private sector stakeholders early in the planning process (see previous sub-section).

Typically, the private sector is a stakeholder in traditional planning both as a user of transportation facilities and services, and as a contractor in their development, implementation, or provision. To avoid “conflicts of interest” and appearances of bias, the private sector for the most part has been kept at a distance in planning/decision making regarding: what to do, how it should be done, and resource gathering/allocation to carry decisions out.

Metro Commute is a private company in New York that provides real time traffic, transit, and weather information via the Internet (http://metrocommute.com). The company obtains direct feeds of traffic data from highway agency loop detectors and video cameras. Transit operators, private companies and users also supply information on how the system is performing. MetroCommute’s income includes advertising revenues from the web site.

However, integrating ITS into planning and decision-making introduces opportunities/need for the private sector to be a partner as well as a stakeholder in the process. Private entities may provide significant components for ITS and operation of the system as: developers of new technologies/systems; vendors/providers of transportation, communications, and information services directly to individuals as well as public entities; and builders/operators of systems. Integrating and maintaining ITS components that must be closely coordinated to continually operate and evolve also requires long-term relationships to be developed with private sector developers. Significant uncertainty and risk is also often part of creating and implementing new technologies and systems. If the public sector wishes to implement and take advantage of these systems new ways of sharing risk and providing long-term commitment are needed. Finally, the private sector has many resources (capital and expertise) that may become accessed by the public with innovative partnerships and joint efforts.

Issues associated with determining the private public sector roles and partnerships are provided below.

IV.A.4.1 Creating a Business Environment For Private-Public Partnership

One of the major impediments to private sector investment and participation in providing the transportation system and services is uncertainty concerning the rules of doing business and their ability to recoup investments and maintain ownership and control over their developments. Overcoming this often requires that partnerships between public and private entities to allow resources (assets, capital, intellectual property) to be commingled, bartered or shared on either a competitive or exclusive basis. These types of formal or informal relationships challenge the existing legal and administrative conventions. Explicit legislative authorization may be desirable to avoid clouding otherwise promising arrangements to access private technology and other intellectual property, capital, and management. This process has been consistently hampered by procurement regulations and conventions based for awards to the lowest bidder that meets detailed pre-determined specifications. These have regularly proven inconsistent with the flexibility required in acquiring software as well as ITS hardware. Project delay, cost overruns, quality problems, complex claims and unattractive commercial risk/returns perceptions have plagued many ITS projects.

Public agencies are more frequently turning to a range of alternative procurement approaches from outside the traditional Federal Acquisition Regulatory process. Approaches developed in other federal agencies and at the state level for non-professional services accommodate scope changes and a more equitable allocation of risks between owner and vendor.. A key challenge is the increased familiarization of public agency personnel with these options through professional capacity building activities

Consequently, it is important to establish the rules and guidelines on their participation and operation as part of defining the new relationships for integrated planning. Some of the issues associated with this include:

Utilization of public resources to support business prospects. This often becomes the basis for resource sharing the narrower sense. Telecommunications companies using public rights-of-way in order to facilitate build-out of the communications infrastructure is an example. This type of sharing of resources can result in a win-win for both parties, as well as the public.

Proprietary issues and confidentiality. The private sector expects to own the rights to their ideas, products, and information. The public sector expects to own the rights to the work that they have funded. Public sector information is also typically just that: available to the public through Freedom of Information Act requests and other avenues. Private sector partners desire to protect their “trade secrets” and information about their operations from their competitors (see Buffkin & Remer, 1997 for further discussion). These concerns must be overcome and general guidelines on the public / private sector ownership of work and information developed as part of the alternative definition. Preserving the privacy rights of individuals and firms must also be addressed. Otherwise, it is likely that ITS services will be defined that cannot be realistically implemented (public sector firms will choose not to provide the services, necessary information flows will not take place, data may not be available for planning or other purposes).

Statutory authority and liability. Partnerships must also be feasible both technically and administratively. Often there are legislative and other barriers to long-term public/private partnerships where every component is not competitively bid, to sharing of information between the public and private sector, and sharing liability and other risks. Liability, in and of itself can be a barrier to private sector participation in ITS elements, especially those that are safety related. The public private partnerships being considered must therefore be examined for their statutory authority and liability issues. If barriers are found the change in legislation must be part of the supporting policies and procedures.

IV.A.4.2 Bringing Private Resources Into The Process Through Partnerships and Risk Sharing

As the private sector appears to be taking on a larger role, one can envision a range of ways in which the private and public sectors might share resources. For example, the private sector is increasingly playing a role in the provision of traveler information. Both the public and private sectors are collecting larger amounts of traveler data, which could be beneficial to both parties. To the extent the private sector collects data of value to the public sector or vice versa, various sharing arrangements might be envisioned. These include:

- Contracting in the traditional manner for, as an example, planning studies,
- Engaging in more complicated turnkey mechanisms where the private may do much of the planning for a given project or facility,
- Developing barter arrangements or in-kind contributions which could involve, for example, sharing of traveler or traffic data for planning purposes,
- Incorporating privately conducted transportation studies into public planning projections and studies, or comparing the conclusions and data of the private studies with the public studies as a method of validation,
- Contributing to studies that may be of mutual benefit to both sectors,
- Using the access of employers to employees as a means to educate or involve employees in transportation planning processes, and
- Enlisting the business community to place its influence behind transportation planning initiatives.

A particularly important concern from above is how to share risk. Oftentimes, the issues of risk can be addressed through good faith negotiations. Sometimes, however, gaps between public and private sector understandings can frustrate the process of agreement, particularly where the partnerships will be more complex.

Some areas of frustration in the development of more complex arrangements include the following:

- Lengthy processes often necessitated by public sector processes and concerns, partly stemming from the number of jurisdictions and agencies that may play a role in any transaction,
- Perception by the private sector of having to accept most of the financial, tort or other risk,
- Desire by a private entity to obtain an exclusive, long-term arrangement when legal and other restrictions may constrain the public sector from this type of arrangement,
- Limitation of the public sector in its ability to compensate a private partner and vice versa,
- Concern by the private sector about protecting intellectual property,

- Lack of clear valuation measures, and
- Inability to utilize public resources or engage in public/private partnerships,

SmartRoute Systems has developed successful public-private partnerships for ATIS systems in cities across the United States including:

- Boston -1991
- Bridgeport -1994
- Cincinnati - 1998
- Philadelphia -1997
- Washington D.C. 1997
- Minneapolis -1998
- Detroit – 1998

From their experience successful public-private partnerships must overcome how each views the other’s perspective:

Public sees Private as: How can I fake a bunch of “in-kind” contributions so I can get maximum public dollars at no risk?

Private sees Public as: What’s mine is mine, and what’s yours is mine.

This achieved both parties must come to a mutual understanding through development of

- Shared goals
- Trust
- Understanding of the partnership
- Flexibility
- Shared Risk

Source: Ruth Anne Bower, SmartRoutes Manager of Public Sector Business development: 1999 TRB Presentation.

Clearly, resource sharing at its most complex should involve a thorough analysis of the existing public authority to act and enter into partnerships, as well as the institutional framework and market situation in which sharing might occur. Compensation is typically a significant issue, as well as the structure of the public/private partnership. But, again, as mentioned above, if care is taken in entering into a sharing agreement, such agreements can have major advantages to both public and private sectors in the provision of transportation services and facilities and in planning.

IV.A.4.3 Incorporating assumptions on private provision of service into planning

As may be seen, the private sector may play a role in many ways. Regional decision-makers and their staffs need to determine where the public and private sectors have mutual interests in transportation and planning, and then set out to fashion arrangements of mutual benefit. These then need to be incorporated into the regional transportation plans and programs and the integrated framework’s path of development at the short, mid, and long-range time frames.

Where private sector resources can reduce congestion, for example, through the introduction of an effective traveler information system that enables the best use of existing capacity, this needs to be factored into transportation planning. If one assumes the private sector will continue to provide more services in the future, which given the increasing technology orientation of these services is likely, then neglecting the private sector contribution may undercut otherwise carefully conducted transportation planning efforts. Greater reflection on the potential private sector role implies a growing dialog with the private sector.

However, the private sector can only be expected to provide ITS components and services if it can cover its costs at a reasonable risk. This depends to a large part on the benefits that an individual receives from the service and the ability to recover costs through direct payments. Services have diffuse benefits to society and not the individual are not market driven and are not good candidates for private complete private sector provision. The issues associated with selecting appropriate ITS services for private sector provision and partnerships are examined in Section V.E under Identifying Alternatives.

Of course, if and when the private sector becomes involved with the public sector, certain requirements may follow. For example, a private sector provider of traveler and traffic data may have to ensure that its operation is conforms to ITS Standards and the regional ITS architecture. In many cases, however, this will be a benefit to private sector companies in that it enable them to more widely sell their products or services.

In recent years, efforts have been made to pay greater attention to the nature and needs of freight transportation in regional planning processes. This attention has often been focused on the facility and capacity needs of freight operators. It has not, however, focused as heavily on the private sector as the provider of passenger transportation services or the provider of various value-added services. These private sector services need to be incorporated into public sector planning, particularly to the extent they change current public sector assumptions about the need for capacity and other resources.

Strategies for including the private sector may include:

- *Identifying and involving private sector providers and stakeholders and inviting their participation in the planning/decision process*
- *Reduce uncertainty and risk by creating a business environment and procurement process that provides for private sector participation and can be depended on into the future.*
- *Come to a mutual understanding on shared goals and what each party expects from the partnerships. Provide for flexibility and shared risk.*
- *Define the expected roles and ITS services for the private sector and or public private partnerships*

IV.B CHOOSING WHAT IS BEST IN A GIVEN CONTEXT?

This section gives insight on different ways that an area (state, region, corridor) may organize to support ITS and operations within the Integrated Framework. Note, that the traditional planning organizations that support the Federal process (MPOs and States) do not necessarily have to be responsible or become the leaders and champions for all the new activities, functions, and products that this requires. In fact, several other approaches exist that may be more appropriate under different conditions. These include:

- Stand alone single agency/implementer planning and implementation;
- MPO centric coordination;
- State-centric coordination;
- Ad Hoc or New Organizations.

Which to choose depends on area’s context, jurisdictions, problems/issues, and existing institutional roles, activities, and expertise. This is not to suggest that the traditional organizations should be supplanted or replaced. The decisions and products (path of development) must fit within and be consistent with the mandated Transportation Plans, TIPs, and other required products/analyses of the MPOs and States. Consequently, they must always participate and be closely coordinated with no matter which option for organizing is chosen. Their activities and responsibilities however will vary depending upon the choice.

IV.B.1 SOURCES/PERSPECTIVES FOR EVOLVING/NEW ORGANIZATIONS

To date most metropolitan areas have implemented management and operations and ITS programs within their existing institutional setting with minor tweaks here or there. In some regional settings, ad hoc adjustments or informal arrangements have been sufficient in the short-term to implement some ITS and/or other management and operational solutions. Other areas are in the process of creating or evolving new institutions and/or relationships to address both ITS and operations. These seem to be originating from two sources and perspectives: ITS oriented entities for operations; and MPO planning.

IV.B.1.1 Operations Oriented Sources

There are a variety of ITS-oriented entities that have been established on an ad hoc basis for one or more ITS services or functions. Often, they are characterized by the following:

- Focus on a particular operational service (such as incident management) but not traffic management
- Focus on a limited regional network
- Handle information transfer but not operations
- Handle a set of real time operations activity but not planning or programming

There are currently two versions of these operation entities:

1. <u>“Formal” operations organizations</u>: These are often established informally by a lead agency, typically the state DOT, as the recipient of dedicated federal funds. These entities are not multi-modal planning entities. They do not have authority regarding categorical state and federal funds. They are typically project-focused and do not trade off investments among a broad range of strategies. They are typically funded with dedicated ITS project funds, both federal and state, and conduct systems integration and operations planning on a multi-jurisdictional basis using those funds. As such they are not directly integrating ITS and operations into the mainstream of regional planning and programming

2. <u>“Informal” organizations via lead agency (a funding jurisdiction)</u>: A jurisdiction with direct access to operations funds or earmarked ITS funds (for example, state DOT or local government) has often become the de facto leader of special operations initiatives within given metropolitan areas. Typically, other jurisdictions are invited to participate. In many cases the lead agency has assumed this role in the absence of MPO leadership or in the face of limited interest from other jurisdictions

Either of these two types of entities could conceivably evolve into established operations planning and implementation entities that receive some share of available transportation funds directly from state and local governments or through MPOs. MPOs would still conduct the remainder of the multi-modal planning activities.

IV.B.1.2 Planning-based Sources

The other “trend” is the incorporation of planning and implementation of operations and related ITS improvements into the MPO process as it currently exists in most regions. Within the MPO setting there appear to be two options that have been followed:

1. **Formal incorporation within MPO:** MPOs and other regional planning entities will incorporate some ITS or management and operations functions. Formal incorporation implies a change in the existing authority of the MPO, the redistribution of decision-making influence, or importing into the MPO decision-making structure decisions made elsewhere. Specific changes in items such as organizational structure or roles or responsibilities may involve modifications in authority, jurisdiction or resource allocation influence within the organization, If so, these are likely to require (or provoke) a change in law or memorandum of understanding among existing organization members.

2. **Informal incorporation within MPO:** Informal changes are characterized by use of the existing organization’s features for new purposes such as the establishment of special subcommittees or task forces, establishing modified procedures, changing evaluation criteria or programming categories, including new, previously uninvolved personnel, etc. – all without substantially altering existing decision making authority. In either case, the MPO could either take on real time operations responsibility itself or simply act as a funding allocation mechanism to other ad hoc multi-jurisdictional operating entities.

To date, the level of ITS and other operations-oriented improvements compared to conventional investments has been small. Much of the funding has come from outside the channels that are the normal purview of MPOs. The constituencies pressuring for increased investments in ITS and operations are modest and largely professional rather than political. For these reasons, MPOs have felt only modest pressures to modify planning processes and programming procedures. However, as system users demand more “fixes” to current traffic problems, congestion, security, and enhanced information, the pressure is sure to increase on policymakers who in turn will influence MPOs. Given their central role in today’s transportation planning as well as their statutory position, MPOs have a strong likelihood of continuing to be regional planning organizations but with an evolving role to include more management and operations responsibilities, or at the least oversight thereof.

A 2001 survey conducted by the Association of Metropolitan Planning Organizations (AMPO) showed 53% of MPOs saw operational issues as a high to very high priority and 64% placed a need for investment in management and operations as high to very high (Taft, 2001). AMPO has identified 5 levels of increasing responsibility for ITS and operations that MPOs can provide:

1. Traditional MPO role, with involvement in management and operations planning limited to existing role in ITS, CMS, etc.
2. Convener of meetings to facilitate the planning for management and operations improvements
3. Champion of plan to improve management and operations efficiency
4. Developer of metropolitan-level M&O plans
5. Operator of the metropolitan system

AMPO states that the current goal of all MPOs should be to develop the capacity to play and effective role as a convener of meetings on metropolitan-level operations planning (#2 above). They recommend, “that ISTEA-21 re-authorization legislation establish an ideal role for all MPOs to play the role of developer of metropolitan-level operations plans and projects” (#4 above) (Taft, 2001, page 17). This can only take place if adequate planning funds are provided to undertake this role.

IV.B.2 WAYS TO ORGANIZE

As stated, the results of any ITS and operations process must be consistent with, and incorporated into, the mandated plans and products at the MPO and State Level. However, many organizational permutations are possible other than those shown above. Their exact nature and which to choose depends on a host of factors. Below are four models that one finds in looking across the United States.

IV.B.2.1 Do It Alone

In some instances, agencies can act, comparatively speaking, alone in moving an ITS agenda. This is rarely true in metropolitan areas, but state DOTs have a fair amount of autonomy in more rural areas. While this is by no means complete autonomy, relatively speaking, state DOTs have more room to act outside metropolitan areas. On the other hand, partnerships with other public and private partners often make sense no matter where or what autonomy a given agency has, as partners can bring strengths, political and otherwise, to enable more rapid progress.

In certain instances, an agency may control its facilities and have the authority to act unilaterally. For example, state DOTs often can plan and install freeway management systems largely on their own. The same is true of transit agencies that control their rights-of-way. Some of the countries’ rail systems are currently installing sophisticated traveler information services for their passengers. Systems such as automatic vehicle location systems can also be installed by an agency acting on its own. This can also be true of local governments that often control much of the transportation infrastructure and, for example, manage transit systems. Sometimes, a local source of funding for management and operations is available and there is no regulatory need for project approval through MPOs or other agencies: The one agency can in fact act on its own. However, when a region adopts an integrated planning framework, there may be an increased sense that a variety of projects that are currently uncoordinated in fact need to be coordinated.

IV.B.2.2 MPO Centric

Several regions have turned to their MPOs to take the lead. Relying on MPOs may make sense in particularly complex areas that span multiple jurisdictions and/or states. In San Francisco, the TravInfo field operational test spanned nine counties, while in the Washington, DC area, the District of Columbia, Maryland, and Virginia share boundaries.

In the San Francisco Bay Area, the Metropolitan Transportation Commission (MTC) served as the lead agency for TravInfo, a field operational test involving the dissemination of traveler information through a phone system and to information service providers. As consensus building was particularly important in the complex, nine-county area of the San Francisco Bay, the MTC seemed the appropriate agency to bring all parties together. The project was guided by the Management Board, which drew members from MTC, three other regional agencies, the regional Caltrans district, and the regional Highway Patrol Division. TravInfo also relied heavily on the private sector as a private contractor operated the Traveler Information Center with oversight of the center through the MTC and Management Board.

In Washington, DC, the Metropolitan Washington Council of Governments is home to both an ITS Policy Task Force and an ITS Technical Task Force. The latter was initially formed after a more ad hoc organization was pulled together to procure the services for an Advanced Traveler Information System, now called Partners in Motion. This group became the nucleus for the ITS Technical Task Force when the Transportation Planning Board (also known as TPB, the local MPO) of MWCOG authorized its creation. The creation of this group was also recommended by an ITS early deployment study. This study, which focused on institutional issues, was completed in 1997.

In 1999, after some concern by TPB members that the Technical Task Force was moving forward without adequate consultation, the TPB also formed an ITS Policy Task Force. This higher-level task force is composed of TPB members. The TPB, with staff assistance from the MWCOG and the two task forces, is now embarked on developing a regional ITS strategic plan and regional architecture. Strong support from the Virginia Department of Transportation and the Maryland State Highway Administration, as well as other local and regional agencies, has enabled the TPB to play an active role. Placement of these task forces within the MPO structure has enabled the MPO to provide coordination services and has served as an incentive to include ITS in the planning and programming process. It has recently be renamed the “Management and Operations and ITS Task Force” to reflect a mission and focus that has grown beyond just ITS issues.

IV.B.2.3 State Centric

In San Antonio, the Texas DOT San Antonio District is the lead agency for the TransGuide Traffic Operations Center, in part because of Texas DOT’s responsibility for operation and maintenance of the state highway system as well as for ITS. TransGuide is truly a multi-modal operation, as the VIA Metropolitan Transit Authority paratransit dispatch staff, the city’s Public Works Department traffic engineering staff, the Police Department traffic dispatch staff, and alternate dispatch points for the Police and Fire Departments are all located in one structure. Each agency performs its separate responsibility but in a way that information can be shared between agencies and modes. In this case, the state is the lead agency.

For the Seattle SmarTrek Model Deployment Initiative, the Washington State DOT (WSDOT) is the lead agency. SmarTrek involves many partners, including WSDOT regional offices, University of Washington, Port Authority of Seattle (operator of Seattle-Tacoma Airport), City of Seattle, Washington State Ferries, and the Puget Sound Regional Council. Each has a role ranging from improving video transmissions of traffic, to better data collection and archiving, to incident management.

IV.B.2.4 Ad Hoc or New Organization

In many areas informal/ad hoc relationships/arrangements, or formal institutions for operations have evolved in response to needs not met by existing arrangements or cross inter-jurisdictional boundaries. These "regional operating organizations" offer new opportunities for cooperation and coordinated operations that were not previously being met due to a number of factors (e.g. political boundaries, legislative barriers, legacy relationships). Recently, the potential for these types of organizations represented by AZTECH in Phoenix Arizona, TRANSCOM in the New York/New Jersey region, and others has been recognized. As a result, the FHWA Travel Management Office and ITE have sponsored case studies and the preparation of the "Organizing for Regional Transportation Operations: An Executive Guide" (Briggs & Jasper, 2001). Two types of new organizations are identified.

AZTECH of Phoenix Arizona represents one approach. It is "virtual organization" or partnership based on voluntary participation. It is not a legal entity and relies on its constituent agencies for corporate functions such as procurement, project management, and staffing. In the AZTech model deployment initiative in the Phoenix, AZ area, the Arizona Department of Transportation and the Maricopa County DOT are co-lead agencies. This resulted from the recognition that each agency brought certain capabilities to the project that the other could not. Therefore, rather than a state-centric or MPO-centric model, the AZTech model might be viewed as a multi-centric model.

The Transportation Operations Coordinating Committee, or TRANSCOM would also fit under the rubric of an ad hoc or new organization. it was formed in a pre-ITS era (1986) to provide a means for setting up a regional cooperative approach to transportation management and improve interagency cooperation in the New York/New Jersey/Connecticut area. Composed of 15 traffic, transit and police agencies, TRANSCOM was viewed as a logical organization to serve as a lead for the tri-area model deployment initiative. It is a private corporation with independent legal status. This enables it to hire staff and perform corporate functions independent of its constituent agencies. Consequently, private corporations can institute processes that are most favorable to the partnership. However, they must also be financially independent, supported through dues, contributions, or private revenue sources. Corporations are best suited for regional organizations that have a well-defined purpose and means of financial support.

IV.B.3 HOW TO CHOOSE: FACTORS TO CONSIDER

Sometimes, the choice on how to organize and who to lead is clear. Often however, it is not and must consciously determined or evolve. Obviously, while the above sections focused on the lead agencies, all of the efforts must be partnerships. As these organizations are generally collaborative bodies, the lead agency is often more the manager of the decision making process than the final arbiter in all matters. This also points out the fact that these organizations are brought together by a perceived shared interest, strong enough to enable them to work closely together. Responsibilities are also shared according to respective agency resources and capabilities.

Other factors that are often important are the consideration of the need for a full-time project manager or other support staff, as well as the need, rationale, and structure of committees that should be formed. Once in place, the organizational structure, including the committee structure, can appear quite complex. Nonetheless, these structures may need to encompass a variety of diverse partners as well as work on multiple issues that may be efficiently handled through a committee structure. As many of these organizations may be operations-focused, the need to include MPO decision-makers and their staffs and their long-range planning emphasis must not be forgotten. Often, MPO staff should be included for a variety of reasons, for example, to keep the MPO informed and educated, and to build support should funding be needed through the MPO-planning process.

Which of the above ways to organize for integrated planning (decision-making) and provision of the activities and functions for ITS depends largely on an area’s local context, history and the issues/problems it faces. Organizations undertake new initiatives and efforts to meet their constituent’s needs and/or respond to other imperatives (Federal regulations) and circumstances. Leaders come to the fore based upon the relevance of the activity in meeting their interests and mission, available resources, and the ability to carry out the effort (resources and skills). New relationships and organizations form and evolve to overcome perceived gaps and deficiencies that are not being met by existing institutions, or activities.

Oftentimes, one agency is likely to be an obvious choice to lead a given effort, perhaps because it has been a leader in ITS projects or has played other coordinating roles previously. Alternatively, one agency may make most sense because of its political influence, ownership of certain rights-of-way, particular procurement capabilities it may have, or other reasons. As seen above in the AZTech Model Deployment Initiative, leadership may also be shared.

The remainder of this section explores these factors that, as they vary, may change the desirable relationships between agencies and other actors in the Integrated Framework. These include:

- The willingness and ability of an entity to become the leader, or champion.
- The geographic overlap of the political jurisdictions, ITS and other systems, and their influence areas.
- Transportation, environmental, and other problems/issues of concern.
- Agency Resources/Skills
- Authorizing Environment (funding sources, legislative authority/mandate, legal issues)
- Historical Relationships

The first step, therefore, must be to inventory the region with regard to these factors. The lead organization and responds best to these factors can then be chosen. Note, that they may change over time and the organizational structure should evolve in response. Thus, a development path can (should) be created to enable an evolution of an organization or organizational structure that is based on that regional context.

IV.B.3.1 Willingness and ability of an entity to become the leader, or champion.

One of the most important factors in determining how to organize is finding an organizations and/or specific individuals to lead and be responsible for the new activities. However, if the efforts are to be successful, these responsibilities cannot simply be assigned, especially given the degree of change in perspective, values, and mission that moving towards integration (ITS and operations) implies. The leading agency must be willing to commit from top to bottom to the effort, and have the resources and capability to carry it out. .

Often, a high-level or executive champion(s) is necessary to force consideration of change in the current way of doing business. Typically, this executive champion needs a counterpart(s)at the staff level who can also champion change. The talents and location of these individuals can make a difference in the speed with which a region looks at change in existing processes. In fact, the identification of champions has been included as a key step in both development of Regional ITS Architectures (National ITS Architecture Team, 2001), and in regional planning for operations (SAIC, 2001). In addition to champions, the number of technical staff, their expertise and resources to them may also effect moving to a more integrated planning process.

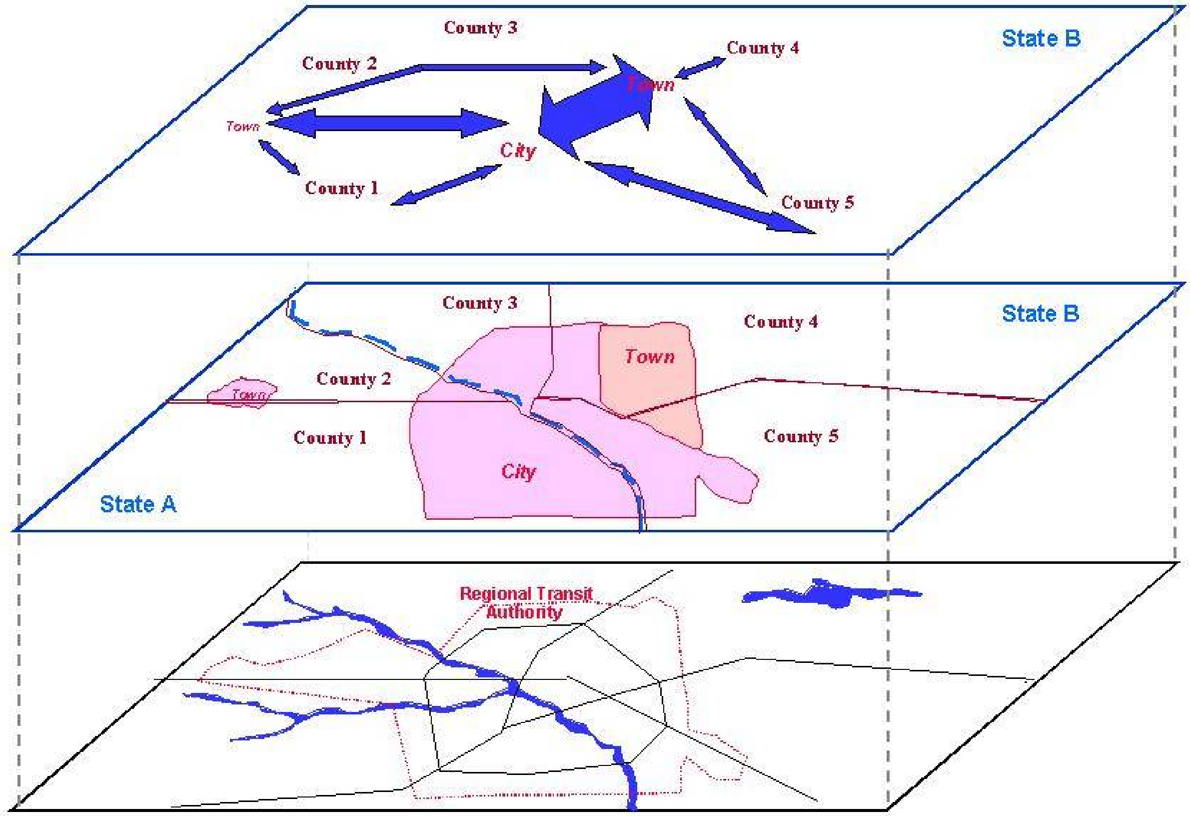
Consequently, if an area already has an agency(ies) and individual champions willing and able to take the lead this is an extremely important asset. Otherwise, the efforts discussed earlier to enable a new authorizing environment and find/evolve champions must become part of the long-term strategy for transition.

IV.B.3.2 Geographic overlap of the political jurisdictions, ITS and other systems, their influence areas.

Another important consideration is the geographic overlap of the transportation and ITS systems, jurisdictions, and challenges that exist within an area or region. In general, one might argue that strong cross-jurisdictional and cross-system shared needs may drive a cooperative search for solutions. The larger the area in which the needs are shared may enable broader crosscutting and systematic approaches to solving transportation issues. On the other hand, where the number of agencies is greater, the task of developing cooperative agreements and shared responsibilities may be larger and therefore more difficult. One must consider agency overlap as well as gaps between agencies and their authority and responsibilities. In short, one must develop an understanding of the geographic area for which a united approach to ITS solutions might make sense, and then consider the jurisdictions and agencies to determine their capabilities in developing unified ITS solutions.

For effective operations and management the boundaries and influence areas (origin and destinations of users, distribution of impacts and costs) of the transportation system and ITS components must in alignment with the decision-making process. This is illustrated in Figure IV-3. Consequently, the organization whose boundaries and responsibilities most closely align with these systems may be the natural choice for organizing and providing effective operational coordination throughout. . It has a vested interest in seeing the overall system perform. Depending on circumstance, this could be an MPO, regional transit authority, State, or other organization that crosses many local jurisdictions. Note, that defining this area for alignment is one of the first steps for the development of a regional ITS architecture.

Figure IV-3 Overlapping Systems, Jurisdictions, Travel/Influence Areas



Where no jurisdiction's or agency's boundaries or responsibilities match the systems of concern it is more important to develop ways to share leadership and decision-making. Examples of this are: urban area's with many political jurisdictions, multiple states, or multiple MPOs. In these instances, commuters and the traveler information systems that they use, transit systems, and traffic control systems may all extend beyond traditional planning area boundaries, or the operations of any one agency. Here, joint leadership may be necessary that combines boundaries to cover the full system. Another option is the evolution of new regional organizations whose boundaries are based upon the need for operational coordination and control such as TRANSCOM.

IV.B.3.3 Legacy Institutions and Historical Relationships

Going one step beyond the political jurisdictions, there are also issues incorporating existing transportation providers/agencies and their relationships with other agencies both within and outside of their respective jurisdictions. Different transportation modes and agencies that support them often have a long history of interaction and allocation of responsibilities. Some regions have primarily highway truck and car traffic, while others have a mix of modes. Some may rely more heavily on public transit, while others do not. Public transit can itself take a number of forms; quite often, the main forms are bus and light or heavy rail although van, ferry, and other types of transportation services may be offered. The presence of airports or seaports can also influence a region's approach. ITS and other management and operations improvements may be appropriately applied to any of these modes or between modes. Agencies may have strained, neutral or excellent relationships with other modal agencies or other jurisdictions. Various agencies may compete and /or overlap in their duties and responsibilities; on the other hand, sometimes no agency has the responsibility for ITS or coordinated operations. Thus, there is confusion when there is a need to respond to an issue having to do with ITS or other issues raised by the Integrated Framework.

As we all know from political science, agencies are often leery of entering into any arrangement that may appear to result in loss of power or resources. Therefore, a great deal of sensitivity exists relative to new approaches that may change existing relationships. Existing ownership and operational relationships are viewed with great importance.

These relationships may well have a bearing on system-crossing innovations. A history of planning or operations coordination and cooperation between agencies, both within and out of jurisdictions, can make a large difference in the appropriate organization and the region's willingness to undertake more complex and mutual projects.

ITS operational tests and early deployment projects have often capitalized on project funding earmarks to provide a catalyst for fledging operational coordination. Often this has occurred outside the MPO process. States as well as other agencies and new organizations have taken the lead. Ad hoc multi-government-level committees and task forces have been set up. Projects have been defined and deployed without proceeding through the standard planning and programming procedures. Ad hoc implementation and operations planning and procedures have been conducted. In many cases these start-up ITS projects have left institutional legacies in the form of ongoing committees and informal personal relationships. In some cases the projects have even developed new permanent activities such as traffic operations centers which function in some ways like formal organizations (Briggs, 1999, Briggs & Jasper, 2001),

IV.B.3.4 Transportation, environmental, and other problems/issues of concern.

Each region has a unique set and mix of transportation and environmental challenges and constraints. Naturally, this uniqueness leads to different responses to given challenges. Congestion, air quality, and the condition of existing facilities all have an impact on a region's ability and need to focus on ITS and operations.

As hypothesized in the World I and World II scenarios, more congested areas are likely to move towards integrated planning more quickly. Systems operations and short to mid-term improvements, e.g., ITS projects, often bring relief that seems rapid in comparison to capacity expansion or other improvements that may take decades to complete. Therefore, level of congestion is often a factor in motivating an evolving planning process.

Environmental laws and regulations, and their effects on (generally metropolitan) areas, are also a factor in motivating change in the planning process. Conformity requirements impose stiff challenges on regions, and sometimes add constraints to building new capacity. When an area is not in conformity the Conformity requirements also change the roles, activities, and functions of many of the transportation organizations impacted. They may in fact be a catalyst for change since ITS and operational strategies can help bring areas into conformity. New organizations may also develop in response such as the recent creation of a super-regional transportation agency in Greater Atlanta.

Other special events and incidents can act as catalysts for change and shape how to organize. Safety, and since September 11, 2001 Security, are other reasons for choosing to utilize ITS and other management and operational improvements. Oftentimes, safety is treated as the highest transportation priority, and elected officials are loathe to wait for long-term infrastructure improvements to remedy problems perceived to be immediate in nature. Other special problems such as a continuing series of special events, as in Branson, Missouri, or severe winter weather have also been recurring reasons to focus on ITS and management and operational improvements. Several ITS operational tests have applied today's technology to corridors with extreme weather, such as the weather warning system in mountainous areas of Washington State.

Another factor that might influence receptivity to evolving transportation planning processes is the regional system’s maturity and current condition. Is the system (speaking broadly of the combination of different modal systems) relatively new with sufficient capacity? Or is it in need of extensive rehabilitation and/or maintenance? In the latter case, a region may want to take a more far-reaching approach to the planning process in order to survey all possible short, mid and long-term alternatives.

IV.B.3.5 Agency Resources/Skills

Differing resources and capabilities between stakeholder organizations can also have a profound influence on organizing to support the continual process of the Integrated Framework. For example, there may be significant differences in the overall issues, the available funding, and the public's concern for a smoothly flowing transportation system between suburban communities (large tax bases, recently built capital facilities, and many commuters), and the inner city (fiscal constraints, decaying infrastructure, a plethora of public needs and concerns). However, for regional operations and coordinated activities to take place both must participate. This may mean that those with resources and skills share them in the interest of the system as a whole. In the Norfolk/Hampton Roads Virginia urban area the approach taken by VDOT was to think regionally from the start and offer/plan a system that could be shared. Consequently, they can provide some key backbone communications and other central services beyond the capabilities of many of the individual entities as an inducement for cooperation.

Another concern that must be addressed is the ability of each participant to raise or commit funds at key points in time to implement phased ITS or operational improvements. Different issues and demands on each agency's or jurisdiction's funds can limit when they can make their contributions. Again, creative solutions must be examined in organizing the overall process to ensure the integrity and operation of the system at all times.

IV.B.3.6 Authorizing Environment

The existing authorizing environment for transportation also has a significant influence on the choices that can be made in organizing to support the Integrated Framework. This includes: current decision-making processes; who owns and maintains each system component; legal authority or legislative barriers; and fiscal issues (funding constraints, scarcity).

One of the most challenging issues in many American metropolitan areas is the number of political jurisdictions, including the overlapping nature of various regional, state and federal responsibilities and roles. Gaining consensus, and overcoming the parochial concerns of jurisdictional leaders and staff, can be a time-consuming process. Often, certain organizations such as metropolitan planning organizations were formed to assist in a broad regional consensus building process and to assist in overcoming parochial concerns. Some regions have been effective at forging regional decision making mechanisms, while others have been noticeably less so. In order to effect ITS or other crosscutting system operations issues, a workable decision making structure is often imperative.

Transportation planning and programming is done differently in different regions. In some cases, a state DOT may exert a powerful influence on, for example, the metropolitan planning process. In others, the MPO may have developed its own significant influence relative to planning and programming. In other cases, dynamic leaders from other local agencies may have forged relationships that provide them with unusual levels of influence. Often, the views of the dominant agency or agencies towards ITS and management and operational improvements will strongly color the overall outcome of the planning process.

Another distinction is that, in some states/regions, the state owns and operates all or most of the highway infrastructure or transit systems, while in others responsibility may be split between the state and regional or local jurisdictions or agencies. In the state-only context, one might consider a movement towards ITS more likely, in that the state DOT is more readily able to act under its own authority (although, in fact, this rarely happens). On the other hand, there may be situations where the regional or local jurisdiction or agency is the driving force behind new ways of doing business, perhaps driven by local needs. The greater number of involved parties may increase the odds of at least one having an urgent need to look at ITS and other management and operational improvements. In any case, the mix of modes, facility ownership and operational responsibilities will color the planning and system improvements orientation.

Sometimes, there are also specific legal and legislative barriers that hamper development of an integrated planning process including ITS, system management and operations. This may be especially true in regions crossing state borders, where the entire governmental structure and outlook may vary between states. Legal authority to undertake tasks; contracting and purchasing requirements; liability, privacy, and public disclosure regulations; and regulations between public-private relationships or partnerships may present hurdles that must be overcome. However, these barriers tend to more ones of perception than reality. Where barriers are perceived, there is often a way to work around them if the political will exists. Conversely, in some cases, legislative incentives have been established to promote an integrated planning process.

Last, funding limitations and/or fiscal constraints often drive regions to look at alternative and cheaper means to improve the transportation system, and are another factor in trying ITS and operational improvements as well as new planning processes. Of course, those same fiscal constraints may be used as a reason for opposing experimentation or innovation. Transportation decision-makers may opt for the tried and true, which, more often than not, is some type of capacity expansion. While this may save scarce dollars in the short-term, lack of innovation may cost additional dollars in the long-term, especially in the rapidly changing transportation environment of today.

The next sections focus on assembling the resources necessary to develop new or evolving organizations.

IV.B.4 ASSEMBLING RESOURCES

The term “resources” refers to the inputs necessary to implement (plan, deploy, operate and maintain) Operations systems and services. These include capital funds to support systems development and deployment, operations funds and staff allocation to support staffing, maintenance and upgrading funds to keep systems up to date.

Existing state and regional transportation infrastructure improvement programs take place in the context of limited funds and staff. Even if where its potential is understood, ITS must compete for scarce financial and staff resources. State and regional funds are programmed on a multiyear basis with federal and state sources being increasing fungible across program categories. Local funds are less “dedicated” and compete with other sectors as well as with other types of transportation improvements. As a result, any new ITS proposals must flow through a pipeline already backed up with existing commitments. Funding is not the critical scarce resource. In an environment of agency downsizing, staff slots are limited and the required skills are increasingly scarce The project development process, involving cross-agency negotiation and cooperation, is very senior and middle management labor intensive. Many operations programs appear to be staff rather than funds constrained.

Traditionally the dedication of resources at the state, local and federal level has been framed in terms of a “systems” or a “program” defined by a network or in terms of performance standards and embodied in the formal state and regional planning and programming process. A corresponding generic definition what constitutes comprehensive operations and management program has not been developed in any jurisdiction. Few states or regions have formal, funded management and operations programs. The hesitancy of state and local entities to define systems management or operations performance standards and related target programs may reflect finance–driven reluctance on the part of agencies instead of conceptual difficulties. That ITS or operations do not appear as a program line item in most state STIPS or regional TIPs reflects the broader reality that systems operations and management as a distinct and major service responsibility is not widely adopted as a policy concept deserving of a separate programmatic, budgeting or organizational response equivalent to “preservation” or “safety”.

IV.B.4.1 Mobilizing Funds

Initial deployment plans have been developed on an ad hoc basis and few jurisdictions have estimated, much less committed, program level funds.

In the majority of states and metropolitan regions, ITS investments are typically funded as special projects, or they are combined with other major improvements. In most cases, ITS investments are considered “special” “demonstration” or “high technology” and are supported with special earmarked funds. A few of the more advanced state programs have obtained special resources through discretionary federal aid such as the Model Deployment Initiative (MDI) programs or where the momentum of an early operational test has developed a strong ITS constituency. At the same time, other ITS components are conveniently combined with major improvements (such as detection or wireline communications) and buried in conventional funding. While this latter approach represents a form of “mainstreaming”, it is often simply the practical recourse when explicit funding for ITS is not otherwise available. In either case, stable long-term program oriented ITS and system management programs are extremely rare.

A key precondition to mainstreaming operations is its ability to compete for funds. The separation of capital and operating funds within the allocation flows from state and federal sources and the current program-defined funding allocations within State DOTs and to regions (and within local governments) puts operations at a significant disadvantage. Redefinition of programs within this process is probably necessary to enable operations to compete effectively

While adequate capital is a continual challenge, a more serious handicap to mainstreaming ITS relates to operating funds. Traditional transportation improvements are capital intensive. This “pay as you go” funding system has disconnected concepts of reserves, life cycle considerations and future operating and maintenance burdens from funding decisions. Furthermore the federal aid program on which states have depended for nearby 45% of capital cost has historically not been available for operations, although these constraints have now been relaxed. The effectiveness of ITS is particularly dependent on support for continuing operations and regular upgrades.

IV.B.4.2 Special Technical Staff Capabilities

Funding alone is not the only scarce public resource. As ITS-related programs expand, staffing is becoming a real constraint. The professional orientation in most transportation agencies has been civil engineering or planning. The personnel with operations or system engineering backgrounds are relatively rare. Additional staffing is limited by state and local policies. At the same time, the technologies on which ITS is based are part of larger information and communications industries, which are fast growing and extremely competitive. Attracting and retaining highly qualified technical staff is increasingly difficult, especially in the public sector where civil service and compensation constraints reduce management flexibility in creating satisfactory career environments. The rate of progress for many ITS programs is therefore limited by the capacity of the ITS-oriented staff. In the absence of organized ITS programs, much of the current deployment is done on an ad hoc basis, substantially dependent on the day-to-day lobbying and individual project facilitation of small ITS-dedicated staffs in state DOTs and local government.

In parallel to budgetary increases for operations, more effective operations planning staff resources need to be built up. Three tactics are emerging for responding to this shortage. First, a major training effort within transportation organizations is necessary. This can play an important role in filling some of the important staff vacuums. At the same time state DOTs and local agencies (based on motives beyond ITS) are seeking more flexible employment opportunities that reflect the expectations of technical specialist in a competitive setting. At the same time public agencies are finding that outsourcing and other forms of partnerships with private vendors is an effective strategy for accessing specialized capabilities

Systems engineering is a discipline not widely available in the planning ranks of state DOTS, local government or MPOs. As a result, much of the ITS architecture development and project planning have been carried out by operational personal that are not part of the normal planning process. It is not clear the degree to which this will substantially handicap the ability of management and operations investments to compete within the established planning process. Many state efforts appear to be limited more by the small number of middle level and senior ITS staff than lack of financial resources

IV.C CONCEPT OF PLANNING

The "Concept of Planning " is designed to capture these shifts. It is to decision making what the concept of operations is to maintaining and operating the overall system. It defines the relationships and responsibilities required to carry out the integrated planning process as it evolves towards the Integrated Framework. It, therefore, recognizes that institutional arrangements and levels of cooperation also evolve over time in response to the changing system.

The shifts in institutions, organizations, and relationships for planning/decision making discussed in this chapter take time to implement and evolve. Shifts are likely to be needed due to the following factors:

- As an area moves more and more towards a World II environment, new stakeholders, interests, and concerns will emerge (see chapter II). It is likely that institutions, organizational structures, and planning/ decision making processes designed to address previous problems and needs will not be able to respond to the new issues. Consequently, changes will occur in what types of decisions are made, how they are made, and who makes them.
- Likewise, moving from where an area is today towards integrated planning will introduce the new stakeholders, considerations, and relationships discussed throughout this Guidebook. Operations and planning stakeholders must be brought together. Mechanisms for balancing near-term and far-term improvements must be developed. New resources and capabilities may need to be assembled or developed.
- As the area's environment changes and the transportation system moves along its development path through implementation of its programmed improvements new stakeholders will be impacted and need to become involved in the process. If stakeholders are invited to participate before they are affected and have a reason to be concerned they are not likely to contribute.

Elements of the Concept of Planning include:

- Identification of new stakeholders and when their participation is likely to be needed as part of the planning process. This might include new types of stakeholders such as incorporating public safety officials as the decisions regarding incident management, emergency evacuation, and security issues are being considered and systems to address them implemented. They may also include new area and jurisdictions as the systems expand to accommodate growth.
- Identification of roles and responsibilities for the new components of planning mentioned above (ITS infrastructure and services, ITS Regional Architecture, operational concepts, and characteristics). This includes the organization/entity responsible for maintaining the inputs and products of the integrated process. For example, one requirement for conformity with the National ITS Architecture is to identify who is responsible and the mechanisms/procedures for updating/maintaining the regional ITS architecture. Other issues that may need to be addressed are the responsibilities for data archiving, analysis, and maintenance, and data rights (ownership, privacy)
- Identification of new organizational structures and relationships that may be needed to match geographic and modal leadership to the problem/impact area of the system and its operations.
- Memorandum of understanding and other agreements on both the decision making implementing/operating responsibilities for the system.
- A path of development for institutional arrangements and planning and operating roles.

A key factor in creating the concept of planning is leadership must exist where the primary transportation challenges or problems are faced and/or primary responsibility and ownership of addressing those challenges and problems are located. An agency assigned planning responsibilities must feel buy-in to that particular set of planning issues it has been handed; otherwise, that element of planning may fail. Part of ensuring buy-in by a given organization or jurisdiction is to closely match geographic, modal nature, and other factors to that aspect of the Integrated Framework's planning. The private sector should also be considered as the partner with the ownership of a issues that concern them, and so various private organizations might take the lead in aspects of the regional planning process.

The path of development of the transportation system also evolves and so should the decision-making and other organizations that support it. Therefore, an organizational path of development and plan should be determined to match the shifts in responsibilities, roles, and stakeholders that occur as the transportation system changes are implemented.

The concept of planning, as a concept of operations, would differ from region to region, depending on specific circumstances, tradition, institutional constraints, and other factors. Moreover, it will also evolve as feedback occurs and the path of development for the transportation system is updated.

Regions would have to assess their own needs, context and setting to determine what would work best.

One might also have a vision of a desired long-range planning structure and develop an evolutionary path or plan to achieve that structure. That vision can help ensure that progress is being made towards a planning structure optimized to meet the challenges of tomorrow.

IV.D CHAPTER REVIEW AND TRANSITION ASSESSMENT

This chapter described the institutional relationships, activities, and functions and how they must change to organizational gap between planning and operations and support the Integrated Framework. The gap exists for a number of reasons including differences in departmental and institutional mission and goals, professional culture and perspective, and institutional structure and rules.

Activities and Functions needed to bridge the gap/hurdle between planning and operations include:

- Redefine institutional/organizational relationships through:
  – Enabling a new authorizing environment
  – Within agency coordination
  – Between agency coordination.
- Expand stakeholder involvement to include planning, operations, and users. It is also important to match them to the services that are/will be provided.
- Determine Public-Private Sector Roles. Who provides ITS can change its characteristics and who uses it. Therefore, need to set policy on respective roles. It is also important to: create positive environment for private sector partnership, develop common understanding of tasks, roles, and expectations, and ensure that both the public and private sectors benefit!

The best way to organize to support ITS and operations within the integrated framework depends upon the local situation and issues. It may change and evolve over time as the situation changes. The options include:

- Do it alone
- MPO Centric
- Sate Centric
- Ad Hoc or new organization

Factors important to the choice include:

- Willingness and ability to lead
- Geographic overlap of agencies, ITS services, and influence areas
- Legacy institutions and relationships
- Transportation and Environmental concerns such air quality non-attainment, and major incidents
- Other agency skills and resources
- Authorizing environment (legal and other issues)

Last, A “Concept of Planning” captures the approach to take and how it should change over time. It defines responsibilities and roles for integrated planning.

Table IV-4 provides some self-assessment questions to help determine what is the best approach for organizing in your area. Mark where you think your area’s relative position is for each question.

Table IV-4 Institutional Relationships, Activities, and Functions Self-Assessment

Question	NO YES
Redefine Institutional /Organizational Relationships	
Do agencies within your area include development/construction, operations, maintenance, and other departmental staff in decisions on service provision, development, or ongoing performance?	NO - - - - - - - - YES
Do agencies with your area have separate budgets for operations, maintenance, preservation, and capital expansion, making it difficult to examine tradeoffs, or develop life cycle approaches? Do other restrictions such as procurement practices or work rules inhibit within agency coordination?	NO - - - - - - - - YES
Have agencies within your area adopted a customer service orientation? Has this new mission been promoted throughout their organizations?	NO - - - - - - - - YES
Is there a current forum for area-wide cooperative decision-making concerning transportation operations and management? Is this carried out through the MPO?	NO - - - - - - - - YES
Do inter-jurisdictional or agency agreements exist for ITS systems, or other system operations? Are they informal "virtual" organizations, or they formal legal entities?	NO - - - - - - - - YES
Has a Concept of Operations been developed as part of a Regional ITS Architecture? Is one now being developed?	NO - - - - - - - - YES
Expand Stakeholder Involvement	
Are transportation operators/providers included in the regional transportation planning process (freeway and traffic operations, transit, public safety and incident management)?	NO - - - - - - - - YES
Are other Stakeholders/Users also part of the process (Motorists, transit riders, commercial shippers, taxi and shuttle operators)?	NO - - - - - - - - YES
Have new forums for operations been created by the MPO or others that provide for the exchange of information between planning and operations?	NO - - - - - - - - YES
Are these stakeholders also participating in the development of a Regional ITS Architecture?	NO - - - - - - - - YES
Is a process in place for continual review and update of stakeholders that need to participate in the decision/planning process?	NO - - - - - - - - YES
Are private sector transportation and ITS providers also participants?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

Table IV-4 Institutional Relationships, Activities, and Functions Self-Assessment Continued

Question	NO YES
Determine Public-Private Sector Roles and Relationships	
Do private-public sector partnerships for ITS or other transportation services currently exist in your area? Do the private sector partners participate in planning and operational decisions?	NO - - - - - - - - YES
Are their procurement or other barriers to developing new extended relationships with private sector partners?	NO - - - - - - - - YES
Have clear principals for private public sector agreements been established regarding responsibilities, liability, ownership of intellectual property, privacy, and/or confidentiality been established?	NO - - - - - - - - YES
Have the ITS and other services that are candidates for private sector provision or partnerships been determined? Are the assumptions on each participant's roles clearly defined? Does each party benefit?	NO - - - - - - - - YES
Factors: Leaders and Champions	
Have leaders and champions for ITS and operations already been established in your area?	NO - - - - - - - - YES
Is this through the MPO, the state, an operating agency, or regional operating organization?	NO - - - - - - - - YES
Do they have the necessary resources and technical skills?	NO - - - - - - - - YES
Is training and outreach to political and other decision makers being carried out to help them understand the benefits of ITS and Operational improvements?	NO - - - - - - - - YES
Factors: Alignment of Systems, Influence Areas, and Jurisdictions	
Do the ITS or other transportation systems or their influence area's in your region cross multiple MPO, state, or other significant jurisdictional boundaries?	NO - - - - - - - - YES
Is there a potential lead organization whose boundaries align with the above? Does it have the legal authority or mandate to provide leadership in ITS and operations?	NO - - - - - - - - YES
Are there ongoing operational partnerships between existing entities that could evolve into new joint leadership for ITS and operations?	NO - - - - - - - - YES
Factors: Historical Relationships	NO - - - - - - - - YES
Is there a history and precedence for cooperation between agencies and organizations in your area?	NO - - - - - - - - YES
Are there historical issues with cooperation due to political differences (suburbs-inner city), or professional perspectives (transit-highway). Have these created barriers to cooperation in the past?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

Table IV-4 Institutional Relationships, Activities, and Functions Self-Assessment Continued

Question	NO YES
Factors: Transportation Environmental and Other Issues	
Is your area primarily part of World I, or World II (see earlier self-assessment)?	NO - - - - - - - - YES
Is part of your area in World I, and part in World II? This may lead to separate programs and agendas for each.	NO - - - - - - - - YES
Is your area a air quality non-attainment area? Are their other environmental issues and concerns that could limit transportation solutions, or introduce new stakeholders?	NO - - - - - - - - YES
Are there special events or activities that may act as a catalyst for ITS and operational considerations (festivals, severe weather)? Do these introduce additional stakeholders?	NO - - - - - - - - YES
Is the transportation system in need of extensive rehabilitation and /or maintenance?	NO - - - - - - - - YES
Factors: Agency Resources/Skills	
Does the MPO have available resources ITS and operations? Do staff understand ITS technologies, system engineering, and architectural development?	NO - - - - - - - - YES
Does the MPO currently operate any ITS or other services (ride-share, traveler information)?	NO - - - - - - - - YES
Is there significant disparity between jurisdictions/agencies in your region with regards to resource levels/budgets, staffing, or staff capabilities?	NO - - - - - - - - YES
Is training on ITS and operational issues ongoing or being considered for both staff within organizations, and public policy decision makers?	NO - - - - - - - - YES
Factors: Authorizing Environment	
Are they multiple operating agencies and political jurisdictions in your area? Does your area cross state boundaries?	NO - - - - - - - - YES
Do states own and operate the freeway and arterial systems in your area? Is this a city, or county function?	NO - - - - - - - - YES
Is the transit agency an independent regional authority? Does it cross jurisdictional boundaries?	NO - - - - - - - - YES
Are there specific legal and legislative barriers that inhibit regional operations and/or coordinated decision-making?	NO - - - - - - - - YES
Are funding sources available and flexible to be used for combined alternatives (ITS, operations, and capital).	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

V TECHNICAL ACTIVITIES AND FUNCTIONS

Key Points of Chapter V

- Cross-cutting issues impact all technical activities and functions:
  - ITS Architectures.
  - Standards.
  - Geographic Scale.
  - Time Scale.
  - Uncertainty.
  - ITS benefits and cost data.
- The Vision, Goals, Objectives, and Measures, must capture emerging issues of reliability, congestion, use of information, safety, security and more (Chapter II).
  - Must be predictable and apply to all alternatives.
  - Reflect all stakeholders.
- Initial Conditions and need/deficiencies analysis must include expanded inventory of ITS and operations components, and use "causal analysis" to identify reason for problem that is sensitive to operations.
- Identifying alternatives balances ITS, operations, and system enhancement based upon the causal analysis.
  - Carried out through short, mid, and long-term to create path of development.
  - Includes new ITS and operational components.
  - Includes public-private roles and technology forecast.
  - May need a feedback loop to earlier time periods.
- Tools are beginning to emerge to help analyze ITS and operations options and their impacts. Analysis and evaluation must include:
  - New performance measures.
  - Recurrent and non-recurrent conditions .
  - Life cycle costs and benefits.
- In the integrated process the importance of programming and its feedback to planning is heightened.
  - New weighting criteria,
  - Bundling of projects,
  - Consider combined ITS and traditional improvements.
- ITS data enables performance feedback and monitoring of how the system varies over time.
  - ITS data is different from traditional data. Need to account for cleaning, management and analysis.

This Chapter describes the technical activities and functions that are associated with the Integrated Framework described in Chapter III. It does not attempt to be a "how to manual" for all of the technical activities associated with planning. Rather, it provides a conceptual overview and resource guide on the technical activities and functions of the Integrated Framework. It focuses on **the changes in technical approach** that may be appropriate for the integration of planning and ITS, system management and operations. Its goal is to provide an understanding of the activities and functions, the options for carrying them out, and where to go to find more detailed technical methods and procedures.

As stressed in Chapter III, planning is best viewed as a decision-making process. In the Integrated Framework, planning is the process through which decisions are made on what transportation investments to make, the priority of those investments, and how to operate the system over time. To help decision-makers understand the choices available to them, planners perform the technical efforts within each decision making cycle (short, mid, long) to identify the transportation and other problems to be solved, and to evaluate alternative ways to address them.

The activities and functions and the sections of this chapter that address them are shown in Figure V-1.

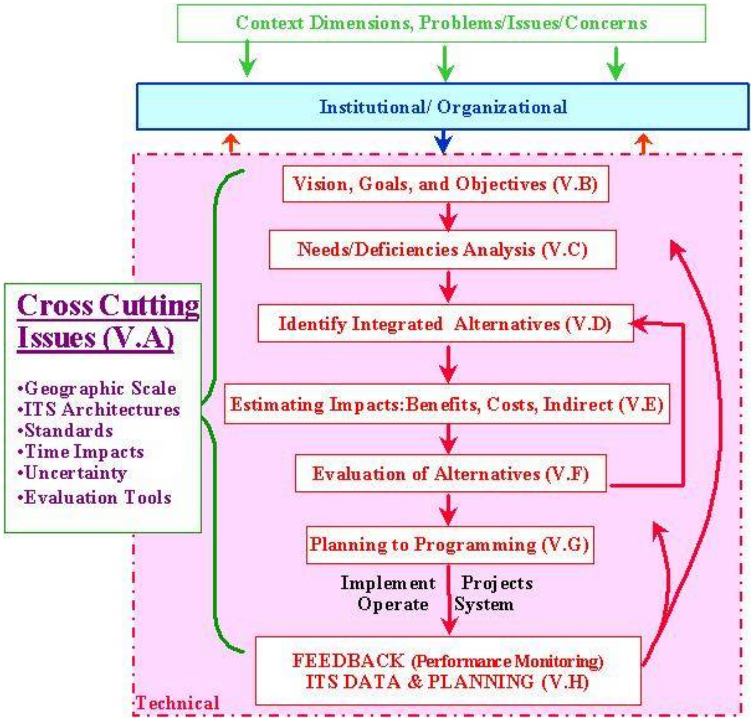
There are a number of crosscutting issues and concerns that impact all of the technical activities and functions as they are carried out. Section V.A examines these first as a base for the sections that follow. These include issues concerning:

- The need and use of ITS architectures
- ITS and other standards
- Geographic scale
- Time scale
- Uncertainty
- ITS benefit and cost data.

Sections on the other activities and functions then follow. These include:

Section IV.B: Identification of Vision, Goals, Objectives, and Measures. During the transition the vision, goals, and objectives of the region should be examined to reflect the operational concerns

Figure V-1 Technical Activities and Functions Within the Integrated Framework



previously not considered within the planning process. These include the emerging issues of congestion, reliability, safety, and security. New measures reflecting these goals and objectives that can be evaluated across ITS and traditional improvements, and are predictable must also be defined.

Section IV.C: Needs/Deficiency Analysis. Inventories of the existing system and conditions must be expanded to include ITS and the other "operational" elements of the transportation system such as the communications system. Ways to conduct a causal analysis on why problems exist and whether they are recurrent/non-recurrent must be developed**.**

Section IV.D: Integrated Alternative Definition. Definition of an alternative must be extended to include the phasing of all changes to the system during its implementation. An "alternative" is now the full path of development, or time stream of actions and activities concerning the transportation system to the horizon year. How the system will operate/perform at each stage in its development and who is responsible for what must also be defined.

Section IV.E. Estimating Impacts (Benefits & Costs). If an integrated process is to be truly implemented then the analysis techniques and methods used must capture the changes that ITS, operational, and system enhancement options alone and in combination cause in the system. Full (life cycle) time streams of the impacts and costs must also be estimated. During the transition these new techniques must be put in place.

Section IV.F: Evaluation of Alternatives. During the transition the evaluation processes must be expanded to account for the new definition of alternatives (path versus horizon year), and tradeoffs in: operational versus system expansion improvements; time stream of benefits; system-wide synergies and the inter-dependence of project elements.

Section IV.G Planning to Programming. Programming and the feedback between the short, mid, and long-term cycles become even more important in the Integrated Framework than they are in traditional planning. For integrated planning one must extend the programming process beyond the TIP/STIP. Changes in operations and services must be included. Ways to balance project versus system impacts and synergies and to look at alternatives that include both ITS and traditional improvements must also be developed. Last, it is critical that the continued operation and maintenance of the systems be incorporated into the funding needs and programming.

Section IV.H: ITS Data and Planning Decision-Making. ITS data provides new opportunities for performance measurement and feedback including the monitoring of both recurrent and non-recurrent conditions. It is important to develop continuous feedback loops to all cycles of the integrated process. Critical to this is implementing continuous data collection processes for the performance based measures previously defined, and planning for data cleaning, management, and maintenance costs.

Every attempt has been made to make each section as independent as possible so the reader may focus on the specific technical areas of concern without having to read every section in detail. Therefore, each of the above sections includes:

- An Introduction and overview that provides a general description of the activity/function and its purpose within the Integrated Framework
- A discussion and comparison of the issues associates with moving from current practice to an integrated approach.
- An explanation of the application of the activity with the Integrated Framework including appropriate examples if they exist.
- An exploration of how the approach may vary in different situations.
- A Section review and transition assessment.

The introduction at the beginning of each section and/or the review and transition assessment at the end can be read first if the reader just wants an overview of the issues contained in the section, or is not sure if it is applicable to their current needs. Note that the review and self-assessment are provided at the end of each section instead of at the end of the overall Chapter to make each section more independent and self-contained.

V.A CROSS-CUTTING TECHNICAL ISSUES

Key Points of Section V.A

- Several issues cut across/impact all of the technical activities and functions of integrated planning.
- ITS architectures provide the "plan" for the ITS components of each alternative and help ensure that they will function when deployed.
  - Regional ITS Architectures are now required.
  - Developed as part of the integrated process, not separately.
- ITS Standards also help ensure that what is deployed in one region will work with neighboring areas, states, corridors.
  - Should be considered as part of architecture development.
  - Not currently required, but provide many benefits.
- ITS Systems planning can occur at many overlapping geographic levels: local, region, state, national.
  - Different decisions are appropriate at each level.
  - It is important to look both within your region and at overlapping larger areas to ensure that what you are proposing is consistent at all levels.
- Similarly the short term decisions must be balanced with the long term decisions through feedback, and consideration of a time stream of costs and benefits.
- Predicting future technology and other changes also lead to uncertainty. This should be addressed through sensitivity and other analyses. Use technology forecasts when they are available.
- Information and tools on the impacts of ITS are now becoming more and more available.

This section examines the crosscutting issues that impact all of the technical activities and functions performed as part of the Integrated Framework. These include:

The Need For ITS Architectures. In the past, as long as the road segments lined up, or the buses ran, the transportation system would function at some level. ITS and communications systems are different from traditional transportation solutions in that different components cannot simply be put together and expected to work. Close coordination over the pieces, how they will communicate with one another, and who will do what as they operate is needed. ITS architectures address this need and provide a "plan" for the ITS components of the system making sure that data exchanges can take place, people know their roles and responsibilities, and in general what needs to occur for ITS to function. There now is also a Federal requirement to develop a regional ITS architecture that references the National ITS Architecture in order to receive Federal Funds In areas where ITS exists or is planned.

ITS and Other Standards. ITS and other standards also play an important role in insuring that there is future inter-operability of each system, and that an area's systems interact in a coordinated way with adjacent states and regions. This is especially important in areas that are outside the control of any particular region and may be being determined at a inter-city corridor or even National level.

Geographic Scale. ITS and other systems may overlap in many ways (see above) each with its own system boundaries and impact/influence area. It is important that an area look for systems and architectures at both larger regions and corridors and smaller sub-areas that overlap with them to make sure that they are planning systems that will work together.

Time Frame. The differing time frames of various ITS and traditional transportation options also must be considered. Each may take a different time to implement and have impacts either occur instantly or take time to develop.

Uncertainty. Uncertainty of technological advances and their penetration into the market place, future social and demographic changes, and future funding for both capital and operations also plays a role at each point in the planning process. Many professionals are hesitant to predict technology beyond 5 to 7 years, yet there are Federal requirements for a 20 year long-range plan and forecast. Ways to address uncertainty include developing alternative futures and carrying out sensitivity, robustness, and risk analysis.

Benefit and Cost Data. There is an overall perception that there is a lack of ITS impact data and analysis tools to assist in the planning process. While these are still developing there is a growing body of both benefit and cost data and tools that can now be used. These include the U.S. DOT ITS benefits and cost data base, and the ITS Deployment Analysis System (IDAS) sketch planning tool.

Each of these is further explored below. This is followed by a section review and transition self-assessment.

V.A.1 THE NEED FOR ARCHITECTURES (THE NATIONAL ITS ARCHITECTURE)

How do we ensure optimal use of existing infrastructure? How do we identify and define the organization and administration required to support the technical solutions we are planning to implement? How do we make sure that what we do today fits with what we want to do tomorrow? The development of a regional architecture is a key element in answering these questions. Creating an architecture is critical to providing a management and operational structure for the development and implementation of ITS. The architecture provides a high level snapshot of what needs to occur in order to achieve interoperability and efficiency in ITS deployment and operations.

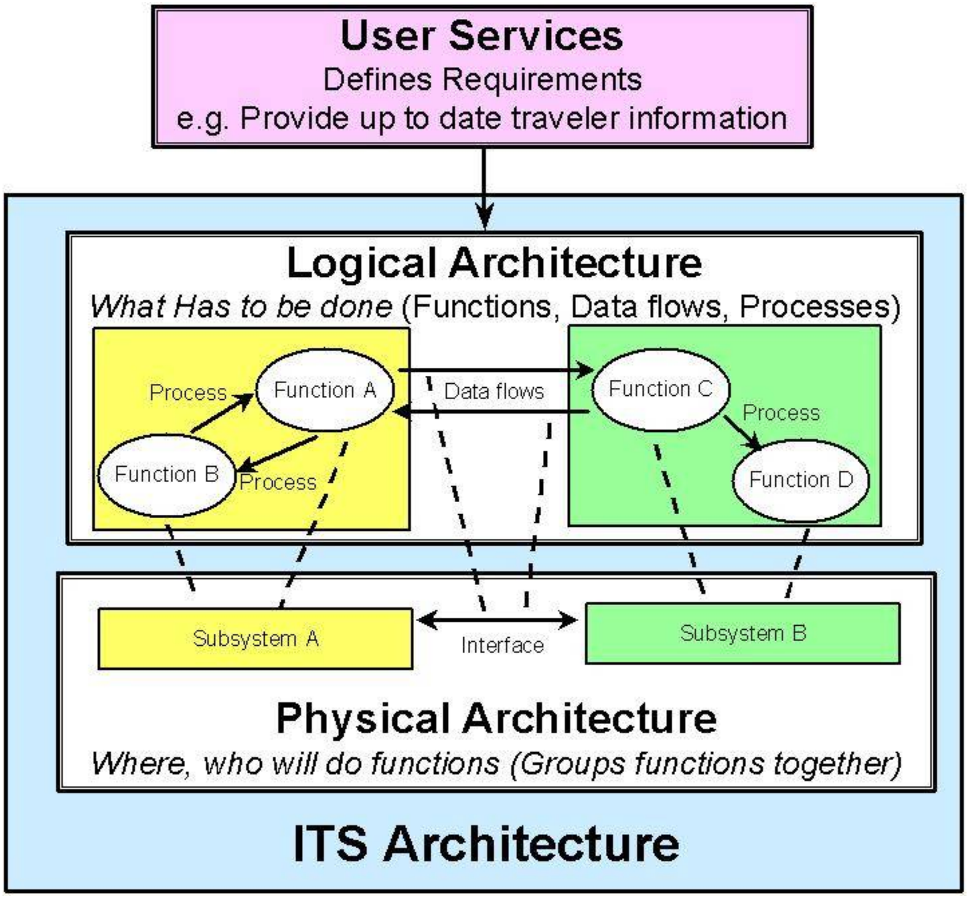
Like the transportation planning network maps and service plans which describe the traditional elements in an alternative, a regional ITS architecture defines ITS functions and services and provides a framework and guide for the implementation of ITS. Since the components of ITS and other services built around electronic communications and intelligent control/feedback of the system must be closely coordinated in order to function and work together, the ITS architecture is vital to ensuring the success of the integrated system. Also, by using architectures to integrate related systems, rather than implementing them stand alone, the total cost of ITS implementation can be reduced. Moreover, by developing integrated systems that share data across system elements, the benefits of ITS can be significantly increased.

> It may be helpful to think of ITS investments as pieces of a three dimensional puzzle. Each piece interlocks with other ITS operations and management strategies, complements existing and future capital investments, and leads to realization of the plan's vision of the future transportation system. The National ITS Architecture provides the framework for such integration.
>
> Sarah J. Siwek, Transportation Planning and ITS: Putting the Pieces Together

An architecture identifies and defines the connections between various, often dissimilar ITS components (Hunt, 2000). Figure V-2 shows that an ITS Architecture is typically composed of "Logical" and "Physical" architectures. Based upon the desired ITS User Services and their requirements the **Logical Architecture** identifies the functions (e.g. gather traffic information or dispatch emergency vehicles) and data flows that must take place. The **Physical Architecture**, in addition to depicting the functions and data flows, also defines the physical entities or subsystems where these functions reside (e.g. along the roadway or in a transit vehicle), and the interfaces (e.g. incident data) between the physical subsystems.

As can be imagined, the creation of an architecture spanning the realm of transportation services is a complex, time consuming, and expensive task. Consequently, the USDOT initiated the creation of the National ITS Architecture to reduce the burden and assist in managing the development and implementation of ITS across the U.S. It provides the logical and physical architectures for the development of the **ITS User Services** which capture from a "users" perspective what we would like the ITS in the United States to do (See the Appendix A Glossary for a complete list, examples include services such as Incident Management, and Public Transportation Management). The National ITS Program Plan first established 29 ITS User Services in 1995. New User Services have been added since then to address changing needs increasing the total to 32 (as of June 2002).

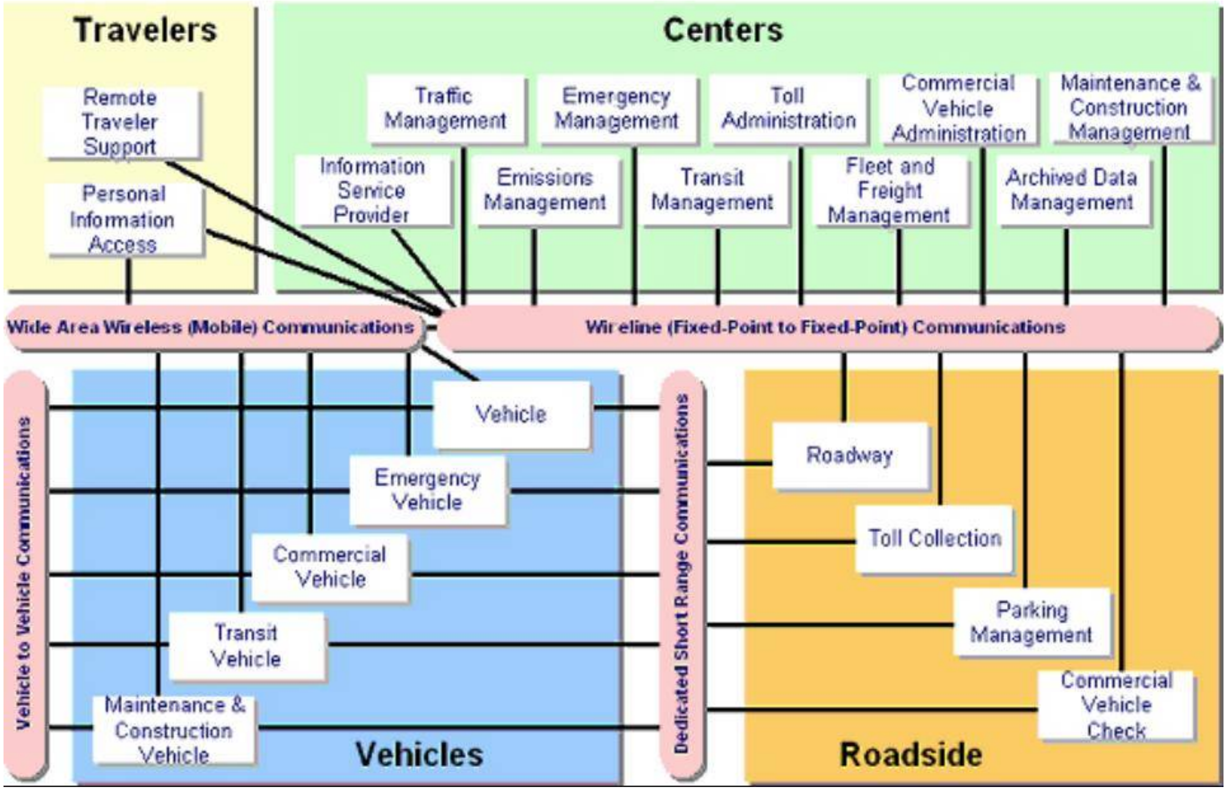
Figure V-2 ITS Architecture Components



The National ITS Architecture provides a general framework for implementing the User Services and integrating ITS strategies within and across agencies, modes, and jurisdictional boundaries. As such, it provides a model for the development of a regional ITS architecture in each metropolitan area, state, or multi-state region. Version 1.0 of the National ITS Architecture was unveiled in 1996. It has been continually updated to incorporate the new User Services as they have been added and to provide additional refinements. Figure V-3 represents the Physical Architecture subsystems, and centers and the communications links between them as described in Version 4.0 of the National ITS Architecture (US DOT, 2002). It shows the *"transportation layer"* (rectangles) composed of subsystems for travelers, vehicles, transportation management centers, and roadside field devices. These are connected by the "*communications layer"* (ovals). Four potential types of communications are shown: wireline, wide area wireless, vehicle-to-vehicle, and dedicated short-range. Note, that the management centers are functional and conceptual. The Architecture does not describe "buildings" or where the functions must reside and how they must communicate. As the locally developed physical architecture is defined, however, it does help determine what functions to carry out and who must communicate with whom. This in turn identifies what agreements must be made to operate the system, what data must be shared, and who must coordinate/cooperate with whom.

The building blocks that the National ITS Architecture uses to provide assistance in implementing the User Services at different levels and configurations are the **National ITS Architecture Market Packages**. Each of the 75 Market Packages describes the subsystems, interfaces and conceptual equipment packages needed

Figure V-3 Physical Architecture (Transportation and Communications Layers)



Source: National ITS Architecture V. 4.0 (US DOT 2002)

to implement a key function used by the User Services. Many market packages are also incremental allowing initial systems to be deployed first and advanced packages to be efficiently implemented based on earlier deployments as needs (and capabilities) grow. The relationship between the User Services and National ITS Market Packages as provided in Version 4.0 of the National ITS Architecture is included as Appendix B of this Guidebook

A full description of the National ITS Architecture and ITS standards development is beyond the scope of this Guidebook. The National ITS Architecture Version 4.0 is provided by the US DOT ITS Joint Program Office on a CD-ROM (US DOT, 2002). It is also accessible via the Internet at http://www.its.dot.gov/arch/arch.htm,

The National ITS Architecture was developed as a base-line tool to assist in the creation of locally tailored regional architectures and the implementation of integrated transportation systems and inter-operability of key ITS services. The regional ITS architecture identifies the various ITS elements that a region chooses to develop and at what level. Much of a regional architecture can easily be derived from the National ITS Architecture, but it is important to note that there are cases where a region may have to derive architecture elements that are unique to their area.

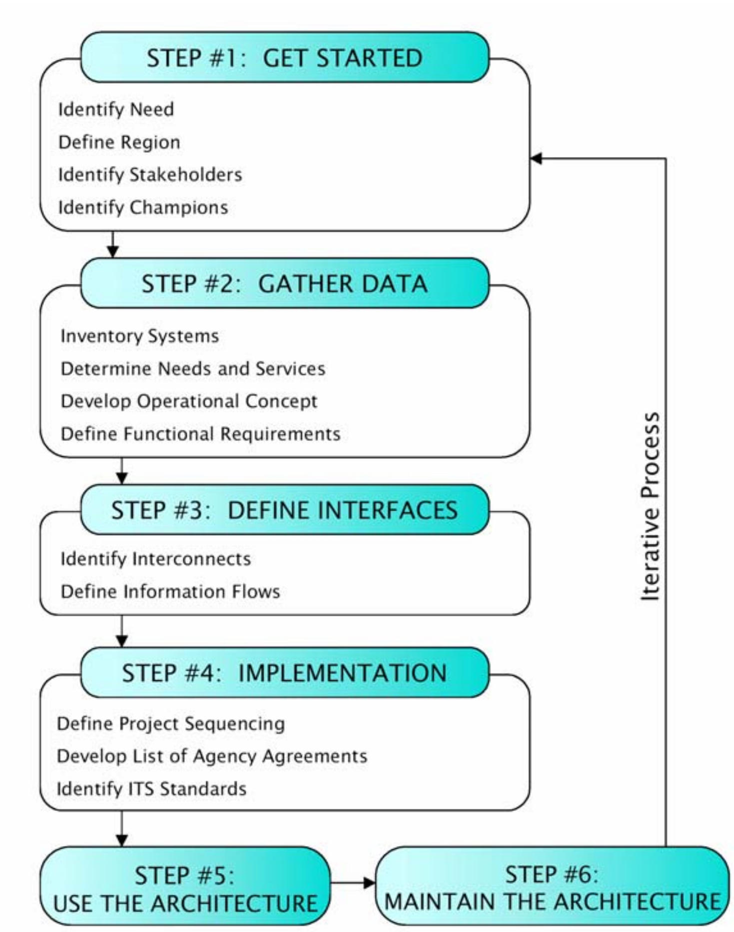
The TEA-21 requirements for the development of a regional ITS architecture and its required components are described in detail in Chapter II. Briefly, a regional ITS architecture must be developed and maintained considering the National ITS Architecture and include at a minimum a:

- Description of the region
- Identification of the participating agencies and stakeholders
- An operational concept that identifies roles and responsibilities of stakeholders
- Any agreements required for operations
- System functional requirements (high level)

- Interface requirements and information exchanges with planned and existing systems and subsystems
- Identification of ITS standards supporting regional and national interoperability
- Sequence of projects required for implementation

To assist areas in meeting the above requirements the US DOT has prepared a Regional ITS Architecture Guidance that lays out a suggested approach for the development of a regional ITS architecture. The recommend multi-step process is shown in Figure V-1. As can be seen the steps are very similar to the technical activities and functions of the Integrated Framework described throughout this chapter. In the Integrated Framework, however, these steps are integrated into and crosscut all of the activities and functions of the overall planning effort and are not carried out as a separate exercise. Stakeholders, are included as part of determining the new institutional and organizational relationships (See Chapter IV). Overall needs are defined as the goals, objectives and performance measures are developed. Desired ITS services are derived from the causal analysis and tradeoffs between other components during the integrated alternative development.

Figure V-4 Regional ITS Architecture Development Process



Source: National ITS Architecture Team, 2001

To aid regional ITS architecture developers carry out the technical analysis and encourage consistency, the USDOT also initiated the creation o the "TURBO" Architecture software tool. It assists in the planning and integration of ITS using the National ITS Architecture. There are two ways for developers to initially enter the information into **Turbo Architecture**: via an interview or directly into tabular forms. The interview guides the user through a series of questions and options that result in the creation of an inventory and a set of services. The user may also go directly to a set of tabular forms to create this initial inventory and set of services. In either case, this information initiates the development of an architecture. Turbo Architecture is now available through McTrans http://www-mctrans.ce.ufl.edu/featured/turbo/. Another resource on the fundamentals of architecture development is the book “Intelligent Transportation Systems Architecture” by Bob and Judy McQueen, Artech House 1999.

V.A.2 THE BENEFITS OF STANDARDS.

An important element of the National ITS Architecture is that it identifies where data exchanges may occur between potential systems. These areas of data exchange or interfaces have precipitated the need for standards. The ITS standards define data communication at system interfaces. The standards may contain technical specifications or other precise criteria to be used consistently as rules, guidelines, definitions or characteristics so as to ensure that materials, products, processes and services are fit for their intended purposes. These standards are being developed in partnership with the USDOT, accredited Standards Development Organizations (SDOs) and other industry experts.

The process by which the standards are being developed is an open process. Open standards are standards that are developed openly by the industry and support interoperability between products, portability between platforms and integration of user interfaces. A big advantage of using interoperable products is the ability to purchase additional components from multiple vendors. The demand for products that are compliant with the open standards brings about consumer choice, creates market competition and leads to lower cost products.

Many legacy (existing) systems were developed using proprietary protocols and data formats. It should be noted that legacy systems or systems currently being developed without consideration of the approved ITS standards may require special planning consideration in the future. These systems often require unique software to be developed in order to translate data into a format that standards compliant systems can use. This could increase development time and project cost.

Having established standards provides a basis for planning and system integration. When developing, costing, and estimating the benefits of ITS, planners will have some assurance of system performance and interoperability.

The FHWA Regional ITS Architecture Guidance document noted earlier also provides a path for identifying ITS standards for a regional ITS architecture. The guidance document reviews the ITS standards process, lists ITS standards resources and tools and provides example standards report outputs.

Table V-1 provides the Standards Applications Areas where Standards are currently being developed.

Table V-1 ITS Standards Now Under Development

National ITS Architecture Interface Class	Standards Application Areas
Center-to-Roadside	Data Collection and Monitoring Dynamic Message Signs Environmental Monitoring Ramp Metering Traffic Signals Vehicle Sensors Video Surveillance
Center-to-Center	Data Archival Incident Management Rail Coordination Traffic Management Transit Management Traveler Management
Center-to-Vehicle/Traveler	Mayday Transit Vehicle Communications Traveler Information
Roadside-to-Vehicle	Toll/Fee Collection Signal Priority
Roadside-to-Roadside	Highway Rail Intersection (HRI)

Additional information regarding ITS standards can be found at http://www.its-standards.net/. A number of training courses from an introduction for policy makers, to advanced courses for system designers are also offered by the US DOT. Their descriptions, as well as on-line versions can be found here: http://pcb.volpe.dot.gov/.

Last, it is important to point out that the final rule for Architecture and Standards (23 CFR Parts 655 and 940) states that "all ITS projects funded with highway trust funds shall use applicable ITS standards and interoperability tests that have been officially adopted through rulemaking by the DOT. As of June 2002, there are approved standards, but there are no "ITS standards" that have been officially adopted through rulemaking by the DOT. Until standards are officially adopted, system developers can decide whether the benefits of using ITS standards are attractive enough to use them voluntarily.

V.A.3 GEOGRAPHIC SCALE

If one is doing planning at one geographic scale, the alternative strategies to consider are limited to those that might be implemented at that scale. For example, planning at the project level would not consider alternatives that entail changes to private vehicles. It would make assumptions about the make-up of the vehicle fleet, and might recognize future uncertainties by testing different scenarios. However, since a local decision at the project level would not significantly affect the types of vehicles produced or customer buying habits, changes in vehicles are not alternatives warranting study at the project level.

Table IV-2 lists the categories of ITS strategies, based on the National ITS Architecture, and the geographical scales at which these strategies are most likely to be considered within planning alternatives. Strategies that are planned at one geographic scale may be implemented incrementally, starting with a smaller geographic area, perhaps on a pilot basis. In such cases it is important that the initial project be compatible with the larger system that is envisioned for the longer term.

Table V-2 ITS Strategies And Geographical Scale Of Planning

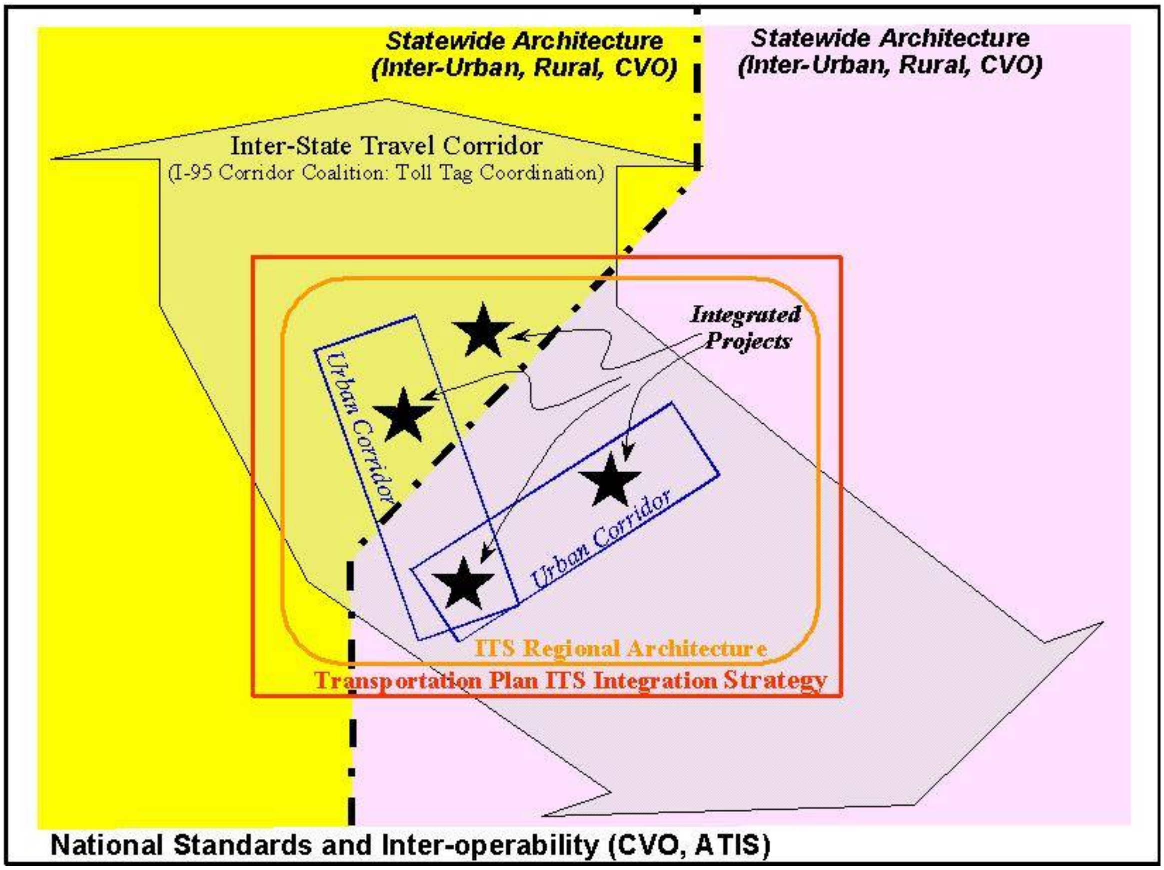
	Public/Private	National	Statewide	Metropolitan/ Regional	Corridor/ Subarea	Municipality/ Local Gov.	Project
Remote Access							
Remote Traveler Support	Public/Private	X	X	X			
Personal Information Access	Private						
Centers							
Information Service Provider	Public/Private		X	X			
Traffic Management	Public		X	X	X	X	X
Emissions Management	Public		X	X			
Emergency Management	Public			X	X	X	
Transit Management	Public/Private			X		X	
Toll Administration	Public/Private		X	X	X		X
Fleet and Freight Mgmt.	Public/Private		X	X		X	
Commercial Vehicle Admin.	Private	X	X				
Vehicles							
Vehicle	Private	X	X				
Transit	Public/Private			X		X	
Commercial	Private	X	X				
Emergency	Private			X		X	
Roadside							
Roadway	Public		X	X	X	X	X
Toll Collection	Public/Private		X	X	X	X	X
Parking Management	Public/Private			X		X	
Commercial Vehicle Check	Public	X	X				

Systems and architectures planned at one geographic scale need to fit with systems planned at another scale. Corridor planning, for example, together, should recognize and be consistent with the regional context. Project planners should look for opportunities to implement systems planned at a larger scale. Planners at all levels ought to be aware of and factor into their studies the changes that are occurring at both broader and narrower scales and look for integration opportunities.

> When creating any ITS plan, developers are encouraged to "think regionally and act locally." "Regionally can mean area wide, statewide, multi-state areas or even, and most importantly, nationwide. Local areas will know best what types of strategies will be successful, both in terms of solving the problem and of being accepted by the public, but it should be kept in mind that every individual project and activity needs to be compatible with a larger "system" if the goals of ITS are to be achieved.
>
> Virginia's Intelligent Transportation System (ITS) Interim Tactical Plan (August 1996)

Error! Not a valid bookmark self-reference. provides an illustration of how higher level requirements from National, Inter-State, or Statewide ITS Architectures may influence the development of regional plans (or Vice-Versa) in order to insure inter-operability, and/or exchange of information. Consequently, as architectures and systems are developed external standards, systems, and protocols should be explored and assessed. As appropriate, they should then be incorporated into the local plans and system development. One important part of the ITS architecture development at all levels of detail is to examine how geographically separate projects and corridors may need to be coordinated for sharing of information and/or ITS services. If the ITS projects in

Figure V-5 Inter-coordination of Architectures



the figure were traffic signal systems for example, then if their coordination was not considered during implementation it is likely that they would not be able to communicate, or coordinate within the urban corridors, or the region.

Local projects must be consistent with the regional architecture, which in turn nests within statewide, or multi-state systems.

A Statewide ITS Plan can provide an additional means for achieving system integration. There is an implied hierarchy as National architecture dovetails with state plans and regional architecture covering different geographic scales.

Just as it is important to integrate ITS strategies and solutions within a metropolitan area and within a state, it is often desirable to integrate the strategies across state lines. Traveler information systems, for example, can alert drivers to conditions in an adjacent state. Transit agencies in adjacent states may share the same automated fare collection systems to make transfers easier for riders.

The Washington, DC metropolitan area spans three states – Maryland, Virginia and the District of Columbia. There, the Metropolitan Washington Council of Governments established an ITS Task Force under the MPO to coordinate the activities of the highway, transit, and other agencies and the private sector involved in transportation technology at the Federal, state and local levels. The Task Force had three goals:

- To identify regional transportation improvements and other opportunities that can be reasonably and appropriately addressed by ITS technologies
- To identify mechanisms for interjurisdictional cooperation to ensure ITS program development and projects are compatible and coordinated
- To identify methods for area decision makers and political leaders to endorse ITS on a regional basis

A regional ITS architecture, statewide ITS plan, or inter-urban coalition all help to set the basis for future planning at the various geographic scales of planning. They may suggest alternatives that should be considered in more detailed planning, identify important linkages between systems, and may provide a basis for estimating costs and benefits.

Virginia DOT's statewide ITS plan provides a long list of ITS improvements that are anticipated to be in place by the year 2015. In the I-64 corridor Major Investment Study, these strategies were included in the No Build alternative. Other ITS strategies that might benefit the I-64 corridor, but which were not part of the statewide plan, were incorporated into the Transportation System Management alternative and the more capital intensive alternatives for the corridor.

V.A.4 TIME FRAME

Transportation planning has traditionally addressed relatively long-term needs – looking at problems and solutions 20 years or more in the future. Operations planning, including ITS, focuses on today's problems and thus has a very short time frame. With rapid advances in technology, long-range planning for ITS can be speculative at best.

The integrated framework sees planning as a continuous stream of problems, solutions and activities, both short-term and long-term. For simplicity's sake our model of the integrated process suggests at least 3 planning horizons – and short-range, mid-range, long-range. The intent is that these not be seen as three separate activities, but rather a continuous stream of activities.

The planning horizon affects the definition of the problem that forms the basis for planning and decision-making. In the integrated process, planners should investigate how today's transportation problems can be expected to change over time, given anticipated changes in population and employment, travel behavior, and technology. As technology advances, for example, the capacity of a highway lane may increase, and new information systems may lead to cause people to change the routes they travel, or the time of day they travel. Problem statements that assume today's technology and today's behavior may miss changes that are possible over time. Traditionally, planners have extrapolated today's behavior and technology into the long-term future, assuming no significant change, but this simplifying assumption causes them to overlook significant changes that occur over time and to miss opportunities.

The time frame also affects the transportation solutions that are available for consideration. Major capital investments take many years to plan, design, and construct, so a long planning horizon is appropriate. The shorter time frame embraced by the integrated framework opens the mind to a host of low capital and operational opportunities that long-range planning studies may overlook. While low cost and operational improvements may not be the solution in the long-term, they may offer more immediate benefits. Ideally, the planning process will lead to decisions on a time stream of staged improvements that correspond to changes in travel and technology over time.

In an integrated planning process, the different time frames fit together and support each other. Strategies selected for the short-term should not only address short-term problems, but also should be consistent with long-range vision – a step in the right direction.

V.A.5 DEALING WITH UNCERTAINTY.

Decision-makers are interested in seeing quantified information on costs and benefits. Yet uncertainty is inherent in any forecast, and the uncertainty becomes greater as the planning horizon is extended. This is particularly true when rapidly changing technology is involved.

Planners are advised to acknowledge the uncertainty in their forecasts and to deal with it through appropriate techniques. Approaches for dealing with uncertainty include:

- Planning for the long-term is often performed in less detail that planning for the short-term, and focuses on the significant differences among the alternatives.
- Estimates of costs and benefits may be provided as a range of values.
- Use sensitivity analysis to test a variety of "what if?" scenarios and develop "robust" solutions that make sense with a range of "alternative futures"
- Use available long-range forecasts of technology and ITS market penetration levels developed by ITS and other experts..

V.A.6 AVAILABILITY OF DATA ON ITS COSTS AND IMPACTS

State and local planners who are considering ITS strategies often complain about a lack of information on "real world" ITS deployments. They believe that they lack sufficient information on what ITS strategies cost to build and to operate, and on how customers would respond to ITS deployments. This perception is largely inaccurate, however. Considerable data does exist and is readily accessible. One only needs to know where to look.

Subsequent sections of this Chapter not only discuss the technical methods that are suitable for analyzing ITS as a part of an integrated planning process, they also point to sources of data that can be used in the analysis.

V.A.7 SECTION REVIEW AND TRANSITION ASSESSMENT

This section described the crosscutting issues and concerns that impact all of the technical activities and functions carried out as part of integrated planning. The crosscutting issues and the reasons that they impact all activities and functions are:

- Development of regional ITS architectures is now required for Federal funding of transportation projects within an area with ITS components. Development is integrated into each activity and function of the overall process, and is not conducted separately. This allows tradeoffs between ITS and other options to be included.

- Similarly ITS standards, help in the development of a region's integrated alternatives. They help ensure that an area's ITS systems will be compatible with others outside of their control.
- There are many overlapping geographic levels that ITS systems are developed for, and that may impact the decisions made in a particular area. Therefore, the planning process should look both within and without its area for stakeholders and ITS or operating decisions that it should coordinate with.
- Differences in the time scale of decisions and their uncertainty must also be accounted for. Short-range and long-range decisions must be balanced against one another. Uncertainty in the future of technology and other aspects should be examined using sensitivity analysis and alternative futures.
- Last, there is a perception that more information on ITS impacts is needed. This is being countered by a growing database and emerging tools for prediction.

Table V-3 provides some questions that might provide some insight into where your region stands concerning these cross cutting issues. . Mark where you think your area's relative position is for each question.

Table V-3 Cross-Cutting Technical Issues Self-Assessment

Question	**NO YES**
Are there neighboring regions, states, or inter-city corridors with ITS systems that overlap your area? Are they developing ITS plans and architectures that you need to coordinate with?	NO - - - - - - - - YES
Has the region for an ITS architecture been defined? Does it encompass all current and planned ITS systems and their impact areas?	NO - - - - - - - - YES
Is the use of ITS Standards being explored ?	NO - - - - - - - - YES
Has a technology forecast been carried out or considered? Does it include uncertainty/sensitivity analyses on key assumptions ?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

V.B VISION, GOALS AND OBJECTIVES AND THEIR MEASURES

Key Points of Section V.B

- A vision provides a view into the desired future state that an area would like to achieve.
- Goals describe, in a general way, the desired end state or outcome necessary to achieve the vision. They are value statements.
- An Objective captures a particular dimension of a goal and is designed to help measure progress towards the goal's attainment.
- A measure of effectiveness (MOE) is a specific measure that can be used to quantify, or describe, the attainment of a specific objective.
- These need to be expanded to address the emerging issues of Chapter II, and capture non-capacity, performance and operations viewpoints. Focus on the Customer's Perspective!
- They should also be applicable, calculable, and predictable for ITS and traditional solutions alone or in combination.
- Measures should capture variation in system conditions, the value of information, and overall performance throughout the day.
- To address your local situation make sure to reflect the perspectives of all stakeholders in the development of the above.

The outset of any planning process begins by articulating what the desired end state should be. One method to capture this is the creation of a **vision** supported by **goals** and **objectives** and their **measures**. This step is the foundation for integrating ITS with the traditional planning process.

Just as there is a wide variation in approaches to long-range planning, there is a wide variation in the interpretation of what vision, goals and objectives are. Some terms found in the review of transportation and ITS plans include "strategic outcome areas", "policies", and "recommendations." For the purpose of this report, the terms are defined below:

Vision: A vision, as the name implies, provides a view into the desired future that the region, or individual agency, would like to achieve. Visions are typically developed as an initial step of the planning process. Sometimes, the creation of the vision is iterative and follows the planning process, with the vision revealing itself as various aspects of the plan emerge. Either approach is acceptable. It is important that the vision aligns with the mission – the business – of the agencies that contribute to realizing it. In other words, the vision should focus on the aspects of the future that the agency or agencies have direct influence over.

An example of a vision or portion of a vision could be "The transportation system provides efficient and safe connections between people and destinations. The flow of goods is balanced with movement of people. Access to public transit is available to all urban area citizens within ¼ mile of their home or office. "

WILMAPCO, the MPO in Dover, Delaware has developed a vision that includes the following statement: "The transportation system is made more efficient through the use of advanced technology." This statement is mirrored in DelDOT's 2020 Plan strategies, one of which is to "Take advantage of New Technologies".

Goal: Goals describe, in a general way, the desired end state or outcome necessary to achieve the vision. They are often in the form of a value statement reflecting the agency's mission. Because of their generality, they typically have many dimensions and cannot be directly measured, or quantified.

Examples of goals include:

"Improve the safety of the arterial network."
"Increase public sense of security as they use the transportation system."
"Reduce delay to travelers during peak periods."

Goals can be realized by applying a variety of different strategies. For example, reducing peak period delays can be accomplished by moving people from their cars into transit, promoting flex-time and telecommuting, by constructing new facilities, by improving signal timing, by instituting freeway ramp metering, and by instituting incident management programs.

Objective: An objective is a specific statement derived from a goal. An objective captures a particular dimension of a goal and is designed to help measure progress towards the goal's attainment. Objectives can be measurable and/or qualitative. Several objectives can also be used to capture a specific goal.

Measure of Effectiveness: A measure of effectiveness (MOE) is a specific measure that can be used to quantify, or describe, the attainment of a specific objective. There may be many choices for measures that can be used to reflect any specific objective.

V.B.1 CURRENT PRACTICE VERSUS AN INTEGRATED APPROACH

Most agencies establish separate vision, goals and objectives for ITS and traditional long-range transportation planning. The Integrated Framework suggests they be merged, which requires a incorporation of all temporal perspectives, as well as broadening the viewpoint to include capital and operations measures.

V.B.1.1 Integration Issues/barriers overview

The following issues/barriers exist:

- **Understanding of the capabilities of ITS:** An educational phase should be included in the development of vision, goals and objectives to ensure that the parties involved in their development understand the complete range of ITS capabilities, and how they connect to an expanded vision, and to new goals and objectives to meet that vision.
- **Including new parties in the planning stages:** ITS introduces new agency connections beyond those traditionally involved in the delivery of transportation such as departments of transportation and transit providers. These new connections include both public and private sector partners.

  In particular, ITS enables stronger connections across multiple modes through the sharing of information. For example deploying multi-modal automated traveler information may provide door-to-door itinerary planning. This service is typically supportive of most agencies missions, at least on a regional or statewide level. On the passenger side, new players include air transportation, private transportation service providers such as taxis, shuttles or tour providers, and maritime transportation such as ferries. Similarly, freight transportation planning could extend beyond the traditional role of regulation and monitoring to include the enabling of intermodal connections to rail, maritime, air and intermodal yards., again bringing new partners to the table.

  Advanced transportation management systems also serve as tools to improve incident response and management. In fact, incident management programs using ITS return one of the highest cost/benefit ratios of all ITS (estimated from 3:1 to 5:1). New partners include emergency responders, towing companies, police, fire, and local trauma centers.

  Other traveler information aspects of ITS open doors to partnering with the public and private sectors. Departments of tourism and/or economic development are key to developing connections to attractions and other business.
- **Expansion to include user perspectives of service and system performance:** Although provision of capacity will continue to be a focus of transportation planning, integrating ITS requires that it not be the sole focus of the plan. ITS shifts the planner's viewpoint from the infrastructure to the user of the infrastructure. Adopting a user or customer based approach to creating the vision, goals and objectives is critical to developing integrated plans.
- **Incorporation of all time horizons:** There are two aspects to the temporal dimension of an integrated planning framework. First, is a shift from planning simply from the very long-term (20 year) horizon. ITS deploys technologies that are changing and can be implemented in much

shorter time frames that traditional major capital improvements. Short, mid and long-term horizons should be established when creating integrated visions. Or, the vision should be time neutral.

Goals and objectives are inherently shorter term for ITS projects than for major capital investments because they are operational and highly responsive in nature. Therefore, the goals and objectives that relate to operational measures should likely not extend to the 20-year horizon.

The second shift is away from a single time period viewpoint, which is usually the peak period, to one that embraces all times of day. Although many capital projects are designed for and accrue the majority of benefits during peak periods, ITS may accrue significant benefits during off-peak periods.

V.B.2 APPLICATION WITHIN THE INTEGRATED FRAMEWORK

Given the issues outlined above, the following provides suggestions for developing an integrated vision and goals and objectives.

V.B.2.1 Developing an integrated vision.

The development of an integrated vision requires that the broader array of stakeholders that ITS connects with transportation planning be brought together with traditional planning stakeholders. The types of stakeholders are described in Chapter IV.

Additional input can be gathered from the users of the ITS systems – both the operators and those affected by operations including travelers, truckers, and other customers. In Kern County California, the San Diego region, San Francisco and throughout Arizona, public input was directly solicited through phone interviews and focus groups. The chief aim of the outreach was to identify needs that could be addressed by ITS. Those needs were prioritized and mapped to ITS applications.

Development of the vision is thus, primarily a bottom-up process with input coming from the end-users. Some top-down influence is required, in that the agency leadership must support the process and potential outcomes.

An effective method of creating a vision is to construct narratives describing a day in the life of various key users of the transportation system. Following a transit user, a commuter, an emergency responder or an advanced transportation system operator through their daily transportation activities can breath life into a visioning process, and make it accessible to a variety of stakeholders including the general public and decision makers. In addition, following a set activities that can occur at times throughout a day will accomplish the integration need of moving the planning focus beyond the peak period.

The vision must also apply to nearer term time horizons. at least one nearer-term time horizon. How will ITS influence operations before the 20 year horizon, and the proposed long-term capital improvements are in place? Making sure that the vision applies to different time horizons, helps in the integration of ITS and infrastructure planning, as it allows an evaluation of the hoped-for outcomes during the life-cycle of most ITS. It additionally allows focus to be placed on shorter term, less capital intensive measures that ITS can enable. Many of these types of measures can help ameliorate conditions in the interim period between planning and construction of a major infrastructure facility. Thus, the nearer term aspects of the vision will translate to nearer term goals and objectives that ITS, in addition to traditional transportation infrastructure and congestion management approaches , can achieve.

In San Francisco at the Metropolitan Transportation Commission (MTC), and at the Washington State DOT, integrated planning approaches were developed in response to intense budget reduction pressure. Each of these agencies has determined that they must get the most out of their existing systems, since funding to expand it is so very scarce. Thus, the primary focus of the agency's transportation missions is on system management and preservation with the aim of providing the most service to the system users.

The MTC plan states: "Underpinning this Regional Transportation Plan is the belief that the myriad of components of the transportation network constitute a single system to be managed and operated as a cohesive unit. " A separate funding element entitled "transportation system operations/management" is included in the plan, which funds various management and operations programs including ITS.

V.B.2.2 Expanding goals and objectives to include operational considerations

Because goals and objectives are so directly linked, in that particular objectives are designed to meet specific goals, the following discussion links them as well. The gaps that exist between planning and operations often result in a lack of understanding of the goals and objectives that may apply to an ITS program, and the need to shift from a focus on the infrastructure at a single time point to a focus on the user at multiple time points. With an integrated vision in hand that bridges those gaps, the development of integrated goals and objectives is facilitated.

At the Ohio-Kentucky-Indiana (Cincinnati, OH) and the Hampton Roads Planning District Commission in Virginia, these MPO's specifically noted ITS in their regional vision, and created goals related to specific types of ITS deployments that will achieve the vision.

Another key gap is a lack of knowledge of the possible set of goals and objectives that ITS enables. The following provides a framework for development of integrated goals and objectives (grouped by category). An excellent resource is the NCHRP publication Performance-Based Planning Manual.

Goal: Reduce negative air quality impacts of transportation

- Reduce emissions

Goal: Increase mobility (with the definition of mobility locally created)

- Expand capacity
- Smooth of traffic flow
- Predictable travel times
- Reduce peak hour spread
- Improve transit schedule reliability
- Increase transit flexibility (paratransit)

Goal: Improve accessibility to transportation modes (accessibility as locally defined)

- Increase mode choice options
- Increase departure choice options

Goal: Increase system safety

- Improve security
- Improve accident survivability
- Removal/mitigation of hazards
- Crash reduction

Goal: Improve efficiency and customer satisfaction

- Improve customer service/interaction with agencies
- Satisfaction with system and services
- Satisfaction that agency is trying to meet needs
- Increase the value for dollar spent

In Chicago, the Congestion Management System CMS, which is used as a tool in developing approaches to meet long-range visions , includes ITS approaches within the CMS goals. Strategies include traffic signal system timing and coordination improvements, incident management strategies, ramp metering, route diversion all supported by closed circuit TV and traffic detection.

When establishing objectives, it is also important to choose ones where progress can be established. In other words, they should have an element of measurability. Objectives can be developed for which accomplishment is the measure, such as those that suggest the implementation of a program or project, or those that suggest the adoption of a policy.

Care should be exercised in selecting objectives that require extensive resources to measure, since marshalling those resources may prove difficult. However, most ITS systems can gather data that aids in assessing meeting of objectives. If quantitative objectives are used, and the data can be gathered, the objectives should be measured fairly often, perhaps biannually. Adjustments to programs can then be made if needed.

V.B.2.3 Developing an Integrated Set of Performance Measures.

Performance measures are used to measure how the system performs with respect to the adopted goals and objectives, both for ongoing management and operations of the system and the evaluation of future options. They should (Cambridge Systematics, 1999):

- Be measurable
- Be forecastable
- Be multi-modal
- Clear to decision makers
- Comparable across time
- Geographically appropriate
- Measure multiple goals
- Reflect attributes that are controllable
- Relevant
- Provide ability to diagnose problems

If the planning process is to provide for the balanced consideration of ITS and management and operations options the performance measures chosen must: 1) Address the emerging issues and concerns that ITS and management operations options are focused on solving; and 2) Be sensitive to the changes in system characteristics that these new strategies create.

As stated, ITS and system management focus on responding to non-recurrent and unusual conditions, gaps in information, and management of the transportation “system” as a whole. Measures must therefore be included to capture variation in system conditions, the value of information, and overall system performance throughout the day. Examples of measures that are sensitive to system operations and the impacts of ITS include (Siwek, 1998, Mitretek, 1999):

- Total recurrent delay
- Total non-recurrent delay
- Schedule delay (time you must leave early to ensure that you will arrive on time)
- Percent of Peak travel in delay
- Coefficient of deviation of travel time
- % of trips that are significantly delayed (Delay greater than X (20) minutes)
- Deferred trips
- Vehicle stops/starts
- Total accidents, fatalities
- Number of person trips that make error in route/mode choice due to lack of information
- Travel time/Best information travel time

- Complaint/information calls to traveler information sites.

It is equally important that both the traditional and new performance measures chosen and their method of calculation are sensitive to the changes that ITS and system management introduce into the system. For example, improving air quality by reducing emissions may be a regional objective measured by tons of pollutants produced by vehicle travel. Coordinated signal systems can have a significant impact on air quality by reducing the number of stops and high acceleration/deceleration occurrences in the system. If ITS strategies are to be credited for these improvements then the methods for forecasting emissions used must also incorporate this change in vehicle operating mode. Measures in general need to evolve from those based on average conditions to those that reflect variability and sum the change from hour-to-hour and day-to-day found as the system operates.

Mitretek in their Seattle Case Study developed an example of incorporating new measures for analyzing integrated strategies for Incorporating ITS into Corridor Planning. They concluded:

During the study we discovered that additional measures of effectiveness were needed to properly represent the impact of ITS. A key phase in any MIS is the development of the measures that are used to evaluate the alternatives under study and that reflect the issues/concerns of those in the community making the decision. Typically, measures of transportation service, costs, mobility and system performance, financial burden, and environmental/community impacts are considered. These measures, however, are usually only calculated based upon the average weekday or expected conditions. Variation in conditions (e.g. travel demand, weather, accidents) and the transportation system's response to them is not part of the analysis and consequently does not enter into the decision process. However, incorporating variation in conditions is key to showing the benefits of ITS and other strategies focused on improving the operation of the system. Accordingly, in the study, several new measures were developed that are more representative of the impacts of ITS. ***Delay reduction*** is calculated as the difference between the travel time in each scenario and free-flow (30% of average demand, no accidents in the system, good weather) travel times. ***Throughput*** measures the number trips starting in the time frame that can finish before the end of the peak period at 9:30 AM. Delay reduction and throughput measures are calculated for each representative day scenario. An annualized figure is then calculated by computing a weighted average of across all scenarios. ***System coefficient of trip time variation*** is calculated by examining the variability of travel for similar trips in the system taken across all scenarios. This statistic is an indicator of the reliability of travel in the corridor. Speed and stops across the network are archived from each run from the whole AM peak period. Speed profiles are then normalized by total vehicle-kilometers of travel in the system to create the statistic ***percentage of vehicle-kilometers of travel by speed range***. A similar technique is applied to stops estimated by the simulation at a link level every 15 minutes producing an expected ***number of stops per vehicle-kilometer of travel***. ***Risk of significant delay*** is also calculated which is the percent of trips with travel times greater than 125% of normal conditions.

(Mitretek, 1999)

V.B.3 VARIATIONS BY SCALE, SETTING AND INSTITUTION

V.B.3.1 Regional Context and Transportation Issues

The key contextual difference that should be considered in developing integrated visions, goals and objectives relates principally to transportation needs. Typically, more urbanized areas have a stronger focus on system capacity and efficiency than less developed, non-urbanized areas. Both types of regions will include a strong emphasis on safety and accessibility. Each of these topics requires slightly different stakeholders be brought together.

V.B.3.2 Institutional Setting and Resource Availability

Generally, the development of visions, goals and objectives differs little among various institutional settings. The main difference is that found between single agency plans and regional or other multi-agency plans. Multi-agency plans require a merger of the multiple agency missions at the MPO or other multi-agency level. However, in any institutional context, new players should be added to the process– private sector, tourism, police, fire, and other emergency responders – and the missions of these agencies needs to be brought into the transportation vision.

V.B.3.3 Planning Cycle

The planning cycle suggests that the vision, goals, and objectives should be developed at the beginning of the process, likely as part of the long-range plan update. However, you need not let this stop you from creating integrated visions, goals and objectives at any time in the planning cycle that would later be folded into the long-range plan. In the interim, policy papers and other vehicles documenting the process and outcomes can be used to establish commitment to integrating ITS in the planning process.

V.B.4 SECTION REVIEW AND TRANSITION ASSESSMENT

This section provided an explanation of the development of an area's vision and the goals, objectives, and measures that support it within an integrated planning process that includes ITS and operations. Key concepts were defined as:

- A **vision** provides a view into the desired future state that an area would like to achieve.
- **Goals** describe, in a general way, the desired end state or outcome necessary to achieve the vision. They are value statements.
- An **Objective** captures a particular dimension of a goal and is designed to help measure progress towards the goal's attainment.
- A **measure of effectiveness (MOE)** is a specific measure that can be used to quantify, or describe, the attainment of a specific objective.

They provide the foundations for moving to a new performance and customer-oriented perspective with the Integrated Framework. It is important to note that they should be developed to address the emerging issues of Chapter II (congestion, impacts of disruptions, reliability, safety, and security), and not to justify ITS or operations in and of themselves. They should incorporate the perspectives of all stakeholders.

Measures should be measurable, predictable, and calculable for ITS and traditional solutions both alone and in combination. They also need to capture variations in system conditions, the value of information, and overall system performance throughout the day. A number of examples were given in Section V.B.2.3.

Table V-4 provides some questions that might provide some insight into where your region stands in the development of an integrated vision and the goals, objectives and measures that support it. . . Mark where you think your area's relative position is for each question.

Table V-4 Vision, Goals, Objectives and Measures Self-Assessment

Question	NO YES
Is there a “Vision” of the region/area's future that includes an integrated perspective of system development, operations, and asset management, in a sustainable way?	NO - - - - - - - - YES
Do the area's goals and objectives include emerging issues of reliability, system preservation, sustainability, and efficient system management?	NO - - - - - - - - YES
Have new customer oriented performance measures been defined? Do they include measures of reliability and variation throughout the day, month, year? Do they apply to all alternatives? Do they include operational issues such as incident response, or accident frequency/location?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

V.C INITIAL CONDITIONS AND NEEDS/DEFICIENCIES ANALYSIS

Key Points of Section V.C

- Needs/Deficiencies built upon the integrated goals, objectives, and measures defined previously.
- Requirements:
  - Expanded inventory to ITS, communication, and operations.
  - Monitoring of system performance based upon a customer perspective and using ITS data.
  - Including both recurrent and non-recurrent conditions and performance throughout the day/year.
  - Sharing of performance data to develop an overall system view.
  - Carrying out a causal analysis to determine why needs occur.
  - Establishing an understanding of how conditions and needs change over time.
- Provides the critical inputs for developing integrated alternatives that include ITS, operations, and traditional solutions and their tradeoffs.

A “need” or “deficiency” can be viewed as the difference between the current or projected performance and the desired level of performance. The desired condition is derived from policies, goals and objectives, plus the input of stakeholders participating in the process. Current and projected performance is compared with the desired level of performance, and gaps are identified. A causal analysis to understand why each need/deficiency occurs is then performed. This provides the critical information for making tradeoffs and defining the appropriate roles for ITS and other solutions in the next step of identifying alternatives.

V.C.1 CURRENT PRACTICE VERSUS AN INTEGRATED APPROACH

Traditionally, transportation “needs” are identified within a rather narrow framework of policy goals and objectives. These tend to include traditional system performance measures such as average peak hour congestion and transit ridership. Needs may reflect other goals as well, such as improved air quality and support for economic development. The Federal aid program’s emphasis on major capacity improvement has led to long-range (20+ year) forecasts of future needs, consistent with the long implementation period periods and life spans of capital intensive improvements.

Conventional methods for predicting long-term needs include:

- System owners maintain an inventory of their existing facilities and services, including data on capacity and usage trends
- Travel demand forecasting models are used to predict long-term demand. The projected demand is then compared with capacity to identify future congestion. These same tools are used to project transit demand and identify potential transit markets
- Air pollutant emissions and dispersion models are applied to outputs of travel demand models
- A qualitative process, supported by models, is used to assess system connectivity

Additional tools that are frequently used to identify short-term needs include:

- Congestion and other management systems, traffic engineering analyses, and transit operations analyses
- Analysis of accident records and highway safety systems
- Customer satisfaction surveys

Extending the traditional approaches to the Integrated Framework suggests the need for several enhancements:

- Developing an extended inventory of facilities and services
- Expanding the monitoring of system performance
- Use of real time monitoring data for planning

- Evaluating performance in broader stakeholder terms
- Establishing an understanding of how needs change over time
- Gathering performance data for both recurrent and non-recurrent conditions as part of the assessment
- Sharing of performance data among transportation agencies and other stakeholders
- Enhancing transportation agency understanding of the underlying causes of system performance deficiencies

V.C.2 APPLICATION WITHIN THE INTEGRATED FRAMEWORK

V.C.2.1 Technical

This section further explains the enhancements noted above and offers possible techniques for achieving them.

Extended Inventory of Facilities and Services

Transportation agencies maintain inventories of the facilities and services for which they are responsible – the roads, traffic management centers, transit services and vehicles, etc. As we move to managing and operating the system and the use of ITS much more needs to be known than is found in the traditional infrastructure inventories used for past planning activities. This base inventory data needs to be assembled to develop the initial conditions analysis and not limit the description of deficiencies and solutions. The Integrated Framework suggests that the traditional inventories be extended to include such items as:

- ITS and operations equipment such as traffic signals, detectors and surveillance equipment, VMS signs and HAR, etc.
- ITS services and their coverage areas
- Incident response systems
- Communications infrastructure and capabilities
- Data flows
- Operating principles and guidelines i.e., the rules that are used to run each component of the system, including the concepts of operations between parties

Expanded Monitoring of System Performance

The Integrated Framework depends upon continuous feedback on how the system is performing. Some data may be needed on an instantaneous basis – so that incidents can be responded to immediately. Other aspects of system performance may be monitored on a daily, monthly, or annual basis. These data are used to identify chronic deficiencies, and to evaluate the success of implemented strategies.

The kinds of data collected should provide a comprehensive basis for evaluating performance, considering the full range of goals and objectives. Thus, the monitoring may go beyond traditional traffic and passenger counts to include data on air quality, incident response times, travel time variability, and other conditions.

This may also include incorporating new short-term need estimation methods into the process. Examples are: Congestion Management Systems, traffic engineering analyses, and transit operations analyses; safety analysis of accident records and sometimes Highway Safety Systems; customer satisfaction and market surveys. All are part of developing an expanded performance monitoring program.

Using Real-Time Monitoring Data for Planning

ITS technologies allow for system performance to be assessed in real time. This not only allows for immediate response to incidents, but also provides a wealth of data that may be used for evaluating performance on a daily, weekly, or monthly basis or longer. The challenge is in saving, synthesizing and analyzing the huge amount of raw data so that coherent reports can be provided to managers and decision-makers. Various data users may desire to see the data summarized at different levels of aggregation for different applications.

The Minnesota Traffic Management Center (TMC) monitors 175 miles of the freeways in the Twin Cities using 3000 loop detectors and 180 CCTV's. The data is saved at the 30 second level and summaries are produced at 5 minute, 15 minute, and other time intervals. MinnDOT uses the data for traffic analysis, construction impact determination, and planning applications. To satisfy data requests other agencies and individuals, a data distribution service has been developed through which data can be obtained through the Internet.

Evaluating Performance in Stakeholder Terms

The goals, objectives and visions provide the basis for identifying transportation problems and deficiencies. These statements of desired conditions ought to be based on a variety of stakeholder outreach activities. They should reflect the interests and desires of the diverse population of customers – the drivers on the road, current or prospective transit riders, and other system operators such as transit, emergency services, and freight operators. These stakeholders may cause the performance assessment to include such nontraditional goals and objectives as:

- Improved system reliability
- Better information on how to use the system
- Real time information on system performance
- Creating a “seamless” system to facilitate transfers between modes and systems

Collectively, these goals and objectives all provide a benchmark for assessing user satisfaction with the system and its performance.

Travel time predictability is often found to be a key “customer service” issue. If a highway facility is subject to frequent incidents, and travelers may be late to appointments, or may start their trip early to cover the contingency of an incident then the user may perceive the facility's performance to be worse than data on average conditions would indicate. Similarly, if a transit route often misses its schedule, customers may consider the route – and possibly the whole system – to be undependable, and may choose not to rely on transit. Reliability and variability analyses can be a helpful tool in understanding transportation deficiencies from the user's perspective.

The decision process should take into account the information and measures on both operations and management and reliability performance. The concerns of “operations” and other non-traditional stakeholders – such as traffic and transit operations, emergency service providers, and fire and police – should be included and reflected in measures.

Understanding How Needs Change Over Time

The Integrated Framework suggests that transportation needs be identified and solutions be evaluated over time. A cyclic approach is envisioned. It starts with identifying and addressing existing problems, then proceeding to the identification of longer-range problems, projecting a continuous time stream of system deficiencies and evolving needs.

In practice, it may it may make sense to identify the deficiencies at three different time frames, corresponding to major products of the planning process. The short-range horizon might correspond to the operating budget cycle or the Transportation Improvement Program. Mid-range analyses might be tied to a six to ten year capital program. The long-range might correspond to the 20+ year horizon of an MPO plan. Some places may find it helpful to establish different goals and objectives, corresponding to short-range and long-range visions.

The analysis of short-term deficiencies will depend upon existing system performance data, whereas mid-range and long-range analyses are likely to use standard forecasting tools. Mid-range forecasts might be obtained by interpolating between existing conditions and long-range forecasts.

Recurrent and Non-Recurrent Conditions

The conditions analysis ought to extend beyond simply examining typical average conditions with no incidents or unusual occurrences. But accidents, hazardous materials spills, adverse weather and other conditions do occur on a regular basis. As the transportation system operates closer to capacity, the likelihood increases that something unusual will cause a system breakdown.

The demand models used in most metropolitan areas forecast travel under average conditions, including in many cases the average peak hour. New tools are becoming available that project atypical conditions:

- In a case study of the Seattle area, existing demand forecasting models were extended to provide a representation of system performance under non-recurring conditions.
- The Intelligent Transportation Infrastructure Deployment Analysis System (IDAS) will provide sketch planning capability to enhance networks and represent ITS.

Understanding the Underlying Causes

Planners typically consider information on traffic volumes, level of service, transit ridership to identify transportation system deficiencies. Their assessments are much more meaningful where analysts “look behind the numbers” to identify the underlying changes in demographics, the economy, travel behavior, and other causal factors. With an understanding of the underlying causes of transportation problems, planners are much better prepared to identify potential solutions for analysis.

This leads to the following steps for the needs/deficiency analysis within the Integrated Framework:

- **Extended Inventory development**
  - Infrastructure (Roads, Transit, ITS and Operations equipment such as traffic signals, detectors and surveillance equipment, VMS signs and HAR, etc.),
  - Services and their coverage areas (Transit, ITS, traffic systems)
  - Communications (data flows – if they exists -, communications infrastructure and capabilities),
  - Operating principles and guidelines (what rules are used to run each component of the system, what are the concepts of operations between parties).

- **Existing Conditions and Performance Analysis**
  - Measures of Effectiveness refinement (must fit data collection, projection capabilities).
  - Collecting Data on Existing Performance
  - Reliability
  - Satisfaction
  - ITS as a data collection tool
  - Typical Analyses: Travel time studies; Incident/accident analysis (impact, duration, cause); Bottleneck and delay analysis (recurrent and non-recurrent).
- **Deficiency Analysis**
  - Compare with conditions with goals / objectives
  - Typical vs. a-typical conditions
  - Engage stakeholders for priority assessment
  - Output Existing(time point) deficiencies

- **Causal Analysis**
  - Critical point, flow/Operations Analysis
  - Travel demand patterns
  - Reliability/Variability Analysis (including incidents)
  - Typical vs. a-typical conditions

- **Forward/Backward Pass for Future Needs/Deficiencies**
  - Future system definition (sketch level)
  - Projecting Future conditions (travel, unusual conditions)
  - Projecting Future Performance

Again, it is the deficiency analysis and it’s causal evaluation that provide the basis for developing and evaluating the future alternatives and selecting a preferred development path. This becomes an iterative process, and performance evaluation and feedback to the management and operation of the system is continually performed.

V.C.2.2 Institutional

In many instances, stronger institutional linkages will be necessary to achieve a more comprehensive assessment of deficiencies. A complete view and analysis of the overall transportation system will require the cooperation and commitment of different levels of government, different modes, and both planning and operations personnel from those agencies. This will require the sharing of data and information across traditional boundaries, both among and within agencies.

It may also require new relationships. For example, state, regional, city, and county transportation agencies need to connect with incident response staff. This may include state and local police, fire departments, ambulance services, hazardous spill clean up staff. Private sector entities such as tow operators and freight haulers may also be engaged.

Houston’s TranStar is a multi-agency information and transportation management center that coordinates the collection, processing, and dissemination of an extensive network of traffic, transit, and transportation data. It houses the ATMS and ATIS for TxDOT, METRO, the City of Houston, and Harris County. TranStar hardware includes CCTV monitors, operator control consoles, high resolution projectors for map displays, control computers, information data bases, and communications hardware. The center is staffed 24 hours a day, seven days a week, with approximately 70 full time equivalent staff.

The regional Metropolitan Planning Organization (MPO) may provide an appropriate forum for bringing all parties together to discuss their mutual interests, share information, and develop a comprehensive assessment of system needs. MPOs might serve as a data repository, compiler, and/or analyst of the create new checklists/formats for members to provide new inputs to regional planning process needs assessment.

V.C.3 VARIATIONS BY SCALE, SETTING, AND INSTITUTIONS

What to include in the needs/deficiency analysis and how to carry it out also varies by the region’s characteristics and transportation problems it faces, its institutional setting and available resources, which planning cycle is being developed.

Transportation issues tend to be more complicated and interrelated in areas that: are congested, have air quality problems, and have multimodal systems,. Larger metropolitan areas tend to have greater resources than smaller areas, but there are many competing demands on those resources. There are more entities to involve in designing and implementing a comprehensive performance monitoring program. While this makes coordination more difficult, there may be are greater opportunities for mutual benefit through information sharing.

The transportation problems of non-urban areas differ significantly from those of urban areas, but they are no less real to the people affected. The problems may include the movement of freight over rural highways, weather-related disruptions, an influx of visitors during certain parts of the year, or lack of transit service. Performance monitoring activities should focus on this different set of issues.

Non-urban areas are likely to have far fewer resources available for planning. The principles described above generally apply – collecting data on the system and its performance, assessing atypical conditions, consulting with stakeholders, understanding the root causes of transportation system deficiencies – even though the problems may be different. Data collection and analysis would focus on the kinds of issues that exist and are anticipated to exist.

Different levels of data aggregation are used for different types of planning. Short-range planning might be oriented to addressing the fluctuations in system performance day to day. Hourly and daily performance data may be most meaningful. Long-term planning may pay more attention to longer-term trends that can be discerned from annual or multi-year data.

V.C.4 SECTION REVIEW AND TRANSITION ASSESSMENT

This section described the activities associated with carrying out a needs/deficiency analysis as part of integrated planning. The analysis is based upon the transportation systems performance in meeting the integrated goals and objectives developed previously.

Important issues to consider in the carrying out a needs/deficiency analysis include:

- Developing an extended inventory of facilities and services to include both ITS and operational characteristics
- Expanding the monitoring of system performance and the use of real time monitoring data for planning
- Evaluating performance in broader stakeholder terms
- Establishing an understanding of how needs change over time
- Gathering performance data for both recurrent and non-recurrent conditions as part of the assessment.
- Sharing of performance data among transportation agencies and other stakeholders.
- Enhancing transportation agency understanding of the underlying causes of system performance deficiencies.

After the needs/deficiencies are defined a causal analysis must also be carried out to determine why they occur. It provides the critical information for developing alternatives that include ITS, operations, and traditional solutions and their tradeoffs.

Table V-5 provides some questions that might provide some insight into where your region stands in how they carry out a needs/deficiency analysis. . Mark where you think your area's relative position is for each question.

Table V-5 Needs/Deficiencies Analysis Self-Assessment

Question	NO YES
Needs/Deficiencies Analysis	
Does the system inventory include ITS facilities, equipment, and services? Does it capture how the system operates? Communication, traffic, and surveillance networks? Does it include operating rules and concepts ?	NO - - - - - - - - YES
Does the analysis include operational issues and problems throughout the day? Does it include all stakeholders' points of view (incident response)? Does it include both recurrent and non-recurrent conditions within the peak and non-peak travel periods?	NO - - - - - - - - YES
Is causal analysis performed on the identified needs and deficiencies to determine why they exist (lack of capacity, high accidents, poor signal timing, etc.)?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

V.D IDENTIFYING ALTERNATIVES

Key Points of Section V.D

- Identifying Alternatives is an iterative incremental process that results in the development path of actions from today to the long-range horizon year.
- Different alternatives represent different paths of development created from different policies, principals, and values (i.e. transit versus highway)
- Each alternative must also include the new elements needed to incorporate ITS and operations
  - ITS and communications facilities and equipment
  - ITS and operations services
  - Regional ITS Architecture
  - Concept of Operations
  - Operating principals/concepts and characteristics
- Combined ITS, operations, and traditional options are created in each cycle based upon causal analysis of the identified deficiencies compared with the changes caused by each type of treatment.
- Other factors that need to be considered are:
  - Uncertainty and technological change
  - Private/public sector roles
  - Incremental implementation of enabling technologies
- What to do also depends on the region’s problems, modes, infrastructure condition, terrain, weather and other characteristics. The Population size impacts the planning requirements and process, and available resources may limit future options.
- As the time horizon grows the level of detail defined within the alternative diminishes.

This Guidebook has defined transportation planning as the process to support all transportation-related decisions on what the future transportation system will be, its characteristics, and how it will operate. Defining, evaluating, and selecting alternatives for the future is, thus, at the very core of transportation planning and decision-making. Consistent with this view of planning an “alternative” is:

A set of linked interrelated infrastructure investment, operations, and maintenance actions to implement, operate, and maintain the transportation system and services over the planning horizon (from today to the long-range horizon year).

In order to bridge the operations and infrastructure planning worlds and recognize the importance of performance feedback in the system an alternative describes one “path of development” of decisions leading to a future system. It describes not only what the transportation system will be (infrastructure and services) in the horizon year, but also how to get there from today.

As important as the path of development, is the realization that in the Integrated Framework an alternative is not simply the ITS or traditional components (sub-systems) defined separately. Rather it is the **combined set of actions** (infrastructure, ITS, systems management, operations, and policy) which best meet the region’s goals and objectives in a cost effective manner. The actions fall into three categories that interact:

- Managing transportation supply (transportation infrastructure and services and their operations);
- Managing travel demand (information, pricing, alternative modes, TDM policies), or
- Managing the environment (urban form, zoning, mixed use incentives)

Each alternative definition is some combination of these three types of actions (see ITE, 1998 for a more complete discussion). For example, congestion on a freeway can be reduced (at least temporarily) by adding additional capacity. It may also be addressed by a combination of demand (mode shift and pricing incentives) and land use policies. ITS can assist in directly managing both transportation supply and demand. It can also support policies that manage the environment and land use.

Each alternative must be defined in enough detail to perform the subsequent travel, costs, and other impact analyses and meet the requirements of the transportation planning process and day-to-day operations feedback. As explained in what follows, the level of detail required will vary by the scale of decisions and the point in the planning/decision cycle being considered. In general, however, as the time frame increases (along with the scale and uncertainty within the scenario) less detail will be warranted.

The process of alternative definition in the Integrated Framework, thus, becomes one of determining how traditional and ITS/management & operations elements will be combined to create the development path for the transportation system from now to the horizon year. This process and the issues it raises are discussed throughout the rest of this section.

V.D.1 CURRENT PRACTICE VERSUS AN INTEGRATED APPROACH

This section compares alternatives in current traditional processes with those in the Integrated Framework. First, new elements become part of any alternative development and definition with the incorporation of ITS and management and operations into the decision process. Since with ITS, operating characteristics within the transportation network will change and regional "management" of the system becomes possible, **operating assumptions and characteristics must now be explicitly addressed**. The alternative must, therefore, encompass development of a regional architecture; concept of operations; operating principals/characteristics; and supporting policies and programs. A comparison between the elements of an alternative derived from the traditional process versus the Integrated Framework is shown in Table V-6.

Table V-6 Traditional versus Integrated Framework: Alternative Elements

Traditional Process	Integrated Framework
Infrastructure: Traditional	Infrastructure: Traditional & **ITS**
Transportation Services: Traditional	Transportation Services: Traditional and **ITS**
	Regional Architecture (Data flows and Functions)
	Concept of Operations (Who is Responsible for What)
	Operating Principals/Characteristics (Performance Relationships)
Supporting Policies and Programs (Public Policy and Regulations)	Supporting Policies and Programs (Public Policy and Regulations)

New components for the Integrated Framework are in **Bold.**

A brief discussion of each of the elements for an alternative in the Integrated Framework is provided below:

- **Infrastructure (ITS and traditional components):** ITS components/equipment used to implement the desired User Services (see below) such as transportation management centers, ramp meters, surveillance, variable message signs, toll and fare facilities, and communications systems all now need to be integrated into the alternative. The National ITS Architecture has identified Market Packages that can be used to identify the functions that the equipment needs to fulfill. Supporting ITS infrastructure components such as a communications backbone and other equipment, and even software should not be forgotten. Traditional components (road, transit facilities, bridges, etc.) and how they are combined with the ITS elements still need to be part of the alternative definition.

- **Transportation services (ITS and traditional components):** The transportation services that operate with/over the physical facilities and other infrastructure components must also be defined. These are the dynamic elements of the transportation system that are the focus of the new management and operations factor introduced by TEA-21. For ITS The National ITS Program Plan has defined 32 ITS User Services which describe what ITS does from the users perspective. The User Services such as "Traffic Control", "Incident Management", or "Public Transportation Management" form the building blocks for defining what functions are to be carried out by ITS in an area. The National ITS Architecture further defines "Market Packages" that are more specific equipment bundles used to implement the User Services. Different combinations of market packages can be used to implement the User Services at different levels. Traditional transportation services include transit routes and frequencies, paratransit services, and Transportation Demand Management (TDM) programs such as rideshare and guaranteed ride home.

- **Regional architecture (data flows and functions).** ITS services depend upon the flow and use of information, to and from surveillance in the field, control centers, control mechanisms and the field, and the public. A regional architecture specifies the information flows, subsystems, and functions, necessary to implement the desired services (both traditional and ITS). Development of a regional architecture helps meet the TEA-21 National ITS Architecture Conformity requirements. It also helps identify areas of coordination and potential conflicts to overcome in providing integrated transportation to the region.

- **Concept of operations including public/private assumptions (who is responsible for what**). The concept of operations addresses the roles and responsibilities of participating agencies (and departments if deemed necessary) in order to implement, operate, and maintain the desired transportation system (both ITS and traditional components). It includes the necessary agreements between parties as well as the allocation of resource and cost responsibilities. The concept of operations also defines the assumptions what will be carried out by the public and private sectors. The level of detail required will change depending upon the point in the planning cycle. At all points, however, the concept of operations is needed since who performs these roles and responsibilities, how they are carried out, and how the costs/revenues are shared can substantively impact the characteristics of the system that the users see.

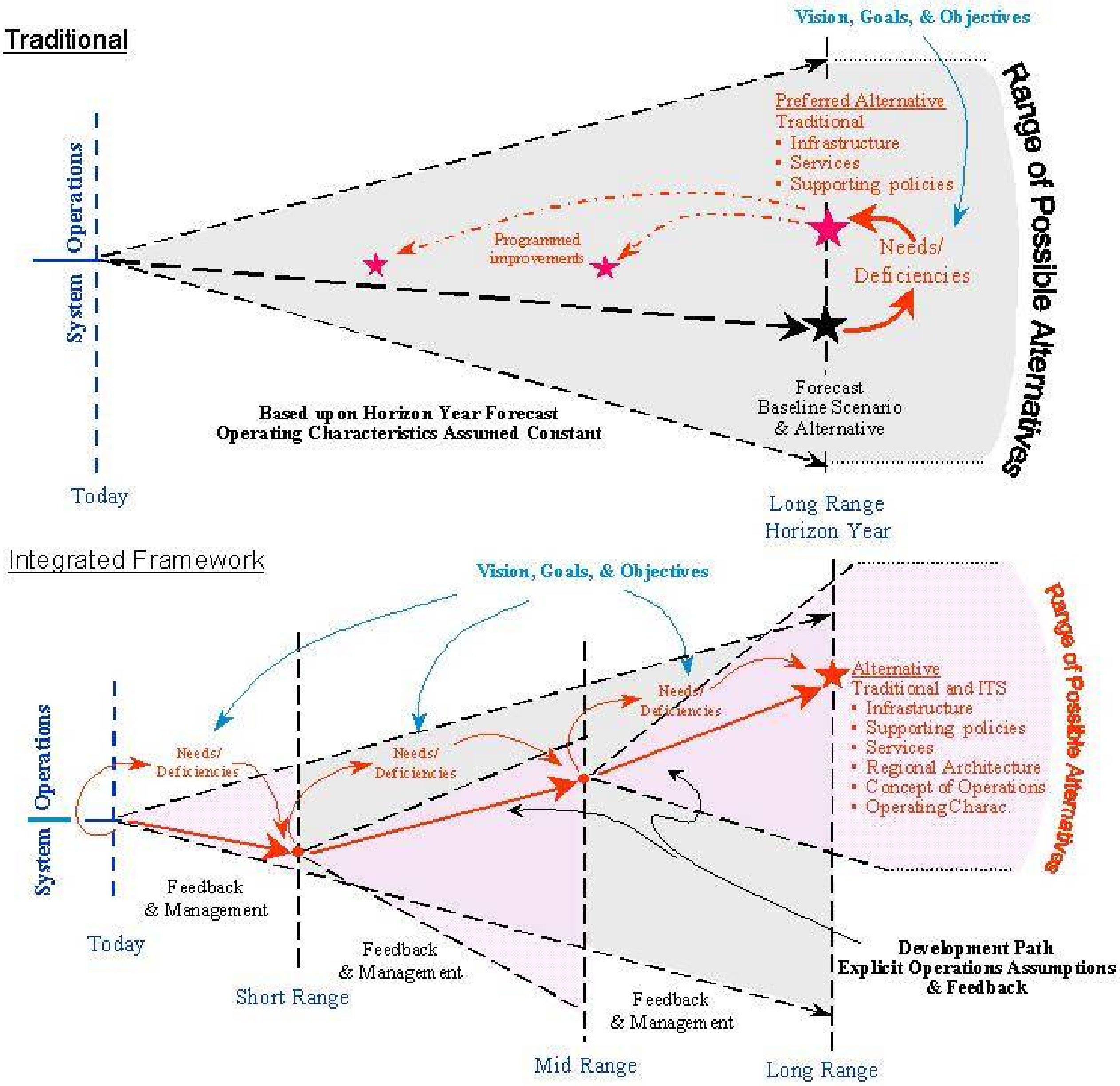
- **Operating principals/characteristics (how the system will perform).** Explicit assumptions regarding the operating principals and characteristics of the system and how it will perform under different conditions must be made. All of the above impact these assumptions. Traditionally, operating characteristics and relationships were implicitly defined in the physical description of the alternative's elements. For example, a 4-lane divided highway's operating speed at 1,000 vehicles per lane per hour would be assumed to be 48 mph. With ITS, however, how the system is operated now directly impacts these performance characteristics. For example, whether a system uses un-coordinated versus coordinated signals, and how the coordination takes place can drastically change the throughput speeds at the same volumes/hour on arterials. For transit, using vehicle tracking and "connection protection" can also change the expected transfer times for passengers changing routes or modes. Thus, performance relationships implicitly assumed previously must explicitly be made to capture the predicted changes in ITS and other decisions affecting operations.

- **Supporting Policies and Programs (Public policy and regulation).** Last, the supporting public policies, legislation, and regulation are a critical component of each transportation alternative. These include land use, zoning, and building/density requirements, taxes and user fee regulations, and other laws and regulations that impact how people travel and use the transportation system. For example, a transit alternative may require supportive land use policies and densities around its transit stations combined with mixed use development in order to attain ridership levels that make it cost-effective and/or financially viable. ITS elements may also benefit from supportive policies such as those regarding access to communications channels (radio and other), privacy and information access regulations, and the Internet. Many of these may be outside the control of local decision makers and therefore need to be addressed as part of the base scenario. Others, however, become important parts of the local decision process and future transportation system.

Chapter III described the cycles of planning within the Integrated Framework. They leads to an iterative and incremental process for alternative development. Initial system components are defined for a planning cycle (short-range, medium-range, long-range); their costs benefits and impacts measured; and their relative worth evaluated (see Sections V.E and V.F). The alternatives are then refined and the process repeated until an option acceptable to the decision-makers and political process is obtained. The system components for the next planning cycle are then developed, and the process repeated until a full path of development from today to the planning horizon is produced (i.e. an alternative). At the same time, elements are being implemented, the transportation system operated, and performance monitoring is taking place through the collection of ongoing performance measures (using ITS and other data sources). This allows continuous feedback and assessment of the vision, goals and objectives, needs/deficiencies, and resultant alternatives. Rather than a static group of "things" that will exist in the long-range horizon year, the alternative becomes the incremental set of management actions into the future for the transportation system.

Figure V-6 provides a conceptual comparison between the traditional and Integrated Framework approaches to alternative development. Traditionally, a long-range base-line scenario forecast and alternative are developed. The needs and deficiencies are then derived from the region's goals and objectives and this "snapshot" of the future. Alternatives are then developed and a preferred alternative selected which best meets the goals and objectives and needs. Alternatives have typically focused on major investment decisions and define the long-range "snapshot" of the infrastructure and transportation services

Figure V-6 Conceptual Comparison of Traditional and Integrated Alternative Definition



(e.g. transit routes and frequencies) for the horizon year. Often, supporting policies and programs needed to implement the alternative are also included in the definition (e.g. transit supportive zoning and mixed use development requirements around transit stations). Typically, only the single horizon year forecasts and analysis are carried out and all operating characteristics and policies are implicitly assumed to remain constant.

Introducing ITS and active management/performance feedback into transportation planning bridges the gaps between the ITS/operations and planning worlds and transforms what alternatives are, and how they are created. First, since continuous performance feedback can actually change what is feasible/possible in the future the full incremental development path should be defined. Figure V-6 shows the impact of this feedback on the development path. Active management of the system allows the system to be adjusted for efficiency and effectiveness at each point in time. As performance monitoring takes place incremental changes can be made to the transportation system and its management and operations. This in turn alters the range of possible alternatives to consider, and may alter travel patterns, land use, and non-recurrent conditions which in turn alters the needs/deficiencies to address as time goes on. The result is likely to be a future system that is much different than one derived from the traditional planning process (note, the different endpoints between the two approaches).

An Integrated Framework alternative, thus, provides the time stream of actions (path of development). It includes each of the above elements and balances the use of ITS and traditional strategies to best meet the region's goals and objectives and overcome the needs/deficiencies of the system. How to do this, however, raises a number of issues that are explored in separate sub-sections below.

V.D.1.1 Deficiencies To Integrated Alternatives: The Importance Of Causal Analysis.

Alternatives are derived from problems. However, since ITS provides new possibilities, simply identifying the symptoms (i.e. the identified needs and deficiencies) is no longer sufficient to develop integrated balanced solutions. As in the field of medicine, the **extent and cause** of the illness must be understood in order to identify the correct cure. For example, if the identified problem is intermittent congestion in a single corridor or facility during peak hours, then ITS strategies may be used to provide route diversion, or shift the time of trip departures. However, if the congestion is recurrent and exists across all facilities in an area, a combination of infrastructure expansion with supporting ITS, system management, operations, and TDM elements may be warranted. The needs/deficiencies, therefore, need to be organized in ways that help identify balanced options so that their underlying causes can be examined. Different solutions (ITS and traditional) may be appropriate depending upon the geographic level and timing of the problems. The applicability and balance of ITS and traditional strategies will also depend upon which performance goal is deficient. One suggested classification of needs/deficiencies is therefore shown in Table V-7: by geographic area, occurrence/incidence, and goal area.

Table V-7 Needs/Deficiency Organization for Alternative Development

Geographic Area	**Goal Area**
• Inter-regional (National , statewide, interurban corridor) • Metropolitan/Regional • Corridor/Subarea • Municipality/agency • Project/site	• Accessibility • Mobility • Economic Development • Quality of life • Environmental and Resource Conservation • Safety and Security • Operational Efficiency • System Condition and Performance
Occurrence/Incidence	
• Recurrent • Random, Non-Recurrent • Prevalence by time-of-day	Example typology (Cambridge Systematics, 1999)

Once the needs/deficiencies are organized, their underlying causes and relationships can then be investigated. System performance is the result of the interplay and interaction between:

- Environmental conditions/factors (e.g. weather events – snow, rain, fog; terrain, topography)
- System physical characteristics (e.g. connectivity, geometry, capacity)
- System operating characteristics (e.g. signal timing, ramp meters, toll and fare collection, HOV strategies, reliability, response times)
- Vehicle/driver operating characteristics (e.g. acceleration/deceleration, driver response, emission rates, mpg, capacity)
- Perceptions and available information about the system (e.g. perceptions on travel times and costs by mode, safety & security, reliability; gaps between perceived and actual conditions)
- Land use and development patterns and characteristics (e.g. urban form, density, type of use)
- Desire for travel/travel behavior (e.g. route , trip time, mode, destination, number of trips)

A qualitative evaluation of the contribution of each of these factors should be made for each of the identified needs/deficiencies. Only then can the balanced set of ITS and traditional strategies be developed in response. For example, the causes behind significant delays in a corridor may be found to be: accidents due to poor physical geometry and site distances, long incident response times, and high peak volumes. The "balanced" alternative developed in response would therefore include: geometric improvements and channelization, roving tow trucks and coordinated incident response, and highway advisory radio/variable message signs to divert traffic to parallel routes when an incident does occur. This need may also be combined with others to provide justification for policies to change traveler behavior at a regional level using TDM measures designed to help promote the use of alternative modes, telecommuting, and flexible work hours. Table V-8 shows candidate ITS strategies that impact travel behavior.

Table V-8 Traveler Response to ITS

	Traveler Responses				
ITS Categories	Route Diversion	Temporal Diversion	Mode Shift	Destination Change	Change in Demand
Traffic Signal Control	X		X		
Freeway Management	X	X	X	X	x
Transit Management	X	X	X		
Incident Management	X	X	X	X	x
Electronic Fare Payment			X		
Electronic Toll Collection	X	X	X		
Railroad Grade Crossings	X				
Emergency Management	X	X			
Commercial Vehicle Ops.	X	X		X	
Regional Multi-modal ATIS	X	X	X	X	
System Integration	X	X	X	X	x

Source: Cambridge Systematics, 1997

The above example and the table illustrate how ITS can be used to support changes in travel behavior as part of an overall strategy to meet a need. Issues associated with creating such "balanced" solutions are discussed next.

V.D.1.2 Building Integrated ITS and Traditional Solutions.

How should ITS and traditional elements be combined to the specific goals/objective deficiencies and needs identified in the deficiency analysis? It is recommended that this be carried out in two steps. First, a rough high level screening of potential ITS User Services should be made: matching the problems and causes with User Services that may contribute to a solution. Second, the level of each and how it should be combined with traditional improvements and policies should be determined.

It is presumed that transportation professionals have established processes for identifying non-ITS components. Table V-9 provides a mapping of the ITS User Services to typical transportation problems. Other potential sources for making an initial determination include the ITS cost and benefit data bases provided by US DOT, congestion management and ITS toolboxes, and ITS handbooks. These initial evaluation tools are discussed more in Section V.E on estimating the impacts of integrated solutions. They should be used in an iterative fashion to explore potential ITS User Services, and incorporate them into the alternative.

Once potential ITS User Services are identified, specific market packages to implement them and how they can be combined with traditional elements must be explored. Ways that ITS can be combined are:

1. No ITS (ITS is non-responsive, or another response is chosen)
2. ITS as a stand-alone, or primary response
    a) To meet emerging goals, objectives, and needs
    b) To meet traditional goals, objectives, and needs
3. ITS as a component of another element, or secondary response
    a) Supportive/Integral
    b) As mitigation

Again, the purpose of the Integrated Framework is not to select and deploy ITS technologies but to develop **balanced integrated alternatives**. Consequently, specific ITS elements may not be incorporated into the integrated alternative even though they are potential candidates. However, it is more likely that ITS will/should be considered. As a stand-alone, or primary element ITS responds to the emerging goals and objectives of the World II environments discussed in Chapter II such as improved reliability, customer satisfaction, and safety. Incident management and HERO services, and real-time multi-modal ATIS systems may meet these needs. ITS can also be included to meet traditional goals and objectives such as improvements in travel time, efficiency, and emissions reduction. Coordinated signal systems to reduce delay (travel time) and frequent stops (emissions) are examples.

The importance of considering ITS as a component of another improvement is often not given enough attention in recent ITS strategic plans. However, this may in fact be one of ITS's strongest roles. Building advanced fare systems, transit priority, and "connection protection" into Bus Rapid Transit (BRT) systems is an example of ITS providing a supportive role. ITS may also mitigate undesirable consequences of other options. In a recent case study it was found that an option that expanded expressway capacity actually created significant additional delays. Traffic diverted to the larger facility increasing its volumes. When accidents and other unusual circumstances did occur the delays were consequently more severe (Mitretek Systems, 1999). ITS elements for route diversion and incident management helped mitigate these conditions.

Again, it is the causal analysis that helps find the balance between the traditional and ITS elements and how they are combined. It provides an understanding of the interactions between transportation supply, demand, and environment (land-use), which result in the problem, and how management of each may lead to a solution. As stated, ITS and traditional elements may be combined to help support each. As an example, Table V-10 provides a comparison between conventional and advanced systems approaches for another set of typical problems. This table should be not be interpreted as presenting two either/or options (conventional and advanced systems) but rather as pointing out some of the considerations and tradeoffs to make when developing an integrated option. In today's world, both will usually be needed.

Table V-9 Mapping of User Services to Transportation Problems

		TRANSPORTATION PROBLEMS											
		Accidents		Inefficiency			Impact on Environment		Reduced Productivity		Reduced Mobility		
		Frequency	Severity	Capacity	Congestion	Customer Service	Emissions	Energy Consumption	Operations Costs	Travel Time	Traveler Security	Travel Stress	Access-ibility
Travel And Traffic Management													
1	Pre-trip Travel Information			Medium	Medium	High	Low	Low		Medium	Low	Low	High
2	En-route Driver Information	Low	Low	Medium	Low	High	Medium	Medium		High		High	
3	Route Guidance	Low	Low	High	High	High	Medium	Medium		High		High	
4	Ride Matching And Reservation				Low	Medium	Low	Low		Low		Medium	High
5	Traveler Services Information			Medium	Medium	High	Low	Low			Low	Medium	Medium
6	Traffic Control	Medium	Medium	High	High	High	High	High		High		Low	
7	Incident Management	Medium	Medium	High	High		High	Medium		High		Medium	
8	Demand Management & Operations				Low		Low	Low				Low	Medium
9	Emissions Testing And Mitigation						Medium	Low					
10	Highway-rail Intersection	Medium	Medium										
Public Transportation Management													
11	Public Transportation Management			Low		Medium	Low	Low	High	Low		Medium	High
12	En-route Transit Information					High				Medium	Medium	High	High
13	Personalized Public Transit					High						Medium	High
14	Public Travel Security					Low					High	Low	
Electronic Payment													
15	Electronic Payment Services			Low	Medium	Medium	Low	Low	High	Medium		Medium	Medium
Comercial Vehicle Operations													
16	Commercial Vehicle Electronic Clearance	Low		Low			Low	Low	High	High		Low	
17	Automated Roadside Safety Inspection	Medium					Medium		Medium	Medium		Low	
18	On-board Safety Monitoring	Medium	Medium								Low	Low	
19	Commercial Vehicle Administrative Processes								Medium			Low	
20	Hazardous Material Incident Response		High		Low							High	
21	Commercial Fleet Management			Low	Low	Medium	Medium	High	High	High		Low	
Emergency Management													
22	Emergency Notification And Personal Security		High		Medium	Medium					High	High	
23	Emergency Vehicle Management		High		Medium					Medium		High	
Advanced Vehicle Safety Systems													
24	Longitudinal Collision Avoidance	High	High	Low		Medium						Medium	
25	Lateral Collision Avoidance	Medium	Medium			Medium						Medium	
26	Intersection Collision Avoidance	Medium	Medium		Low							Medium	
27	Vision Enhancement For Crash Avoidance	High	Medium			Medium						Medium	
28	Safety Readiness	High	High									Medium	
29	Pre-crash Restraint Deployment		High									Medium	
30	Automated Vehicle Operation	High	Medium	High	High	High	High	High	Medium	High	Low	Medium	Low
Information Management													
31	Archived Data Function			Medium	Medium				Low	Medium			
Maintenance And Construction Management													
32	Maintenance and Construction Operations	Medium	Low		Medium				Low				
Additional International User Services													
	Policing/Enforcing Traffic Regulations	High	Medium		High		Low						
	Safety Enhancement for Vulnerable Road Users	High	High										Medium

High, Medium, and Low represent the degree to which the ITS User Services (rows) are likely to address the respective transportation problems (columns)

Source: World Road Association (PIARC), 1999 (adjusted in 2002 to reflect U.S. User Service definitions)

Table V-10 Conventional versus Advanced System Approaches to Selected Problems

Problem	Solution	Conventional Approach	Advanced Systems Approach	Supporting Market Packages	Considerations
Traffic Congestion	Increase roadway capacity (vehicular throughput)	• New roads • New lanes	• Advanced traffic control • Incident Management • Electronic Toll Collection • Corridor Management • Advanced vehicle systems (Reduce headway)	• Surface Street Control • Freeway Control • Incident Management System • Dynamic toll/parking fee management • Regional Traffic Control • Advanced vehicle longitudinal control • Automated highway system	***Conventional*** • Environmental constraints • Land use and community resistance • High cost of construction ***Advanced*** • Near-term services yield modest benefits • Latent demand effects
	Increase passenger throughput	• HOV Lanes • Car Pooling • Fixed route transit	• Real-time ride matching • Integrate Transit and Feeder Services • Flexible route transit • New personalized public transit	• Dynamic Ridesharing • Multimodal coordination • Demand Response Transit Operations	• Privacy and personal security
	Reduce demand	• Flex Time Programs	• Telecommuting • Other telesubstitutions • Transportation Pricing	• Dynamic toll/parking fee management	• Significant component of demand relatively inelastic
Lack of Mobility and Accessibility	Provide User-Friendly Access to Quality Transportation Services	• Expand Fixed Route Transit and Paratransit Services • Radio and TV Traffic Reports	• Multimodal pre-trip and en-route traveler information services • Respond Dynamically to Changing Demand • Personalized Public Transportation Services • Common, enhanced fare card	• Interactive Traveler Information • Demand Response Transit Operations • Transit Passenger and Fare Management	***Conventional*** • Declining ridership ***Advanced*** • Interjurisdictional cooperation • Standards
Disconnected Transportation Modes	Improve Intermodality	• Inter-agency agreements	• Regional Transportation Management Systems • Regional Transportation Information Clearinghouse • Disseminate multimodal information pre-trip and en-route	• Regional Traffic Control • Multimodal Coordination • Interactive Traveler Information	***Conventional*** • Often static and/or slow to adapt as needs change ***Advanced*** • Existing system incompatibilities • Standards
Severe budgetary constraints	Use existing funding efficiently	• Existing funding authorizations and selection processes	• Privatize Market Packages • Public-private partnerships • Barter right-of-way • Advanced Maintenance Strategies	• Transit maintenance	• Market uncertainties make private sector cautious • Telecommunications deregulation makes right-of-way barter a near-term opportunity
	Leverage new funding sources	•	• Increased emphasis on fee-for-use services •	•	• Equity
Transportation following emergencies	Improve disaster response plans	• Review and improve existing emergency plans	• Establish emergency response center (ERC) • Internetwork ERC with law enforcement, emergency units, traffic management, transit, etc.	• Emergency response • Incident Management System • Emergency Routing	***Conventional*** • Interagency coordination challenges ***Advanced*** • Interagency coordination challenges • Standards
Traffic accidents, injuries, and fatalities	Improve safety	• Improve roadway geometry (increase radius of curvature, widen lanes, etc.) • Improve sight distances • Traffic signals, protected left-hand turns at intersections • Fewer at-grade crossings • Driver training • Sobriety check points • Lighten dark roads to improve visibility/better lighting • Reduce speed limits/post warnings in problem areas	• Partially and fully automated vehicle control systems • Intersection collision avoidance • Automated warning systems • Vehicle condition monitoring • Driver condition monitoring • Driver vision enhancement systems • Automated detection of adverse weather and road conditions, vehicle warning, and road crew notification • Automated emergency notification	• All AVSS Market Packages • Intersection collision avoidance • In-vehicle signing • Vehicle safety monitoring • Driver safety monitoring • Driver visibility improvement • Network surveillance • Traffic information dissemination • In-vehicle signing • Mayday Support	***Conventional*** • High costs • Human error is primary cause ***Advanced*** • Mixed results for initial collision warning devices • Relatively slow roll-out for AVSS services anticipated
Air Pollution	Increase transportation system efficiency, reduce travel and fuel consumption	• More efficient conventional vehicles vehicle emissions inspections • Promotion of alternatives to single-occupant vehicle travel • Increased capacity to reduce vehicle delay • Regulation	• Remote sensing of emissions • Advanced traffic management to smooth flows • Multimodal pre-trip information • Telecommuting • Other telesubstitutions • Transportation Pricing • Alternative fuel vehicles	• Emissions and environmental hazards sensing • Surface Street Control • Freeway Control • Regional Traffic Control • Interactive Traveler Information • Dynamic Toll/Parking Fee Management	***Conventional*** • Increasing demand can offset initial benefit of added capacity. • Regulations, inspections are unpopular and onerous ***Advanced*** • Increasing demand can offset efficiency improvements

Source: <u>ITS Architecture Implementation Strategy </u>- US DOT, December 1999

V.D.1.3 The Importance of Developing an ITS Architecture(s).

In the Integrated Framework, the ITS Architecture is a key element in the definition of any alternative. What architectures are and their over-arching role in developing integrated systems is described in V.A. Developing a regional architecture tailored to local needs is also now required to meet the TEA-21 National ITS Architecture consistency requirements.

It is important that planners and other non-ITS specialist not be intimidated by the development and detail required for a locally defined ITS Architecture focused on their needs. First, if they are following the Integrated Framework, essential steps to create an architecture are already part of their process. These include: identifying and bringing into the process key stakeholders (Chapter IV), setting goals, objectives and measures (section V.B), and developing an inventory of existing ITS services and conditions (section V.C). These lay the groundwork for the ITS components of the future alternatives concerned with: what services to provide and the data flows, etc. needed to provide them; how they should be integrated to obtain the greatest synergy with other services (both ITS and traditional), and what must be done today to accommodate future developments. Second, as in planning traditional services , successive levels of system detail should be used as the process moves from overall system concepts, to project design, and then to implementation and operation.

At the highest conceptual level, the major ITS services, their data flows, and how they are to be integrated and coordinated should be determined. Is a centralized transportation management and data control center to be used; are several management centers going to exist, and information but not control of traffic, transit and other services to be implemented; does the region choose not to implement certain User Services, or not to coordinate others? These are often part of an ITS strategic planning effort and should be reflected in the region’s long-range Transportation Plan. They include major decisions on what long-term ITS strategies to undertake, general descriptions of roles and responsibilities, and information flows between participants and the identification of future policy agreements on interoperability, standards, and the operations of key systems. Projects in the long-range plan that use ITS and Major ITS projects, regional ITS initiatives, and projects that impact national interoperability should also be defined.

As significant regional ITS projects are proposed and developed a more detailed ITS regional architecture must also be prepared and/or updated. The regional ITS architecture provides more detail than is needed for long-range planning, but as already discussed must be consistent with the adopted Transportation Plan. The ITS Regional Architecture can be developed for an initial project and extended as new projects are introduced, or for the region as a whole. The key is to address how the integrated system is to be developed and operated and not just separate projects. Regional Architectures are likely to be developed for the mid-range horizon of 5 to 7 years consistent with current EDP and ITS strategic planning. Because of the phasing and resource requirements development/update of the regional architecture and Transportation Improvement Program will likely occur in coordination.

At the most detailed and short-range level each ITS project must undergo a systems engineering analysis as it is designed and implemented and be consistent with the Regional ITS Architecture. Often, a detailed project level architecture is also prepared. This can be carried out separately or for ITS services that are part of other traditional transportation improvements, this would be carried out as part of the overall project design and development. In any case the project specifications will be required to ensure that the project accommodates the sharing of electronic information and operations called for by the ITS Regional Architecture.

V.D.1.4 Incremental Implementation And Enabling ITS Technologies.

Understanding the incremental nature of ITS and the phasing of improvements is also an important consideration when creating the path of development for an alternative. Traditional infrastructure and other improvements can function (for the most part) when implemented, irrespective of other elements. Vehicles can travel over completed roadway segments. Passengers may take transit once it is in service. This is not the case with ITS services. Intelligent Transportation Systems are just that: systems. As systems, different components enable others to function through communications. They cannot operate independently. Thus, **when** different ITS components, or market packages, are implemented **does** matter.

Examples of enabling market packages and functions include:

- Network surveillance
- Transit vehicle tracking
- Dynamic toll/parking fee management
- Transit passenger and fare management,
- Establishing a communications backbone/network and
- Installing advanced signal controllers.

These provide many of the basic functions needed for the more advanced User Services and the market packages that implement them (see the National ITS Architecture Implementation Strategy for additional examples of key market packages and core functions from a National perspective – U.S. DOT, 1999). Deploying the basic functions early allows for efficient incremental deployment of new services over time by building on existing capabilities. Through feedback the earlier implementations also impact the system and demand for travel. An example of how incremental ITS investments lead to an integrated system is shown in the callout box.

Strategic Incremental ITS Investments Lead to an Integrated System

A municipality or transit operator may implement an **Automatic Vehicle Locator (AVL)** system using Global Positioning Systems (GPS) technology that is linked to a transit center. This improves on-time performance. Next the locality may want to connect the bus system with the local **Emergency Management Services**, so that bus operators can report emergencies on-board and receive quick emergency assistance. At this point, it will be important that transportation agencies have implemented **Compatible Communications Technologies** that allow the transit system to communicate with the local emergency services. Later a locality may want to add technology allowing emergency vehicles to communicate with **Traffic Signal Systems** or **Signal Priority Systems**, as examples to allow an ambulance or fire truck to hold a green light longer. To do this they will have to have traffic signal controllers that can easily be retrofitted with the compatible communications technology. In all cases, agencies and localities will need to ensure consistency with the **National ITS Architecture** and standards. As can be seen, strategic but incremental investments lead to an integrated system of systems and sharing of data and information; all of which lead to the provision of better information to system managers and customers

Source: Siwek, 1998

Each region needs to identify its own set of enabling market packages and core functions to implement first. This should be done as the regional ITS architecture is developed. It should also account for the integration and sharing of common functions and data and future ITS and traditional services (based upon last cycle of analysis).

Integration of the system functions, data, and control should also evolve over time. This evolution needs to be reflected in the development path and incremental descriptions of the ITS architecture. An example from Chicago is provided below.

Chicago is part of a multi-region Gary-Chicago-Milwaukee ITS Priority Corridor, which created a corridor-wide system architecture consisting of a Gateway, four hubs (Illinois Regional, Illinois Transit, Wisconsin, and Indiana), and multiple sub-systems. The Gateway allows separate systems to operate through their own control centers and coordinate as need (now or in the future). In developing the Northeastern Illinois Strategic Early Deployment Plan (SEDP) the Chicago Area Transportation Study (CATS) adopted this architecture as the regional architecture. However, it recognized that a fully integrated communications and ITS system could not be implemented overnight. Four levels of integration were therefore defined: **Level 0**: No connectivity to the Gateway; **Level 1**: Read-only data sharing through the Gateway; **Level 2**: Data is shared between individual systems and the Gateway; **Level 3**: Data and limited control is shared with the Gateway; **Level 4**: All system functions and data are seamlessly networked with the Gateway.

The SEDP was developed around the implied assumption that it is the intent of all ITS sub-systems to ultimately integrated with other sub-systems. Existing systems were then analyzed to determine their current level of integration (Level 0) and how to migrate over time to higher levels. "Regardless of an Agency's current status or future goals, they can increase their level of connectivity with the Gateway by specifying compatibility in requirements for system up grades and expansions.

Source: Zavettero, 2000.

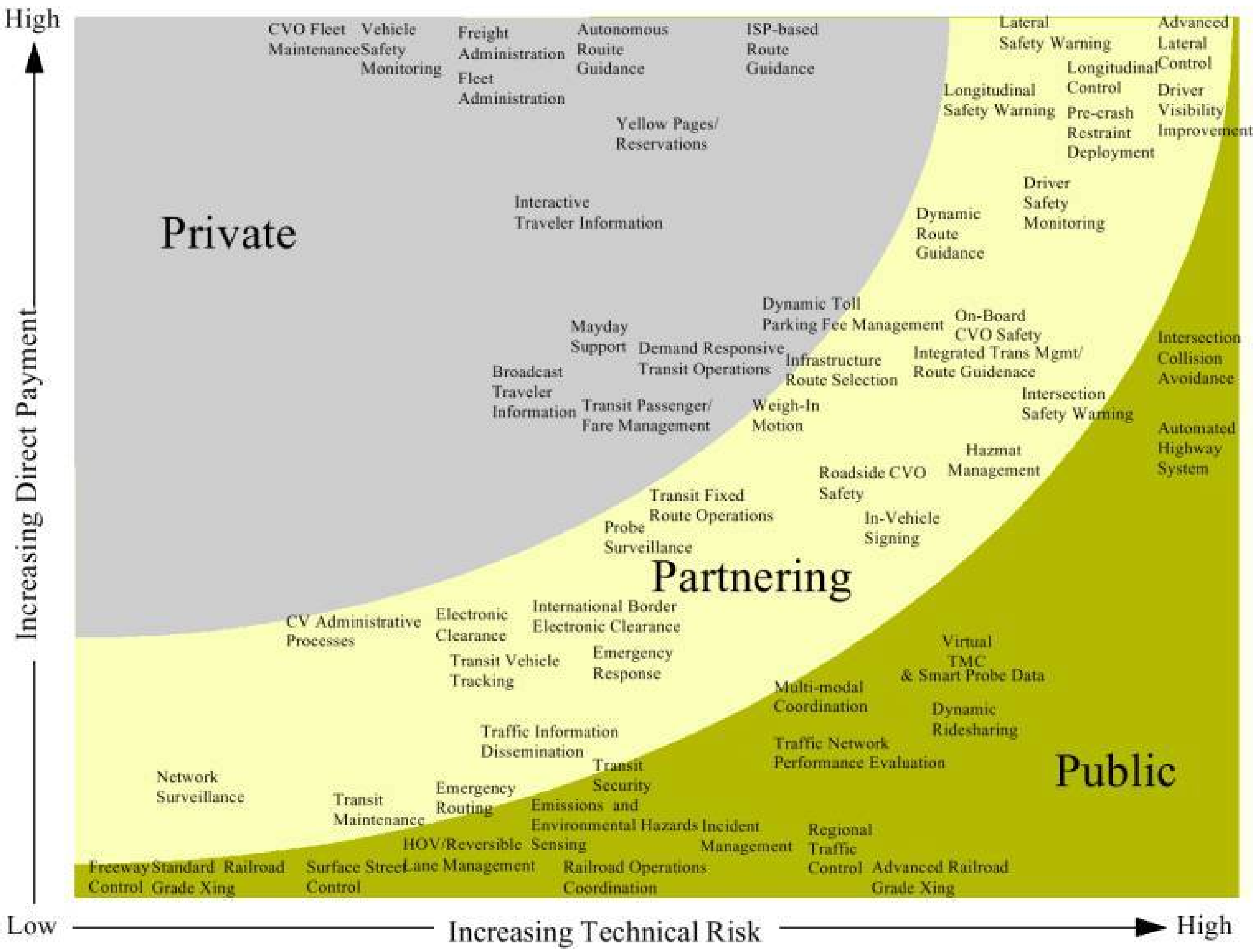
V.D.1.5 Integration of public and private projects.

Many of the issues associated with public/private partnerships have already been discussed in Chapter IV. Determining public versus private provision of future transportation services and how those services are to be provided also plays a significant role in defining alternatives. Who provides: Advanced Traveler Information Services (ATIS); collects processes and archives data (ADUS); Mayday and other Emergency Management Services (EMS); background communications networks; and other ITS functions can have a profound impact on their costs and benefits/impacts, and which users receive them. Consequently, it is important to identify who is to provide ITS services and other management functions as part of an alternative's definition in its concept of operations. Since the private sector is not "within the control" of the planning process or its decision-makers, simply describing future performance characteristics and assuming that they will be met by whoever provides the service in not sufficient. Therefore, assumptions on what is to be provided by the private sector through public/private partnerships should be carefully examined to insure that they are realistic and likely to be provided as described.

The private sector can only be expected to provide ITS components if it can recover its costs under reasonable risk. Figure V-7 depicts the ITS Market packages from the National ITS Architecture and their potential for private, public, or public/private partnership provision based upon technical risk and their ability to recover direct costs. Services whose costs can be recovered through direct payments at little technical or other risk or likely candidates for private provision based upon market forces. Services that may have diffuse benefits to society and not the individual and are not market driven, or which have high risk are candidates for public provision. Others fall in the middle and may be provided by public/private partnerships. This figure can be used to help identify which services are likely candidates for public and/or private deployment. Note that the labels "public" and "private" here refer to who has "control" of the service and its characteristics. Private contractors can be used to implement and operate public services. Likewise, there may be instances that a "public" sector organization chooses to provide a service as a competitive market based enterprise.

Note, that simply because the private sector is a likely lead for a particular market package does not mean that they should blithely be given the responsibility for the service, or presumed to provide the service independently. Careful analysis should be carried out on what is expected from each party (public and private) and if partnership is in the best public interest. ATIS and private sector information service providers (ISPs) provide an example. As stated above ISPs often would like to retain ownership of the data they collect and publish and place limits on the information use and re-production. However, ITS data plays a significant part of the planning process and feedback of performance in the Integrated Framework. Often, there is a desire to use this information in public meetings and other forums. Consequently, the policy implications should be carefully considered before turning the ownership and rights to this information over to the private sector. Another consideration is the distribution of benefits when the services are provided by ISPs and other organizations on a fee basis. Wide use and distribution of the service may be needed to meet congestion reduction and other goals, but this may not be likely if only high income users can afford the service offered by the ISPs.

Figure V-7 Public/Private Potential of ITS Market Packages



Source: National ITS Architecture Implementation Strategy (US DOT, 1999)

V.D.1.6 Uncertainty and Technological Change

ITS and communications technologies are advancing by leaps and bounds every year making it difficult to forecast what will be available in the future and the level that it will be deployed. Unforeseen ten years ago was the explosion of the Web and the Internet, the ubiquitous use of cell phones and the emerging wireless market, the popularity of electronic toll collection (both from the users and operators perspectives), and the growing use electronic enforcement for red light running. Each of these as well as other advancements is re-shaping the use of ITS today and into the future. Given this advancement, ITS and management and operations planning (e.g. early deployment plans, ITS strategic plans) are typically only carried out in a 5 to 7 year time-frame. In fact, when asked in this project's Discussion Forums ITS professionals repeatedly stated that they could not make predictions concerning ITS beyond 5 years in the future. However, to meet Federal requirements and to make long-range decisions transportation planning must extend at least out to the 20 year horizon required for the transportation plan, and possibly further (25 years to ensure that the 20 year requirement is always met). **At a minimum the mid-range technology forecasts, strategic plans and regional architecture analyses that the ITS community is comfortable with should be incorporated into the path of development**. Issues concerning the remaining gap in time frames and how it may be overcome are further discussed below:

The biggest obstacle to overcome may be the cultural differences between planning and operations. ITS professionals and other operations staff spend their days focused on the details of making sure their services are operational. By necessity, their decisions concern programming and budgeting of actual equipment, staffing, and operating rules, and making them all work together in the short-term. It is hard to get them to make predictions without knowing all the details. Planners on the other hand are trained to think in terms of long-term options for today's decisions and not on how the future systems will operate. Both perspectives are needed. ITS and operational staff must realize that they are the best candidates for predicting the future characteristics of their systems, even if the details of how the systems will be operated are not known. Planners need operational staff's "reality check" to insure that their future systems are in fact feasible. Active participation in the alternative development and creating a focused dialog between the two is the only way to begin to bridge this gap.

The dialog should not simply ask open ended questions, such as: "what ITS will be deployed in the future?" Rather it should use available sources, and walk the participants through thinking about the future characteristics and penetration of each ITS User Service. This should be done in steps. First the mid-range 5 to 7 year expectations should be developed. Then, possible paths from this point should be explored. Also, as uncertainty increases into the future, a shift in the description can also occur from technology and operational specifics in the short run for input into operational budgets and implementation schedules, to supply side performance characteristics in the longer term (speed/volume relationships, reliability indicators, information content and availability/responsiveness) that impact travel demand and major investments. It should also separate out what the participants feel is within their decision process, and what trends/services lay outside their control.

There are a number of available sources that can be used to help define the long-term trends in ITS and communications technology. The National ITS Architecture's Vision (US DOT, 1999) provides one picture of what will exist in 2012. It envisions: 40% of vehicles on the roads to have basic on-board ITS instrumentation; extensive use of wireless hand-held and in-vehicle personal information devices providing up-to-date traveler information; the use of universal payment media for all aspects of transportation (transit, parking, tolls) as well as other function; and extensive use of ITS data for planning purposes and automation of TMC functions. The U.S. Bureau of Transportation Statistics has also released it's Trends and Choices Two for U.S. transportation through 2020. Private sector forecasts that must be purchased from their authors are also available such as those by Hagler Bailly (Hagler Bailly, 1999), SRI Consultants (SRI Consultants, 1999), and Automotive World (Tucker, 1998). At this time, however, no National base-line on ITS technology trends and potential future market penetration of services geared toward local decision making and regional architecture development is available. It does seem, though, that such a document would be extremely useful in integrating ITS into the overall planning process.

In addressing technological change and uncertainty it is therefore recommended that a base-line scenario be defined from today to the horizon year which encompasses trends and assumptions outside of the local decision process. Using the above sources as well as local expertise and consensus it should define:

- Technology development and availability in the short run, and User Service characteristics in the longer term
- National, inter-state corridor, or state-wide standards and services provided due to legislative or other initiatives. CVISN and other CVO requirements are examples.
- National trends in privately provided/purchased services (in-vehicle navigation and mayday, in-vehicle IVI technologies, universal payment media)
- Base-line market penetrations of the above.

Each alternative can then be developed by defining:

- Which technologies and User Services to implement in the region or corridor (based upon the availability defined in the base-line scenario)
- The use of local Information Service Providers (ISPs) and the characteristics of the services they provide.
- The impact on the base-line levels of privately provided/purchased services and their market penetration. For example, providing exclusive High Occupancy Toll (HOT) lanes and parking facilities may increase the penetration of universal payment media throughout the region.

Uncertainties regarding the availability of ITS technologies, User Service characteristics, or market penetrations can then be addressed using sensitivity analyses on the scenario assumptions. One approach used by planners in the past when faced with uncertainty is to make sure that the chosen alternative is “robust” under different likely conditions studied under sensitivity analysis.

The I-64 Corridor Major Investment Study from is one of the few planning examples to include ITS technologies in the definition of its base-line (Nobuild Alternative) scenario. It separated out assumptions regarding the ITS trends and decisions made outside the corridor (National and State-wide) and included them in the base-line scenario. Assumptions regarding both technology and market penetration were made. Examples include:

- 100% coverage of data collection and surveillance with advanced communication and processing
- Use of transit vehicle tracking and transit information.
- Web and kiosk based pre-trip travel information.
- 10% market penetration of in-vehicle route guidance
- 100% penetration of Smart Cards for electronic payment
- Driver and vehicle condition monitoring and collision avoidance standard on all new vehicles

Corridor specific ITS was then developed as part of the alternatives. It included: variable speed limits with end of queue warning systems; advance signal system time with freeway incident management and route diversion; ramp metering; and transit route deviation.

Source: Rush & Penic. 1998

V.D.2 APPLICATION WITHIN THE INTEGRATED FRAMEWORK

While the preceding section focused on issues and concerns regarding defining integrated alternatives, this section describes the process and steps that should be carried out for full integration of ITS, systems management, and operations within alternative's development. Again, the goal is to determine the overall mix of ITS, management and operations, and traditional improvements to meet the region’s goals and objectives. This will consist of a **time stream of ACTIONS** aimed at **managing** the future transportation system and its influences. The actions may take the form of managing the **supply** of transportation, the **demand** of transportation, or the **environment**. ITS can directly influence both the supply and demand of transportation, and support policies that manage the environment.

Nowhere else is it as important to recognize that the Integrated Framework transforms planning from developing cross-sectional solutions based upon horizon year forecasts (single point) to a continual performance based feedback process than when developing alternatives. The integrated system's path of development is continually updated as near term actions are implemented and the system's response is observed (through ITS data). At any point in time options for the direction the path may take from that point on are explored, their implications evaluated, and incremental changes incorporated. Note, that since this is a cycle the work from prior iterations exists and provides a starting point for the next update cycle (e.g. budget period, TIP development, transportation plan update, and corridor/subarea study).

The process to update a development path and/or create alternative paths of development (i.e. alternatives) is described below. The steps are briefly summarized based upon the discussion of the issues and concerns raised in the last section. These are carried out within each cycle of the overall process described in Chapter III. Starting with current deficiencies and short-term options, it makes incremental updates in the system forecasts and conditions, and develops the next time period's actions. This repeats until the full development path is created.

Step 0: Carry Out Prior steps.

Developing alternatives fits within the overall Integrated Framework. Consequently, the steps prior to the alternative development must be carried out in preparation. In addition, the base-line scenario/alternative and external influences must be identified, and the existing development path actions inventoried. These preparatory activities are:

- Gather stakeholders (maintain their involvement in each of the steps below)
- Goals/objectives/vision
- Inventory/deficiency analysis
- Identify Base-line scenario and external considerations
- Existing development path
- Needs/Deficiency and Causal Analysis.

The importance of organizing the identified deficiencies and carrying out causal analysis for each is discussed in the previous section. Again, the causal analysis helps understand how the deficiency occurs and what actions will cause it's performance to change. The deficiencies should be grouped by: geographic area, occurrence and incidence, and goal area. The degree that different types of conditions create them should then be specified. These are:

- ITS/management and operations oriented (non-recurrent incidents, events, or unusual conditions, lack of information, poor operator or other human response)
- Demand and traveler behavior (Time of departure, trip destination, route choice, mode choice, activity and trip making)
- Infrastructure/service conditions (sub-standard geometric design, in-adequate sight and stopping distances, capacity, equipment reliability, and system connectivity).

This can be either a subjective evaluation, or a more analytic process depending upon the decision to be made and the time period under analysis. While some deficiencies may be the resultant of only one of the above, it is likely that most will be influenced to some degree or another by all three.

Step 1: Initial Screening of Potential Solutions: ITS, System Management, Operations, Traditional, Environmental/Land Use

Based upon the causal analysis and categorization and using Table V-9 and other sources previously identified a rough level screening should first be carried out. This screening identifies what: ITS User Services; other management and operations strategies; traditional infrastructure and service improvements; or environmental/land use policies have the potential to contribute to solving the identified problems, or improving performance on other goals. It separates out what should be examined in the next step for developing integrated/combined solutions.

Step 2: Integration/Combination Review.

This step further explores how ITS can be integrated with the other components (traditional infrastructure and service, travel demand, land use) where the potential that ITS can contribute has been identified (where ITS cannot contribute during this time period has been screened out in the last step). ITS User services during this step can either be (see previous discussion):

- Identified as stand alone options to meet ITS oriented goals and deficiencies
- Identified as stand alone options to meet traditional goals and needs.
- Included as an integral component of other options
- Included to mitigate the undesirable impacts of other options.
- Dropped (or delayed) from further consideration due to implementation time frames, lack of supporting services/functions, or large enough need to support implementation.

The output of this step is the set of ITS User services for the area under consideration and where they are needed. In developing the combined response to each deficiency/problem consideration should be given to: the ability to respond to all its dimensions (ITS may be warranted to address non-recurrent congestion when it occurs, and additional capacity warranted to address recurrent congestion), tradeoffs in costs, and public policy directives. Different alternatives are developed to explore different choices in the mix of ITS, traditional, travel demand and, and policy options (e.g. land use and zoning).

Step 3: ITS User Service Refinement.

Simply identifying the User Services does not create an integrated transportation or ITS system. This step examines the identified services to determine how they should be coordinated and bundled to create an overall system. First, they should be grouped and compared by shared functions, geography, and service providers. How the potential service will appears to it's potential users should assessed. The goal is to provide seamless integrated functionality to users (all else being equal). This analysis is used to help determine how the service may be provided, who will provide it and the required information flows between agencies/providers to do so. For example, an MPO may have within its jurisdiction several cities and towns (e.g. Detroit and Ann Arbor Michigan are both part of the South Eastern Michigan Council of Governments). Transit agencies in each may plan to implement electronic fare payment and automatic vehicle location systems for their bus fleets. The overlap of users (little) and geographic area (little) determines the benefits of creating single or separate transit management centers to implement/operate these services, and the need for a centralized coordinated system (low). On the other hand, areas with several transit agencies that share geographic corridors, that passengers transfer between may need to have closely integrated universal fare and AVL systems that share information for both cost allocation and overall system management.

In this step, a forward/backward analysis along the development path also needs to be carried out. This is especially important in subsequent passes of the process for the mid and long-term time frames. If nearer term actions need to be added to previous periods, or actions further along the development path updated this should be done. This makes sure that the path is consistent and reconciled across all time periods.

At the end of this step, the desired User Services and their combination with other actions should be defined. The geographic scale that they will be implemented/coordinated at (region, corridor, site, agency, see Section V.A) is also specified. Conceptually who will carry out the basic functions for the User Services and the required information flows between participants are also defined.

Step 4: ITS Market Package Selection.

As stated, The National ITS Architecture had defined 63 "market packages" as "building blocks" for implementing *Integrated ITS systems*. They can be used to assist in implementing the desired

User Services at various levels and configurations (see Appendix B). Several market packages may be used to implement a particular configuration of a User Service and different configurations change the complexity and features of the service provided. Several different User Services may also share a market package. This allows for incremental implementation of ITS functions as well as integration and synergy of the deployments. For example, the Traffic Control User Service may use up to 11 separate market packages in its implementation from network surveillance, to probe surveillance, and from surface street and freeway control, to regional traffic control, to traffic forecast and demand management. Likewise, the surface street control market package is shared between the Traffic Control, Incident Management, and Highway-Rail Intersection User Services. What market packages to implement, when, and how depends upon the level of integration and sophistication desired and constraints/opportunities that may exist.

This step takes the desired User Services from the last step and determines which market packages to implement given the previously implemented ITS system and information flows and institutional, financial, or resource (staffing) constraints which may exist. It must also explores the desired degree of public / private cooperation and integration in the provision of the services because of its impact on resources and the features of the services that may be provided. Market packages can be interdependent, provide common functions, share information, or be complementary. Thus, it may be important to implement certain basic enabling packages such as network surveillance as early as possible. As the system grows s and interconnections /dependencies mature more advanced features (i.e. probe surveillance) can be implemented in time periods later along the development path.

This step’s outputs are the set of market packages, their interfaces, subsystems, and equipment packages to be implemented for the time period under investigation. It also describes the public / private relationships and roles chosen to implement these services.

Step 5: Describe Alternative Components and Obtain Stakeholder Input.

While stakeholder involvement and interaction must take place throughout the process it is at this point that the alternative’s development path up to the time period under investigation should be assembled and described to the stakeholders and feedback on the integrated description obtained. Each major component that makes up an Integrated Framework Alternative should be described. Again these are:

- Traditional and ITS infrastructure components
- Traditional and ITS transportation services
- Regional architecture including data flows, functions, and major providers of all services (not just ITS)
- Concept of operations for the integrated system (not just ITS)
- Operating principals/characteristics
- Supporting policies and programs

It may be important to develop a simplified table for decision makers showing how each regional goal/objective or identified deficiency is addressed by a mix of these components. Other than this summary table the analysis and decisions that must be supported determine the level of detail provided. In the near term specifics on technology and detailed operations may be needed to determine implementation and operating budgets and support project development. Further along the development path this may give way to higher level User Service descriptions and estimates of the supply side operating characteristics needed to determine major directions along the development path today and carry out required Federal analyses (air quality, environmental impact assessments, etc.)

Step 6: Update System Description And Forecasts.

Based upon the base-line scenario and the alternative definition for this time period, the system description (supply and services), and other inputs to the system forecasts must be updated and an incremental forecast created. While, this seems onerous, incremental forecasts are being required more and more to account for transportation-land use inter-relationships and their affect on travel. Also, based upon the decision at hand, the analysis should be adjusted to the appropriate level of detail, whether this is the use of sketch tools, regional network models, or operational simulations. The important concept here is no matter what the level of detail incremental forecasts/analysis is needed. Also, the forecast/analysis methods should be sensitive to ITS and other system management and operations strategies. The issues associated with impact analysis are examined in Section V.E.

Step 7. Go to Next Time Period and Repeat Steps 1-6.

Start the process over by updating the conditions and deficiency analysis for the next time period. New options that may take longer to implement, respond to conditions that could not be addressed up to this point in time, or respond to new conditions created by the feedback and growth in the system can now be considered.

This process continues until the planning year horizon is reached and a full development path is created. *Different alternatives are created by using different priorities and choices along the path as it is created.* For example, an alternative that invests in transit options and incorporates supporting ITS elements and land use decisions can be developed and compared to an alternative that maximizes the traffic flow and the convenience of the private auto using ITS and capacity expansion.. Once the alternatives are defined their impacts must be estimated and evaluation must take place. These steps in the Integrated Framework are described in sections V.E and V.F.

V.D.3 Variations By Scale, Setting, And Institutions

Though the steps described above remain basically the same, the capability to develop and implement the alternatives, who is responsible, and outputs of the process (alternative components, level of detail, documentation) will vary greatly depending on the regional context and decisions that are under consideration. Alternatives are developed to respond to needs and problems. Certainly, whether an area falls into “World I” (extra-capacity, un-connected, low density, available land, stable) or “World II” (urban, congested, connected, built/dense, un-stable) described in Section II.C will shape the integrated system needs and type of ITS services desired and deployed. Though they overlap significantly, other important dimensions in developing alternatives include: the size of area and regional characteristics and the transportation and environmental problems faced; and the institutional complexity/historical relationships and resources to carry out the definition/implementation of the integrated alternatives that exist. These are examined below.

V.D.3.1 Regional Context and Transportation Issues

The regional context, characteristics, and the transportation issues that are of concern in an area all shape the appropriate integrated transportation alternatives and ITS’s role within them. Probably most significant is the difference between urban and rural environments and their associated network characteristics, travel patterns, and deficiencies/needs.

Rural America accounts for a small and dispersed portion of our nation’s populations, yet it encompasses a significant portion of the transportation system. Rural areas account for 80% of the total US road mileage and 40% of the vehicle miles traveled. The rural transportation environment of long distances, relatively low traffic volumes, relatively rare traffic congestion, travelers unfamiliar with the surroundings, and rugged terrain in remote areas creates much different system requirement, user needs, and maintenance and operation costs than urban areas.. Furthermore, rural characteristics that solicit ITS solutions include an over representation of fatal crashes (About 60% of traffic fatalities and 55% of work zone fatalities occur in rural areas), safety problems related to high speeds on non-interstate rural roads and increased response time for Emergency Medical Services. Many rural communities now have excellent all-weather road systems, but many rural residents remain isolated because of their inability to travel. Presently 38% of the nation’s rural residents live in areas without any public transit service and another 28% live in areas in which the level of transit service is negligible.

The typically un-congested conditions, severity of accidents and difficulty of emergency response, long distances, and unfamiliar travelers shift the focus on ITS needs in rural areas. The priorities become safety, efficient provision of services, and information provision, versus those of urban systems, which are aimed at congestion relief (time savings) and increased throughput.

Because of the differences the US DOT has developed a separate ITS program area to serve rural needs, The Advanced Rural Transportation Systems (ARTS) Program. In response to the diversity of conditions traveler and user needs the ARTS program has defined 7 Critical Program Areas (CPA) Clusters around which rural systems can be developed and deployed to meet specific stakeholder and user group needs (e.g. tourist areas and their visitors). Table V-11 provides the CPA clusters and potential ITS applications that might be used to provide services to them. This is similar to the grouping and aggregation of user services and market packages carried out in developing urban architectures. Other sources for rural solutions are the ITS Rural Toolbox for Rural and Small Urban Areas (Castle Rock and Black and Veatch, 1998), and Technology in Rural Transportation "Simple Solutions" (Castle Rock, 1997).

Additional factors that influence the level and type of ITS services that may be warranted include: urban size, terrain and topology, weather, urban form and growth rate, the existing or planned modes, and the existence of special generators and events (see Transcore, January 1998).

Urban Size: Large areas tend to have higher levels of congestion and more system variability. They operate closer to capacity and the impact of incidents and unusual occurrences consequently can be significant cascading throughout the system. Because of their complexity, navigation during "events" or for unfamiliar travelers through these systems can be difficult. They often have large complex transit systems as well. Appropriate ITS services include traffic and transit operations, multi-modal ATIS that includes route diversion, and Incident management. Systems need to be closely coordinated and integrated. Medium areas tend to have lower congestion that still may be significant at times. A core set of ITS applications may still be warranted. ITS may be driven by special characteristics of the region (e.g. tourism). Small areas may not have significant benefits from widespread application of ITS. Deployments may be focused on specific corridors or locations such as a through freeway, or major generator (university, beach, etc.). May be incorporated into rural/small area ITS development.

Terrain and Topology: The terrain and topology can also have significant influence on developing integrated alternatives including ITS. Major river crossings may warrant surveillance and traveler information focused on the bottlenecks they create. Unique Incident Management systems may also be called for to insure that they are not blocked for significant periods when an incident does occur. Emergency services may also be desired for tunnels and areas where hazardous spills would endanger lives. Mountains and hilly terrain may also limit parallel routes, additional surveillance in key locations, and call for special incident response, clearance, and environmental sensing to detect hazardous conditions. Flood warning and alternative routing systems are important for flood areas, created by lakes, streams, or other bodies of water.

Weather: Weather conditions such as black ice, snow at mountain passes, heavy snow in rural areas, fog areas all can benefit from surveillance and detection technologies, plus roadside and other information services. In addition, ITS can play a key role in Tornado and Hurricane prone areas assisting in evacuation procedures, traffic management and routing during evacuation, and emergency services.

Urban Form and Growth Rate: The urban form and density also shape ITS needs. This includes the existence or lack thereof, of right-of-way for expansion, parallel routes, and the condition of the existing facilities. Areas with limited expansion opportunities, high maintenance costs on deteriorating plant, and stable growth, may need to place a premium on maintenance and management of their system using ITS technologies. On the other hand, high growth areas with available land have the opportunity to install ITS communication and surveillance as the system is expanded providing for immediate incident management and future traffic management opportunities. The existence of parallel routes also changes the type of information services that may be emphasized allowing for en-route diversion. If no parallel routes exist, pre-trip information becomes more important.

Table V-11 Rural Critical Cluster Areas and Potential ITS Applications

Traveler Safety and Security	Wide area information dissemination systems (via radio, computer, TV, etc.) both pre-trip and en-route of safety information, such as weather and road conditions
	Site-specific safety advisories and warnings (e.g., the enhanced radar detector for hazard warning, visibility sensors, variable speed limits, collision avoidance, work zone detection/intrusion alarms, rail crossing alerts, shoulder detection, etc.) to alert motorists of imminent problems
	Safety surveillance and monitoring (e.g., on transit vehicles (for malcontents and for ill riders), at park-and-ride lots, rest areas, etc.); and
	In-Vehicle monitoring and detection systems including such items as driver monitoring (alertness, status), vision enhancement, perimeter detection, shoulder detection, etc.
Emergency Services	Mayday systems to alert dispatchers of location and nature and extent of a problem (e.g., crash, breakdown, etc.); and
	Advanced dispatching and vehicle-based response systems (e.g., on emergency medical services & law enforcement vehicles, disaster response vehicles, tow trucks, etc.) to get to the scene quickly, and provide appropriate care (perhaps for the judicious enforcement of traffic laws as well).
	Emergency communication systems to link critical agencies and to feed information services for en route travelers.
Tourism and Traveler Information Services	Information services (electronic yellow pages, route guidance, etc.) provided at fixed locations (e.g., in hotels, at rest areas, at modal transfer stations, etc.), and en-route;
	Mobility services (transit, paratransit, parking systems, etc.);
	Smart card payment/transaction systems for transit and tourist transactions; and
	Portable event management systems that include such services as traffic management, variable message signs, hotel and service availability and directions on how to reach services when they are available.
Public Traveler Services and Public Mobility Services	Advanced transit, paratransit systems, etc., using AVL and improved dispatching (e.g., taking advantage of improved rural addressing (i.e., using Global Positioning Satellites), etc.);
	Smart card payment/transaction systems for rider payment and tracking (beat fraud); and
	Advanced ride sharing and ride matching systems.
Infrastructure Operations and Maintenance	Appropriate traffic signal and traffic management systems for small urban areas, ultimately linked together (as well as with large metropolitan TMCs) as part of a statewide, distributed information system;
	Automated management systems (e.g., bridge, pavement, roadside hardware, etc.); and
	Advanced work zone management and traffic control.
Fleet Operations and Maintenance	Advanced dispatching and routing systems (e.g., for snow plows, transit operators, etc.) (includes central processing systems and vehicle-based systems such as Automatic Vehicle Location);
	Advanced vehicle tracking systems (e.g., guidance for snow plow operators to track through dangerous areas covered in snow)
	Fleet maintenance and management systems.
Commercial Vehicle Operations.	CVO-specific requirements/needs within the other critical program areas (e.g., rural addressing, logistics, vehicle and driver monitoring), vehicle location systems for alerts to other travelers as well as for other tracking needs, assistance for agricultural harvesting, collecting and tracking CVO specific information needs (e.g., CVO-enhanced weather advisories);
	Services to assist Agricultural Harvesting and Migration
	Other services in support of small rural commercial enterprises. On the road communications and paging, low cost vehicle location for employees in the field, etc., to help make rural commercial activities more viable and cost-effective.

Source: ARTS Strategic Plan, (US DOT, 1997)

Existing or Planned Modes: The existence of transit, HOV, or other modes (e.g. ferries) and the complexities of their systems either adds or subtracts from the ITS User Services to consider, and how the chosen ITS User Services will be integrated. Commuter, heavy rail, and light rail advanced technologies are currently not considered part of ITS, but the Federal Transit Administration has recently begun an ITS-Rail initiative to include them. In any event, ITS that coordinates with rail service such as "connection protection" and highway-rail intersection services should be investigated when these systems exist. Likewise, the needs of the CVO and goods movement community must also be included in the development of an integrated system. This is especially true at, or around, major inter-modal transfer and other freight facilities. Toll facilities provide for the introduction of electronic toll collection and probe surveillance using the toll tag transponders.

Special generators and Events: Special generators and events often generate the need for unique transportation solutions including ITS. Tourist areas are characterized by large numbers of unfamiliar travelers and can benefit from information at key locations (kiosks, hotel information channels) for both transportation options and other services. Stadiums and periodic events may call for mobile traffic and parking management systems. Recurrent special generators (beaches, amusement parks, and airports) can benefit from variable message signs, parking management and routing, and universal electronic payment medium. Universities and "campus" office parks often well served by transit services using advanced transit management, paratransit, route-diversion, and other ITS transit elements.

V.D.3.2 Institutional Setting, Planning Requirements, and Resource Availability

The institutional setting and Federal planning requirements determined by an area's size and air quality conformity also can have a profound impact on the ability of areas to generate/analyze alternatives and on the type of alternatives generated, implemented, and operated. These as well as other factors influence resource allocation. Resources must exist, be available, and be capable. In addition to fulfilling the planning requirements, resources must exist to implement, operate, and maintain the desired services. In any case the desire to implement potential services must be mitigated by the ability to plan, analyze, implement, and operate them.

The size of an area determines to a large degree the planning institutions, requirements and resources and consequently the ability to analyze and implement alternatives. The differences between rural, small/medium and Metro areas are therefore discussed below. Multi-jurisdictional/Multi-state impacts are then briefly examined. **Rural (population < 50,000):** Rural areas are outside the boundaries of Metropolitan Planning Organizations and their requirements for developing a long-range transportation and transportation improvement program. Their road system planning, maintenance, and operations are therefore typically the responsibility of the state department of transportation and are included in the Statewide Transportation Improvement Program (STIP) and plan. Transit is limited and may fall outside the purview of the organizational carrying out the principal/system planning functions. Paratransit is often provided through human service organizations. Traveler and other information is not existent, or is organized/provided by specific corridors and/or major tourist destinations (e.g. Yosemite National Park's information system).

The lack of a centralized planning institution and process makes coordinating integrated alternatives difficult. This project's discussion forums pointed out the need to develop partnerships and ad-hoc relationships in order to achieve this integration (Mitretek, 1999b). Participants also have to see a direct benefit in their participation since it may not be legislatively mandated. Alternative and systems there may need to be organized/developed around inter-urban travel corridors and/or major destinations/tourist areas. Public/private partnerships with area chamber of commerce, tourism boards, and others are much more critical for the success of services than in urban regions. These relationships need to become part of the alternative description and development process.

Resources and staff availability/capability are often at a premium in rural areas, both for developing and implementing alternatives. State agencies may have one or two staff assigned to their entire "rural" area, or they are assigned along modal/facility categories. The ability to provide ongoing operating budgets, and technical expertise to implement publicly provided ITS services, especially information services may not exist. Again, services if they are to be implemented at all may have to be provided through partnerships, and “pay for themselves” in some fashion (this could be through advertiser or participating organization contributions or other means). The U.S. DOT’s “Simple Solutions” for rural areas helps match services with capabilities of these areas. Also, rural areas may be part of larger inter-urban corridor efforts such as the I-95 Corridor Coalition of the North Eastern United States with many of their ITS decisions determined externally.

Small/Medium Size Areas (50,00 to 200,000 in population): These areas are required to be part of a MPO and to develop both a Transportation Plan, and Transportation Improvement Program (TIP). TIP projects, however, are selected by the State in *cooperation* with the MPO, and not directly by the MPO themselves. Often, the MPO staff for these areas consists of only one or two professionals who must carry out all the planning and programming functions for the agency. Therefore, resources and specialty knowledge of the type required to develop *Integrated Alternatives* may not exist. In fact, small MPOs repeatedly stated that they did not understand ITS and felt out of the loop both in expertise and in the Federal support/thought process during this project’s discussion forums (Mitretek 1999b). This was further verified by an AMPO survey of Mops regarding ITS. Developing simple ITS solutions that recognize these limitations, and simplified analysis methods to accompany them is important if these areas are to embrace ITS in their alternatives development. .

Large Metropolitan Area. (Greater than 200,000 in population): Areas greater than 200,000 population are designated as Transportation Management Areas (TMAs) as part of the Federal planning regulations. TMAs must develop a Congestion Management System Plan as part of their Transportation Plan (CMS) to manage congestion and provide information on system performance and develop strategies for alleviating congestion and enhancing mobility. ITS can and should play a key role in the CMS development.

These areas, typically have the staff and resources, either within the MPO, operating agencies, or other ad-hoc ITS organizations to carry out integrated planning and develop the specialized knowledge necessary to do so. Their ability to develop integrated alternatives may be constrained by either multi-jurisdictional or multi-agency issues, or by additional requirements introduced by non-attainment of the National Ambient Air Quality Standards (NAAQS).

Multi-jurisdictional / Multi-Agency Regions: Many regions are either multi-jurisdictional and/or include multiple operating agencies providing transit and other services. In these cases integration and coordination of ITS and other services may become problematic if the agencies, or jurisdictions, choose not to be part of an overall system, or give up control of their operations in some fashion. In these instances, the alternative and its analysis must reflect the level of integration that is agreed to: from none, to data sharing without control, to data sharing and system-oriented control.

Air Quality Non-Attainment or Maintenance Areas: Air quality non-attainment or maintenance areas have additional planning and analysis requirements as part of the Federal planning regulations. First, components must be specified in sufficient detail to permit air quality analysis in accordance with the U.S. EPA conformity requirements. This includes all ITS elements as well, especially if they are expected to reduce emissions. Second, the Transportation Plan and its ITS elements (the proposed ITS Integration Strategy) must be updated more frequently in these areas (every three years versus every five). Third, if a TMA is in non-attainment any project which results in substantial SOV capacity expansion must be part of an approved CMS plan and “incorporate all reasonably available strategies to manage the single occupant vehicle (SOV) facility effectively (or to facilitate its management in the future). Consequently, ITS Traffic Control and other User Services may become key mitigating components associated with any system expansion in these areas. Last, ITS elements may be identified as Transportation Control Measures (TCMs) and incorporated into the applicable State Implementation Plan for Air Quality (SIP) if emissions benefits can be shown to occur. MPOs and others may, consequently, include additional ITS elements to in attempting to create a Transportation Plan or TIP that meets air quality conformity requirements. When they do so this may become a legal mandate to provide the level of service described, and ITS providers should pay special attention to ensure that it is feasible.

V.D.4 SECTION REVIEW AND TRANSITION ASSESSMENT

This section described how an alternative is developed within the Integrated Framework. First and foremost, an alternative takes on new meaning. It is a development path of actions from today to the horizon year. Different alternatives are created by changing the assumptions, values, and principals used to determine choices along the path. For example, a transit oriented could be developed and compared with a TDM or highway oriented option.

Alternatives in the integrated framework also include the new components needed to incorporate ITS and operations. These include:

- ITS and communications facilities and equipment
- ITS and operations services
- Regional ITS Architecture
- Concept of Operations
- Operating principals/concepts and characteristics

The tradeoffs and combinations of ITS, operations, and traditional solutions are examined within each cycle of the integrated process based upon a causal analysis of the needs and deficiencies defined earlier. How to combine them to address each problem depends upon the values being used to build the alternative and the changes that each type of solution induces.

Alternatives are also influenced by the types of problems the area is facing and its other characteristics (terrain, weather, existing modes, condition of infrastructure). The size of the population can change the planning requirements that must be met, and the resources that are available to both plan and implement the chosen solution.

Last, as the horizon is extended out into the future the detail included in the alternative diminishes.

Table V-12 provides some questions that might provide some insight into where your region stands in how they carry out a needs/deficiency analysis. Mark where you think your area's relative position is for each question.

Table V-12 Integrated Alternative Definition Self-Assessment

Question	NO YES
Do short, mid, and long-range plans exist? Are they developed incrementally with feedback between each cycle to create a path of development?	NO - - - - - - - - YES
Does alternative development include the new elements for integrated alternatives (ITS and operational equipment and facilities, ITS services, concept of operations, ITS Architecture, operating concepts, and performance relationships, public private assumptions) FOR ALL FUTURE TIME PERIODS?	NO - - - - - - - - YES
Does alternative development include participation of all stakeholders from both the planning and operations worlds?	NO - - - - - - - - YES
Do alternatives combine ITS, operational, and system enhancement improvements to address the identified needs and problems?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

V.E ESTIMATING IMPACTS, BENEFITS AND COSTS

Key Points of Section V.E

- Estimating impacts is part of an iterative cycle of developing options, estimating their impacts, and evaluation. It occurs as part of performance monitoring, within each planning cycle, and alternatives in the Integrated Framework.
- Estimating impacts includes capturing changes in:
  - Transportation supply
  - Demand for travel
  - External impacts
  - Costs of the transportation system.
- Issues that must be addressed
  - Variation in conditions, and unusual events.
  - Time streams and lagged affects
  - System synergies
  - Life cycle costs
  - Cost sharing and allocation
  - Uncertainty
- Available methods and tools include:
  - Benefit data bases/tool boxes
  - Empirically based Sketch techniques (rules of thumb)
  - Causal sketch models and post-processors (IDAS, emissions and safety models)
  - Regional Network Models
  - Simulation (macroscopic and microscopic)
  - Linked travel demand and simulation tools
  - Models based upon new paradigms in travel forecasting (TRANSIMS)
- The detail and precision of the analysis varies with where one is in the planning cycle.

The meaning of, “evaluation” and “estimating impacts” varies depending on whether you come from the operations, or planning worlds:

Operations professionals see evaluation as ongoing performance measurement of the systems they operate and manage. Estimating impacts involves **ongoing measurement of the before and after conditions** caused by the changes in the system operations that they introduce.

Planners on the other hand see evaluation as examining future alternatives in order to make an informed choice. Estimating impacts involves making **predictions of the differences in performance between alternatives** before they are implemented in order to assist in decisions when they must be made.

The Integrated Framework combines both of these perspectives. It is performance oriented using the performance measures chosen to reflect the region’s vision, goals, and objectives to evaluate an alternative. Starting with current conditions and the needs/deficiencies analysis it implements and monitors the management and operations of the system through feedback as time progresses. It must also predict the changes in performance into the future for the path of development of each alternative. This results in a *time-stream of impacts* (changes in performance) consistent with the time-stream of actions found in the path of development.

The rest of this section is concerned with the issues and methods associated with capturing the time stream of changes created by an alternative organized around the following:

- Transportation Supply, travel behavior (demand), and System Use Issues/Methods
- Transportation cost issues/methods
- External Impact Estimation (safety, air quality, equity, etc.) Issues/Methods

As discussed above this step measures and forecasts the change in system characteristics and travel behavior/use for each alternative. It then estimates other impacts and prepares performance measures for use in evaluation. Note, that for the base-line scenario and alternative the time stream of system characteristics, system use, and impact measures is established either in “absolute” values, or relative to current conditions. This is needed for environmental assessments and financial feasibility analysis. It is common practice to estimate the impacts and develop measures relative to this base-line for the other alternatives.

Estimating the impacts, benefits, and costs feeds the evaluation of alternatives, which is discussed in Section V.F. The last section on identifying alternatives described how estimating the impacts of the alternative is part of creating it's path of development. Incremental forecasts are made, feedback of impacts assessed, and the alternative's definition extended to the next time period. This incremental performance oriented process bridges the gap between the operations and management of today, and the long-term planning of the future. Once an alternative's complete path of development is fully defined all of the performance measures can be calculated and compared against other alternatives. Again, alternatives are refined and impacts estimated and evaluated until an option acceptable to policy makers and the political process is obtained. It can also not be stressed enough that estimating impacts and updating the management and operations of the system is performed continually through ongoing performance monitoring and feedback.

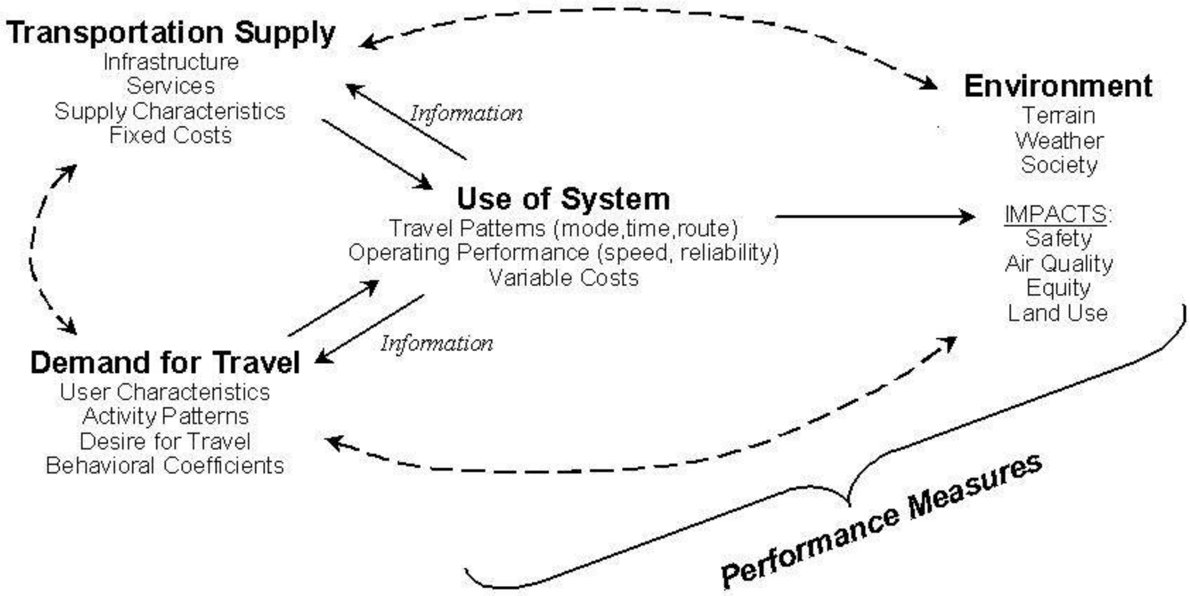
V.E.1 CURRENT PRACTICE VERSUS AN INTEGRATED APPROACH

This section discusses the issues associated with estimating impacts of integrated alternatives which include ITS and system management and traditional elements, and respond to both the emerging concerns of today's world and traditional issues. It provides a general approach and compares traditional estimation techniques to what is needed in the Integrated Framework.

Figure V-8 provides a general schematic of the interactions between transportation supply, demand, and use of the system created by an alternative and the benefits, costs, and impacts that result. As shown estimating impacts benefits and costs of an alternative concerns capturing how the alternative changes the:

- Transportation supply (Inputs)
- Demand for travel and use of the system that results (Outputs)
- External impacts of these to the environment and society (Outcomes)
- Costs of the transportation system

Figure V-8 Transportation Supply, Demand, & Impacts



Transportation infrastructure and services are provided in response to the demand for travel (determined by location and land use, user characteristics, activity patterns, and behavioral values/tradeoffs). These interact to determine the actual use of the system (travel patterns –mode, time, route – operating performance (speed, reliability) and adjustments in the variable costs (additional labor, vehicles, etc.). As the system characteristics change this again impacts the demand, supply, etc. Understanding and estimating how an alternative influences this transportation supply/demand/use interaction is the first basic step in determining its overall impacts. One class of impact estimation methods consequently concerns forecasting the transportation system characteristics and travel behavior that result from a future system.

Once the transportation infrastructure and services and their use are determined the costs of providing them must be estimated. This includes both the fixed capital operating and maintenance costs and the variable costs that are a function of system use. Cost estimation and its issues form another class of methods for impact estimation. In this Guidebook "costs" refers to the resources used by implementing, operating, and maintaining the integrated system. The changes the alternative causes to the users and the environment are its "impacts". Impacts may be positive (i.e. benefits), or negative (i.e. societal, environmental, or user "costs").

The transportation system and its use also create external impacts to the society and the environment. These include among others the impacts on air quality, noise, visual intrusion, safety, equity, and changes in land use. A third class of estimation methods uses the results from the transportation system and behavior analysis and cost estimation to forecast one or more of these external impacts. This is often done as post-processing to the travel demand estimation.

Note, that the performance measures described in Section V.B are created from the outputs of the above either singly, or in combination. For example, cost effectiveness measures combine the costs of providing the system with its performance on a particular measure. FTA has long used the Cost per New Rider has one its principle project evaluation criteria.

V.E.1.1 Transportation System and Travel Behavior Estimation Issues.

Figure V-8 applies for decisions made in both the traditional and Integrated Framework processes. However, each has very different underlying system and behavioral assumptions. Traditional solutions and the analyses that support them have tended to focus on facility/service improvements to meet capacity constraints arising in a typical day. They are consequently, focused on average conditions, or insuring that "demand" under normal maximum loads (85% day) will be met. The traditional flow based four step travel forecasting process (Network and data development, trip generation, trip distribution, mode split, and assignment) also assumes that people learn and understand the system over time (i.e. they have perfect information about their choices/consequences) and based upon this knowledge make decisions leading to a "User Equilibrium" where no individual traveler can improve their travel through independent decisions. Traditional analyses typically are based upon recurrent conditions and eliminate from both their data collection and methods unusual events such as accidents, weather, construction, or celebrations/events that create high/low demand. Because they were based upon infrastructure investments highway analyses also typically ignored operations and maintenance costs, and focused on the capital investment and its ability to meet the forecast "demand" in the horizon year.

ITS strategies on the other hand use technology, communications, and a "systems" perspective n order to meet the emerging concerns mentioned earlier and help adjust the system to conditions as they are realized on a day-to-day basis or evolve over a longer time frame. They focus on improving:

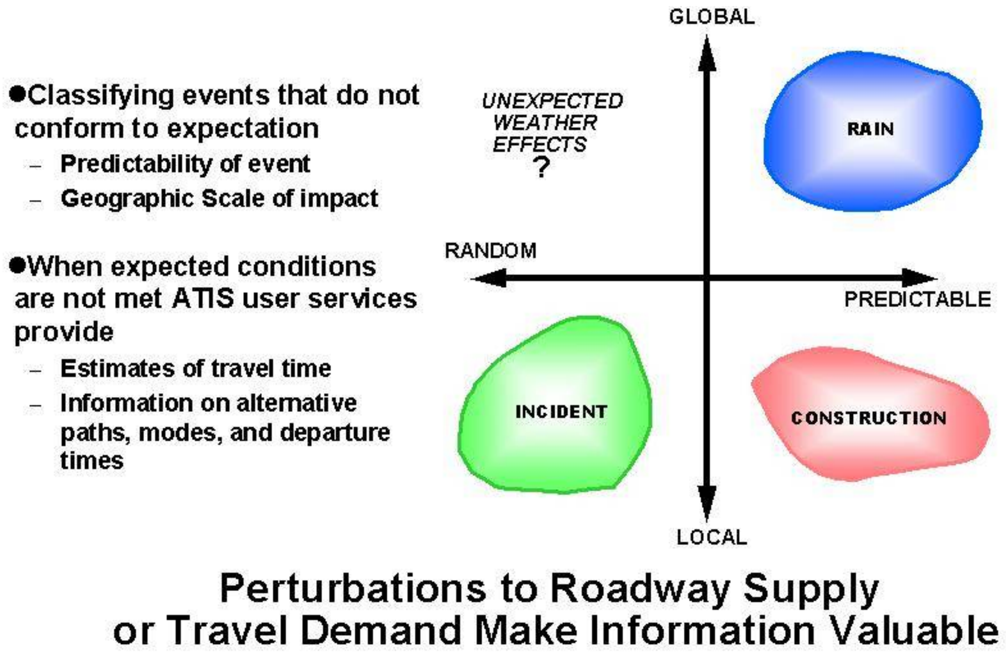
- Operations under expected or recurrent conditions,
- Response to Non-recurrent conditions, and
- Availability of up to date information.

By providing a coordinated systems perspective to the operations and management of the traffic/transportation system, improving the response to incidents and other non-recurrent events, and providing better information to the traveler and system manager many of the mobility and congestion problems found in an urban area can be addressed. Consequently, if ITS strategies are to be analyzed, then their impact on operations, response to incidents, and improved information must also be incorporated in the analysis. Capturing their interaction and combined effects with traditional capacity improvements (lane widening, new connections, service improvements) is also very important if the overall conditions of the transportation system are to be analyzed.

Variation in Conditions

It is important to capture the effects of non-recurrent variation in demand due to incidents, weather, construction, etc. Expanding the analysis to include the variation in conditions when incorporating ITS/ M&O strategies into the analysis is critical to capturing their true impacts. This can be represented by condition scenarios, or representative days, which are selected to capture a type of incident/occurrence that may lead to the traveler experiencing very different conditions and possibly a different travel choice. Figure V-9 shows some of the issues that may determine how/why the scenarios are selected. An important consideration is the randomness of the event, and its area of influence. The system response to a local predictable event such as construction may be very different to a global unpredictable event such as a severe rain storm or typhoon.

Figure V-9 Importance of Information to Unexpected System Variation



- Classifying events that do not conform to expectation
  - Predictability of event
  - Geographic Scale of impact
- When expected conditions are not met ATIS user services provide
  - Estimates of travel time
  - Information on alternative paths, modes, and departure times

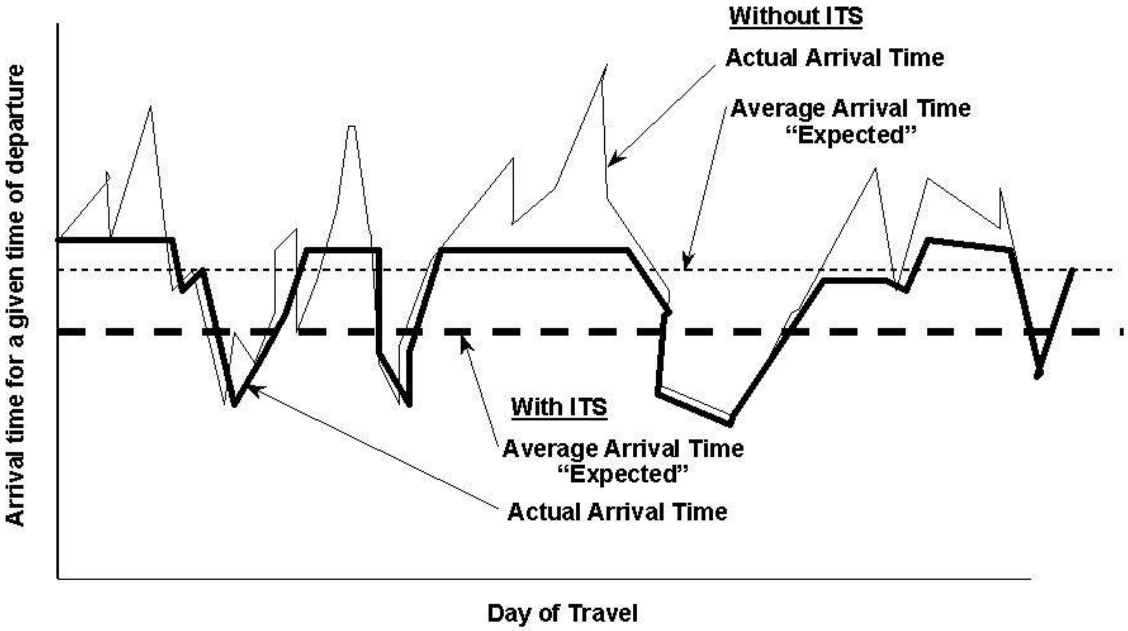
Perturbations to Roadway Supply or Travel Demand Make Information Valuable

Source: Mitretek, 1999

Average versus Variable Conditions

As shown in Figure V-10, the improvements in reliability and/or variation may also have an impact the expected conditions represented in the regional model system that can in turn influence the day-to-day travel decisions individuals make. Figure V-10 shows the arrival time for a given departure time for different days throughout the year. For example, if someone leaves their house every morning at 7:00 AM they will arrive late due to accidents, weather, and just random incidents on some days, and on other days they will arrive early. The figure shows both the observed arrival time and the average or expected travel time with and without ITS. Without ITS bottlenecks occur and people are caught in the congestion caused by incidents, etc. With ITS traffic can be re-routed, incidents are cleared faster, information is provided prior to the trip, and the worst cases of delay are thus avoided. This in turn can change the expected arrival time for a given mode and the travel choices people make. If the chance that they will be an hour late on a mode such as transit (due to missed transfers, etc.) can be eliminated, the average travel time is improved and the likelihood that they will take transit increases. The results from the representative day simulations are therefore combined to estimate the change in expected, or perceived, conditions. If, as is common practice, non-recurrent events are not included in the base measurement of system conditions, the change in the average due to ITS can’t be captured. More important, in many instances analyzing only average conditions will under estimate improvements even if non-recurrent events are part of the base measurement because of the disproportionate affects of incidents.

Figure V-10 Conceptual Impact of ITS on Average Conditions



Source: Mitretek, 1999

Time Stream Issues.

As already stated, in the Integrated Framework the time stream of impacts, benefits and costs must be estimated. Section V.D on alternative development described how this requires an incremental approach to estimating the overall impacts of the development path rather than simply estimating the horizon year conditions. Equally important, is understanding the temporal dimension of each ITS strategy on behavior and the time it takes to produce an effect. Table V-13 shows some of the temporal affects of different ITS elements, and when different types of effects might occur, from instant impacts on operating characteristics, to long-term changes in trip making, economic activity, and land use patterns. If time-streams of impacts are to be estimated understanding when the impacts effects will take place due to an improvement is very important.

Integrated Services and Synergy of ITS services.

Because ITS is focused on operating and managing the overall transportation system it is often difficult to separate out the impacts of individual components. Consequently, bundles of services and/or market packages need to be analyzed. This also means that it is often difficult to implement a "minimum buildable segment" as is often the case in traditional improvements and achieve the maximum benefits that can be produced. The different ITS strategies can also interact to support one-another and create synergistic effects that are greater than if implemented separately.

All of these point to the need to have a conceptual model of how each alternative will impact travel and behavior. This provides a check and balance to ensure that the benefits that are calculated are properly captured and are reasonable.

Table V-13 Temporal Dimensions of ITS

	Time of Impact			
ITS Element	Instantly	Short	Mid	Long
Traffic Signal Control	X			
Freeway Management	X			
Transit Management	X			
Incident Management	X			
Electronic Fare Payment	X	X		
Electronic Toll Collection	X	X		
Railroad Grade Crossings	X	X		
Emergency Management Services	X	X		
Regional Multimodal Traveler Information	X	X	X	
System Integration.	X	X	X	
Type of change				
Operating Characteristics	X	X		
Time of Departure	X	X		
Mode		X	X	
Route	X	X		
Trips and destination	X	X	X	
Activities	X	X	X	X
Economic Activity and Land Use			X	X

Other Methodological Issues

Just as a reminder, any inputs, outputs, and measures that are required for planning analysis must be forecasted. This creates differences between the near term measurement of actual conditions, and the longer term forecasts required for planning future systems. For example, the occurrence of accidents on a road segment and variation in conditions can be measured. However, to conduct future analyses assumptions on the future level of accidents in the base case must be made, or a model/relationships developed to predict them.

Also as discussed in the application section. A Tool box of techniques should be developed to match the levels of analysis and available resources to the decision needs at hand.

V.E.1.2 Costing issues

Costs for each integrated alternative must also be estimated. Agencies have less experience with implementing ITS and hence have less experience on how to estimate their capital and operations and maintenance (O&M) costs. Because the operations and maintenance requirements for ITS are typically higher, continuous, and more uncertain than those of traditional construction projects, funding for on-going operations and maintenance is a major concern for agencies that decide to implement ITS. Many agencies are beginning to recognize after the fact that ITS improvements require operations, management, and maintenance resources on a continuous basis. The issues associated with conducting consistent cost analyses across all elements of an integrated alternative are examined below:

Life Cycle Costs

As already discussed this includes estimating the life-cycle costs to implement and operate all elements, both ITS and traditional. Failure to consider the capital and O&M costs of ITS during the planning and development phases could lead to funding shortages, or even worse, the inability to properly operate and maintain a deployed system. Plans and developments including future ITS improvements will not bode well if systems already deployed with taxpayer dollars are improperly operated or inadequately maintained. The ITS Joint Program Office (JPO) has provided and maintains the ITS Unit Costs Database (http://www.benefitcost.its.dot.gov/) that includes ITS components, lifetime estimates, and associated capital and O&M costs. The database structure closely follows that of the National ITS Architecture.

There are 21 subsystems each of which are further defined by individual components or elements. Elements include equipment installed at the roadside and within centers as well as labor categories to account for operations costs. Capital costs are provided as one-time startup costs while O&M costs are provided as annual estimates. Because the database provides data that is not directly related to a specific region or product vendors, capital and O&M costs are provided as a range from low to high. The database is available for transportation agencies and their consultants to develop cost estimates of future and planned ITS improvements. As will be discussed later in this chapter, tools are available to assist planners and project engineers in estimating the lifecycle costs of ITS improvements. The ITS Unit Costs Database is a source for one of the planning tools. However, life cycle costs for traditional elements may still be difficult to come by.

The Maricopa Associations of Governments (MAG), the MPO for the Phoenix area, has included a cost requirements section in their MAG ITS Strategic Plan Update (MAG, 2001) to assist planners in estimating and predicting cost and resource requirements of ITS projects. These cost estimates are useful in budgeting and operations planning, and determining the level of funding required to provide sustained operations and maintenance of ITS deployments. Costs from the ITS Unit Costs Database are used by MAG; however, local cost are used whenever available. In addition to estimating capital and O&M costs when comparing the estimates for various deployments, MAG also determines the annualized costs of deploying, operating, and maintaining an ITS improvement, and replacement of ITS equipment as it reaches its expected lifetime. This annualized cost is obtained by amortizing the capital cost over the expected lifetime for each ITS component. The annualized capital value is added to the annual O&M costs to obtain the annualized cost value. This cost figure is useful to planners in securing resources for the long-term operation of ITS projects. Likewise, this figure is useful in benefit/cost analysis to determine whether or not an ITS improvement is cost effective. To further assist planners with scaling ITS projects and estimating associated costs, capital, O&M, and annualized costs are broken down as infrastructure and incremental. Infrastructure costs include the basic underlying components of an ITS center that must be in place in order to support the operation of field equipment. Labor categories associated with systems operations are included under infrastructure. Incremental costs include the cost of each piece of field equipment deployed. Care must be taken to avoid double accounting of infrastructure costs. Computer software and hardware used to process and control variable message signs also may be used to process and control traffic detection data from roadside sensors.

The Florida DOT began to actively address costs of ITS deployments when the agency realized discrepancies in costs of ITS projects throughout the state. A statewide cost analysis was performed and results were published in the ITS Costs Analysis Issue Paper (PB Farradyne, 1999) and incorporated into the Florida Statewide ITS Strategic Plan (FDOT, 1999). The purpose of the cost analysis was to establish cost ranges for future ITS deployments, identify various project factors affecting cost, and provide general guidance for control ITS project cost. Cost implications associated with project lifecycle phases are described. Agencies preparing for ITS improvements may want to review the cost strategies in use by the MAG and Florida DOT.

Although O&M costs of ITS improvements need greater attention than received in the past, the capital costs of software development also warrant greater attention. Software used to process the vast amounts of data collected from ITS sensors, and control the processing and communications within and between traffic operation centers is a relatively new concept in the traditional surface transportation world. Similar software germane to defense systems is notably expensive and requires planning, development, training, and testing that spans several years. Transportation agencies embarking on large, complex software projects should be aware of the costs associated with such an undertaking. Not only are the initial startup costs high, but maintenance of software can be high as well. Factors to consider when estimating costs of an ITS improvement include determining whether or not software should be developed as a specific regional application or purchased off-the-shelf, and how does the use (or not) of standards affect cost.

As agencies consider the cost of different approaches and designs alternative financing options should be included. Examples in use today include resource sharing along freeway right of way between agencies and telecommunication companies, and expanded partnerships in electronic toll payment systems. Other alternatives to cost include taking advantage of Internet-based solutions to help keep cost down, reusing of software, and considering out-sourcing all or portions of operating centers. The latter alternative may be higher in the long run, but may be worth it because the transportation agency is better able to retain qualified staff

Economic Life of ITS and Communication Elements

The economic life (or lifetime) of individual system components impacts how a project is discounted and the replacement need when estimating life cycle costs. The typical design life of roadway projects is 20 years, and rail structures may have up to a 100 year design life. Due to rapid advancements and early obsolescence technology elements have much shorter lives of as low as 3 to 5 years (PB Farradyne, 1999). PCs for example rapidly become obsolete and parts and software become difficult to maintain. Information supporting either complete equipment replacement or major upgrades needs to be considered as design and maintenance alternatives. Communications equipment may need to be replaced frequently depending on technology advancements. When comparing costs the economic life assumptions should always be examined.

Shared Costs, Cost Allocation, and Cost Breakdown Structure

Whether costs are shared among different ITS services, and how they are allocated between roadside, and center systems can have a significant impact on how costs are reported. As mentioned earlier, the ITS Unit Costs Database is based on a subsystem structure. Components and cost are grouped based on their physical location. That is, cost of a CCTV video camera would be found in the Roadside Detection subsystem and computers for processing and controlling the camera would be found in the Transportation Management Center. To estimate the cost of a camera deployment, cost would need to taken from the two subsystems. More important, because ITS is relatively new there is no standard cost breakdown structure to use to allocate costs consistently. Often reported costs become a function of the budget structure found in the operating agencies and the historic distribution of responsibilities. Thus, labor costs for system operations, may be reported in maintenance budgets, or vice-versa (Daniels, G. & Starr T. 1996). Transportation Management Center costs may be separate, or allocated to the services they support. Also, costs are often reported at the system level making it impossible to retrieve unit cost necessary to develop incremental deployment estimates.

Given the high cost of software development projects there are several cost sharing options to help agencies procure the system functionality while minimizing costs: pooled fund projects and software reuse. Pooled fund projects usually require a setup or participation fee from all participating agencies. Additional costs are incurred when software is modified to meet the individual transportation agency’s needs. The Condition Acquisition and Reporting System (CARS) is an example of a pooled fund project. The DOTs of Iowa, Minnesota, Missouri, and Washington were the initial participants with an additional four more states actively participating. Reuse of software developed by another transportation agency typically by in-house staff is yet another way to contain the costs of ITS improvements. If not properly structures, planned and managed costs can skyrocket. Porting of the Georgia DOT NaviGAtor system, all or in part, into other transportation management systems is an example of software reuse. State DOTs using or considering use of the NaviGAtor include Florida, Oregon, and Utah.

When using cost estimates from previous deployments and other costs sources it is imperative to understand the assumptions associated with the cost figures, the components included in the cost estimate, knowing whether or not maintenance was incorporated into the cost and more importantly how the maintenance cost was determined. Depending on the ITS component, maintenance can be provided by in-house staff or by the vendor. With the latter, vendors may rollup a year or more of maintenance as part of the initial purchase. Knowing how and what is included in cost estimates allows planners to adequately budget for ITS projects.

Need for Causal Costing Methods

In the past, many cost estimating methods have calculated O&M costs as a percentage of capital costs. This is fine for fixed facilities where there is a history of experience and cost factors are well known. It is fraught with problems when evaluating advanced technologies. Every attempt should be made to develop cost build-up models based upon logical cost factors such as hours of operation and full time labor equivalents. This may also be important when allocating shared center costs among services.

When available, the O&M costs in the ITS Unit Costs Database includes a description of each ITS component and indicates cost allocations to operations and maintenance. In many descriptions of labor components, the number of staff and salary range are provided.

User Costs for ITS Services

Because some ITS strategies (such as ATIS) involve consumer purchase of equipment or services, alternatives that depend on such decisions must address these costs somewhere in the analysis. This issue is non-trivial since assumptions must be made about the costs and number of users (or market penetration). These costs should be treated as a user disbenefit rather than a cost, since cost is generally defined as public agency costs. In addition, since the private sector is expected to play a big role in the delivery of ATIS services, the treatment of private sector service provider costs is another issue to be addressed. One way to handle this may be through keeping the actual costs to the private sector internal to the cost analysis system by estimating user fees as the cost transfer mechanism. This in turn is a way to address the user costs.

Uncertainty of Emerging Technology Costs

With any developing technology there is a natural adjustment in costs as it reaches wide market penetration. Fax machines, computers, cell phones are examples where prices have dropped beyond all past expectations as advancements have been made and they have become ubiquitous in society. Predicting future costs of ITS products is therefore difficult at best. Where possible, national forecasts and experts should be used

Telecommunications – particularly wireless – is an ever-evolving market that can change given shifts in policy and technology advancements. Different deployment options such as shared resources (right-of-way sharing between the transportation agency and communication providers), lease versus own, or combination should be considered. Cost estimates using complete lifecycle costs should be developed for each option. Communication rates vary regionally and from carrier to carrier as such obtaining cost estimates from local providers may prove more useful.

V.E.1.3 Secondary Impact estimation issues

Last, are the external impacts that result from the transportation system and travel impacting the environment and society. Often these impacts are closely related to the goals and objectives of the region. They include:

- Emissions
- Energy
- Noise
- Safety (accidents and fatalities)
- Social equity

These impacts are the result of the interaction between the transportation network and travel demand and behavior and are consequently, typically analyzed using post-processing of the outputs of the Transportation and Travel Demand analysis. Again, the methods for estimating these impacts must now reflect how ITS changes the system. This should include changes to operating relationships as well as the occurrence of unusual or special events. Examples include developing new “modal” emissions models that capture changes in high accelerations and decelerations, and accident models that use Volume to Capacity ratios, and/or number high accelerations and decelerations to estimate crashes (see NHI, 1999).

Estimating the impacts of integrated alternatives combining ITS and traditional elements requires that the influence each have on the system be accounted for consistently. ITS provides information to both system operators and users. This allows both to respond to variations in expected conditions altering the supply and use of the system. Estimating impacts such as safety and air quality must also incorporate new relationships in how the system functions and performs. For example, introducing a coordinated signal system can drastically alter the stops and starts in traffic flow and as a result reduce emissions. Emissions models based upon average speed which do not account for these changes will consequently under predict air quality savings for the signal system. All components must also be treated the same in the system. For example, in the past maintenance and operations costs have often not been included in analyzing road improvement options. Now the life cycle costs of all elements including both ITS and traditional improvements need to be estimated.

V.E.2 APPLICATION WITHIN THE INTEGRATED FRAMEWORK

In the Phase I data collection for the development of this Guidebook, the perceived lack of ITS impact information (benefits and costs) and methods for their estimation was continually raised as the number one issue/barrier for integration of ITS into planning (Mitretek, 1999b). This included not only a need for documented examples and evaluation studies, but also ways to capture the impact of ITS within their existing planning processes/measures and reflect the new dimensions that ITS focuses on trying to solve. The inability to capture the synergies of combined ITS strategies and integrated solutions was also raised.

Research found, however, that a large amount of information on ITS impacts is now available and is growing rapidly. Special efforts have also been made to develop new methods for impact estimation. This section briefly describes these available resources and methods as well as the issues and concerns associated with estimating impacts of alternatives (ITS, M&O and traditional improvements) within the Integrated Framework.

How to estimate the impacts depends upon the level of detail needed, resources (time, staff skills, and cost), and the point in the decision cycle being addressed. Approaches that are available, or under development, include:

- Benefit data bases/tool boxes
- Empirically based Sketch techniques (rules of thumb)
- Causal sketch models and post-processors (IDAS, emissions and safety models)
- Regional Network Models
- Simulation (macroscopic and microscopic)
- Linked travel demand and simulation tools
- Models based upon new paradigms in travel forecasting (TRANSIMS)

These vary by: coverage and level of detail; complexity and ease of use; and their internal causal relationships and ability to capture integrated solutions. Which to use when within the Integrated Framework and the Issues and concerns associated with estimating impacts in general is examined throughout the remainder of this section.

Impact data bases, Toolboxes, and Qualitative Assessment

These provide valuable insights in the early stages of alternative development and the exploration of elements for the Integration Strategy. Their applicability is based upon the assumption that the region's/systems are similar and will provide similar results. They rely on previous experience or expert judgment. These assessments are used everyday by project managers in selecting the candidate projects for further investigation, and making quick evaluations. Some sources of information are:

- ITS Benefits and Unit Costs Database (http://www.benefitcost.its.dot.gov/)
  Since December of 1994, the United States Department of Transportation's Joint Program Office for Intelligent Transportation Systems has been actively collecting information regarding the impact of ITS projects on the operation of the surface transportation network. Data collected under this effort is available in the ITS benefits database. Several related reports are also available for viewing and downloading, including a one page desk reference that summarizes available data. The ITS Joint Program Office (JPO) also collects information on ITS costs, and maintains this information in the ITS unit costs database. The database is a central site for estimates of ITS costs data that the ITS JPO can use for policy analyses and benefit / cost analyses. In addition, the database can be viewed and downloaded as a costing tool for ITS implementers. The Data Needs section of this site contains information related to

the effort to identify the areas of ITS application in greatest need of evaluation to assess their impact on the surface transportation system. Mitretek Systems Inc. maintains and analyzes the information collected for each of these efforts.

- Intelligent Transportation Systems Benefits: 2001 Update (Maccubbin, R.,2001)
  Periodically, the ITS Joint Program Office publishes a report as a compendium of reported impacts of ITS that have been collected from a number of sources. The purpose of the report is to provide the JPO with a tool to transmit existing knowledge of ITS benefits to federal, state, and local decision makers and to the interested public. This report is also intended to provide the research community with information about where further analysis is required in the ITS program. The 2001 Update provides a comprehensive discussion of the reported impacts of ITS contained in the online database, with brief summaries of the documents entered since the 1999 Update report.

  - ITS-Transit Impacts Matrix (http://web.mitretek.org/its/aptsmatrix.nsf)
    The web site provides a single source for displaying the impacts -- benefits and costs -- of Intelligent Transportation Systems (ITS) for transit. It was created to make this important information more accessible to the transit community. Transit ITS is a comprehensive approach to applying information technologies to transit to improve customer service and reduce system capital and operating costs. For the 30+ Transit ITS technologies/services (automatic vehicle location, transit priority treatment, pre-trip transit information, guidance/steering assistance, etc.), the following information is provided: Details of technology/service, and Qualitative Impacts and Quantitative Impact Examples (where available) of technology/service. Mitretek Systems Inc. maintains this web site on behalf of FTA.

  - Congestion Management and ITS toolboxes
    - A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility (Meyer, M for the Institute for Transportation Engineers, 1998.)
    - ITS Rural Toolbox for Rural and Small Urban Areas (Castle Rock, & Black & Veatch, 1999)
    - Technology in Rural Transportation “Simple Solutions” (Castle Rock, 1997)
    - Improving Transit With Intelligent Transportation Systems (Smith, H. ,1998)
  - Other ITS Handbooks
    - ITS Planning Handbook: Intelligent City Transport (ERTICO ITS City Pioneers, 1998)
    - ITS Handbook ’99 (World Road Association - PIARC, 1999)
    - Integrating Intelligent Transportation Systems within the Transportation Planning Process: An Interim Handbook (Transcore, 1998)

Sketch Planning Techniques

Generally straight-forward, parametric, or spreadsheet analyses that provide an approximation of potential impacts (may rely on historical data). These are often used when there are a large number of options to evaluate, the impacts are localized, or the individual projects relatively small. They are also used to screen an initial set of alternatives to likely candidates for further study. They may also be used to calculate adjustments to the inputs of planning and simulation models. Two Recent tools developed by the U.S. DOT to support ITS Analysis are the Screening for ITS (SCRITS) sketch tool, and The ITS Deployment Analysis System (IDAS).

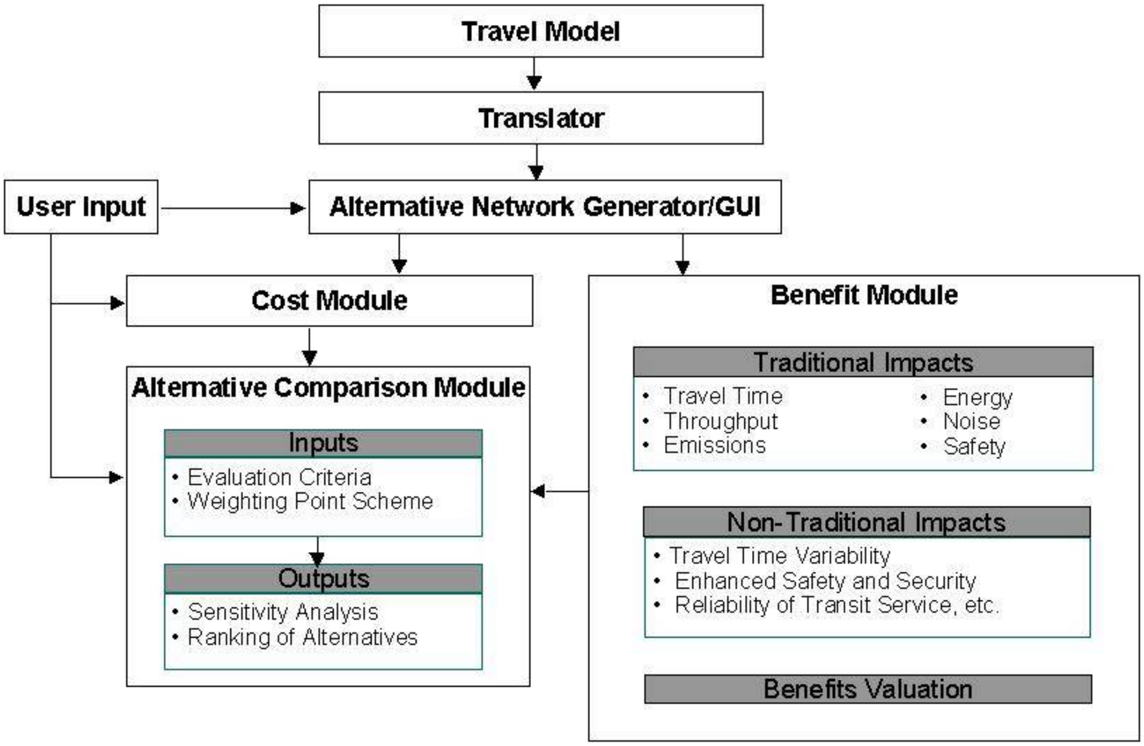
SCRITS is a spreadsheet sketch tool that can be used for estimating the user benefits and screening ITS options (SAIC, 1999). It provides daily analysis only for 16 different types of ITS. The user inputs base-line data and then SCRITS estimates changes in VHT, VMT, emissions, vehicle operating costs, energy consumption, number of accidents, and user economic benefit. It does not estimate system operating or capital costs. Information on SCRITS can be found at the FHWA website: http://www.fhwa.dot.gov/steam/scrits.htm.

IDAS is a new tool designed to assist public agencies and consultants in integrating ITS in the transportation planning process. It is designed to work as a post processor of regional planning models using their networks and trip patterns as inputs (Cambridge Systematics & ITT Industries, 2000). It comes with an extensive ITS benefits library for comparison of expected impacts, a ITS cost and equipment data base, and its analytic procedures with default impact settings. ITS components considered by IDAS fall into one of seven categories:

1. Multi-Modal Traveler Information Systems
2. Arterial Traffic Management Systems
3. Incident Management Systems
4. Freeway Management Systems
5. Advanced Public Transportation Systems
6. Electronic Payment Systems
7. Commercial Vehicle Operations

IDAS estimates the impacts on both costs and benefits at the system and user level. Its overall framework is shown in Figure V-11. Changes in network performance may engender impacts in both assignment, mode choice, temporal choice and induced/foregone demand. These impacts are then fed through a range of impact assessment modules, which identifies travel time/throughput, energy, emissions, noise, and safety impacts. Non-traditional measures used to capture the unique characteristics of ITS include changes in travel time reliability, transit service reliability and enhanced Safety and Security. Costs of ITS deployments are constructed with implicit cost-sharing arrangements identified internal to the software. For example, a new traffic management center (TMC) need not be constructed for each ITS component deployed – IDAS automatically assumes shared costs through an integrated deployment. Benefits are converted to dollar-figures and cost-benefit ratios of particular alternatives can be displayed within a alternatives comparison module. IDAS also allows risk and uncertainty analysis to be performed on many of the assumptions and inputs.

Figure V-11 IDAS Overall Analytic Framework



Source: Zavattero, D (TRB, January 1999)

Planning models

Models that forecast average (steady-state) travel and transportation demand and associated impacts over a given time period (daily, peak period, etc.), typically using some variant of the four-step method (trip generation, trip distribution, mode split, and assignment) with inputs from demographic and land-use projections. These tools are used to capture long-range impacts of transportation system changes at the regional level. They are also often used with refinements and additional detail for corridor and other more focused studies. They may be combined with sketch techniques and post-processors to analyze the impacts of ITS. ITS impacts that affect the overall capacity and performance of each facility are coded into the transportation network. Examples include the impact of coordinated signal systems, electronic toll and fare cards, HOV and advanced transit management improvements. Other shifts in behavior such as response to ride share programs or transit security can also be integrated into the regional models to determine their network impacts. Last, route diversion may be studied using special mode runs (See Module 10 of National Highway Institute's Advanced Urban Travel Demand Forecasting Course). It is difficult, however to capture the impacts of non-recurring conditions, or traveler information in regional models.

Simulation models

These models explicitly represent the movement of vehicles, traffic flow, and their interaction with the network through time (e.g., signals are explicitly modeled). They can represent unusual incidents in the system, and/or the availability of information to specific travelers and are consequently being used with more frequency to examine ITS strategies. Ramp metering, signal priority schemes, HOV analyses, and incident response are particularly appropriate. Since they must track vehicles by time they, however, typically do not have the capacity to represent complete regions in their analyses. They are consequently used more often for corridor and project operational and design analyses. Simulation tools may provide key inputs to a project's design and/or operation that cannot be addressed using other tools. Examples of simulation tools include: Macroscopic tools such as CORFLO, FREQ, TRANSYT-7F, SATURN, and CONTRAM; Microscopic tools such as CORSIM and INTEGRATION. (See NHI, 1999 for a summary of these tools).

Combined Planning and Simulation Methods

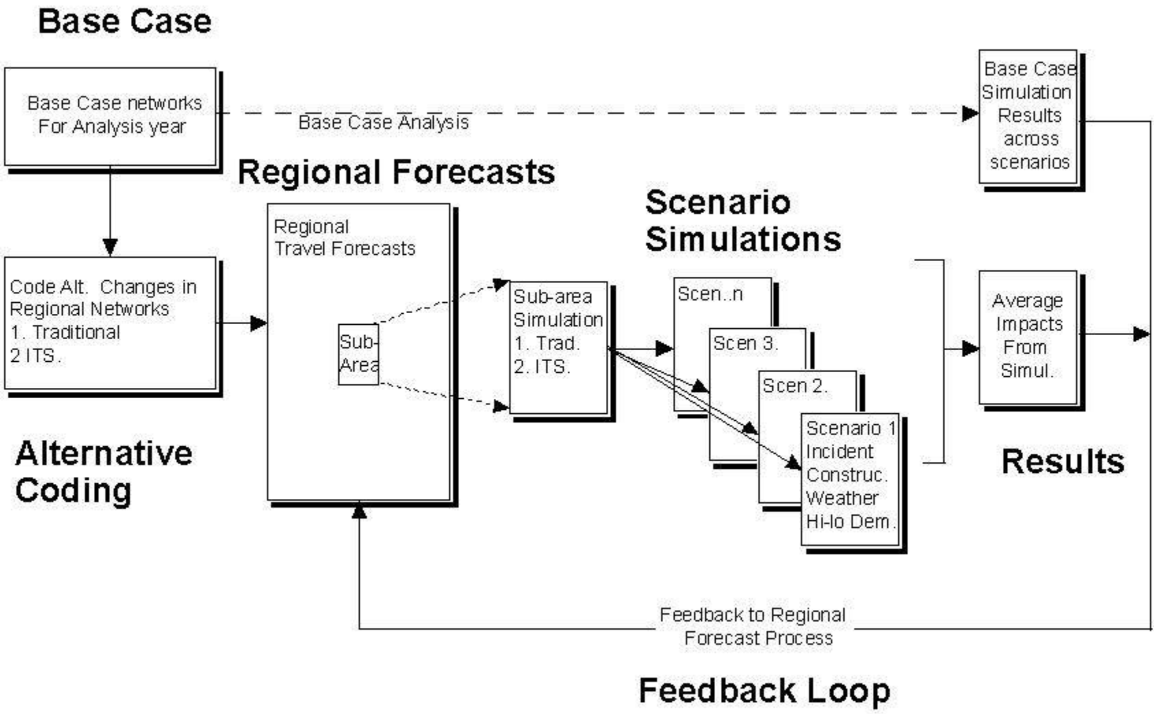
Combined planning and simulation methods interconnect planning and simulation models in an attempt to capture both recurrent and non-recurrent conditions in the analysis. They still are encumbered by the network limitations of the simulation systems they use, but are particularly useful in corridor or sub-area analyses of integrated ITS and traditional improvements. Outputs from the regional models can be used as inputs for subsequent post-processing using simulation. This, however, does not provide for feedback to impacts on travel patterns and behavior. A more elaborate linking allowing feedback can also be carried out. The I-64 Corridor Major Investment Study carried out between Richmond and Norfolk Virginia used the former (Rush & Penic, 1998). Mitretek Systems developed the Process for Regional Understanding and Evaluation of Integrated ITS Networks (PRUEVIIN) analysis framework for a Seattle Case Study using the latter (Mitretek, 1999).

The I-64 study used the regional forecasting models, and estimates of changes in travel times and trips due to ITS strategies to estimate overall travel demand and patterns in the corridor. Trips were reduced to account for demand oriented ITS strategies. Travel times and capacities were changed to account for capacity enhancing strategies such as ramp meters or auxiliary lanes. Post-processing simulations were then carried out to analyze traffic operations. Results from the simulations were used to estimate accidents, air quality, and other non-travel impacts. The study resulted in significant accident reductions and both recurring and non-recurring annual vehicle hours of delay due to the ITS strategies included in the alternatives.

PRUEVINN is a two level modeling framework developed to capture the overall travel impacts of ITS/operational improvements to the transportation system; the response to time-variant conditions (both recurrent and non-recurrent); and the impact of improved information. The model levels and their interaction are shown in Figure V-12. At the first level the analysis of overall travel patterns and the systems response to average/expected conditions is addressed in the traditional regional model system.

Outputs from the regional analysis must be interfaced with the more detailed second level of analysis. This level captures the time-variant and operational details of the transportation system using a sub-area travel simulation system. At this level the detailed traffic operations, queuing, and buildup/dispersion of demand is captured and the accuracy of the traveler's information on the system can also be represented. Another key element in capturing the impacts of ITS is the representative day scenario analysis to represent non-recurrent conditions. Last, feedback is carried out to ensure that the impacts to expected conditions estimated in the sub-area simulation are reflected in the regional analysis.

Figure V-12 PRUEVIIN Model Framework



Source: Mitretek, 1999

The Seattle Case Study found that the SOV Capacity Expansion alternative with the greatest capacity under average conditions diverted regional traffic, which caused it to show no improvements over the TSM option when the variations in conditions and incidents were introduced. Key attributes of how an alternative might perform under expected travel conditions This could not have been predicted using only the regional model.

New Paradigms in Travel Forecasting

New travel analysis tools that combine regional forecasting with simulation and activity analysis are now under development. TRANSIMS is a longer range travel forecasting model reformulation and development project being carried out by Los Alamos Laboratories for the US DOT. It will be based upon a traveler's activity patterns throughout the day and use simulation techniques to model ITS and other transportation system elements. TRANSIMS first release is now complete and ready for testing, however, the ITS capabilities are not yet available. It is expected that these features will be added sometime during the mid 00's. The Dynamic Traffic Assignment (DTA) program also represents the road network and individual vehicle movements in detail. It is focused on developing real time predictive control strategies for traffic operations. Currently, the DTA models such as DynaMIT developed by MIT have been used extensively for research and development, but are not available for general application.

V.E.3 VARIATIONS BY SCALE, SETTING, AND INSTITUTIONS

As discussed above to support the decisions that must be made within the planning process, a wide variety of analytical techniques are used to provide estimates of the potential transportation impacts and costs of alternative investment strategies. At each level of the process the appropriate analysis techniques differ in level of detail and effort required to use them (translating to the amount of resources required) depends on a variety of factors including:

- The scale and level of anticipated impacts of the decision (both geographic and temporal)
- Costs
- The number of alternatives
- The project time frame
- The decision time frame
- The phase in the project development cycle (concept, scoping, development, design, construction, operation).

Usually, less rigorous evaluation approaches are sufficient to support early, screening-type decisions (occurring early in the planning process) and more rigorous and detailed approaches and tools are desirable to support decisions with higher investment implications (either later in the planning process or for establishing a preferred alternative that will be considered a major investment to be folded into the transportation plan). For example, regional analyses using “planning model network tools” and representing “regionally significant” projects are usually used to support the transportation plan and its conformity analysis. Due to the long time-frame of the transportation plan these analysis techniques attempt to capture the major changes in travel patterns and location decisions, introduced by major options in a region’s future transportation system. Corridor analyses perform much a much more detailed examination of the impacts of alternative decisions within a corridor or sub-area. Their goal is to distinguish between the options to solve the corridor’s need and problems statement, and assist decision makers in making a preferred choice. The level of investment decision, issues to be resolved, time schedule of a typical corridor study usually allow fairly complex and detailed analysis procedures to be carried out. On the other hand, TIP and CMS analyses must select from a wide variety of projects and strategies, usually with a short analysis and decision time period. Sketch techniques that can be used to evaluate a number of alternatives quickly capturing localized effects and pivoting off of current (near term) conditions often suffice for these analyses.

V.E.4 SECTION REVIEW AND TRANSITION ASSESSMENT

This section provided a general overview and resources for estimating benefits, costs, and impacts of alternatives within the Integrated Framework. It is part of an iterative cycle of developing alternatives, estimating their affects, and evaluating their performance against the base case or other alternatives. In The Integrated Framework this occurs both within each planning cycle, and between different development paths, or full alternatives.

Estimating the benefits, costs, and impacts requires capturing how the alternative changes:

- Transportation supply
- Demand for travel
- External impacts
- Costs of the transportation system.

To capture the impact of ITS and operations one must include the variation in the system characteristics and unusual events, the time stream of impacts and their potential delay, and system affects or synergy of ITS and other components.

Costs need to reflect the time stream of when they will occur and the full life cycle for each alternative. Other issues include determining the economic life of new technologies, and cost allocation of shared services. Of course, uncertainty is always a factor as well.

Secondary impact assessment must capture how the integrated alternatives impact air quality, safety, and other social criteria such as equity and/or environmental justice.

A number of sources of information and methods are developing to help in the estimation of the above. These include:

- Benefit data bases/tool boxes
- Empirically based Sketch techniques (rules of thumb)
- Causal sketch models and post-processors (IDAS, emissions and safety models)
- Regional Network Models
- Simulation (macroscopic and microscopic)
- Linked travel demand and simulation tools
- Models based upon new paradigms in travel forecasting (TRANSIMS)

The level of detail and precision needed also varies by where you are in the integrated process. The benefit and cost databases and sketch tools are appropriate when one is investigating initial User Services, and long-term development path options. Simulation tools provide detailed operating support for ongoing services, or those that are in the process of being designed and implemented.

Table V-14 provides some questions that might provide some insight into where your region stands in how they analyze the benefits, costs, and impacts of integrated alternatives. Mark where you think your area's relative position is for each question.

Table V-14 Estimating Impacts, Benefits, and Costs Self-Assessment

Question	**NO YES**
Estimating Impacts, Benefits, and Costs	
Are the area's professionals aware of the US.DOT ITS benefits and costs databases and ITS Resource Guide? Have they used them to help determine potential ITS impacts?	NO - - - - - - - - YES
Is system variability and congestion accounted for in the analysis of alternatives?	NO - - - - - - - - YES
Is the IDAS sketch planning tool for ITS, or other methods, used to estimate impacts of ITS in the planning process?	NO - - - - - - - - YES
Are the time streams (life cycle) of benefits and costs estimated? Do these include all costs to operate and maintain each component of the system in a sustainable way?	NO - - - - - - - - YES
Are operational simulations or other analyses performed during system development?	NO - - - - - - - - YES
Is data collection and performance measurement used to continually make incremental service and other adjustments?	NO - - - - - - - - YES
Are plans underway to update the area's forecasting processes and assumptions to include operational assumptions and ITS (advanced traffic signal control, Transit Signal Priority, Transit AVL, etc.)	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

V.F EVALUATION OF ALTERNATIVES

Key Points of Section V.F

- Evaluation concerns the comparison of choices, or alternatives within the integrated process. It occurs at several places within integrated planning.
  - Within each cycle of planning (short, mid, long) as the path of development for an alternative is developed.
  - Between different paths of development, or alternatives.
- Evaluation within integrated planning raises a number of issues:
  - A broader set of objectives, measures, and evaluation criteria.
  - New uncertainties in technology, benefits, and costs.
  - The need to include operating or life cycle costs.
  - The need to address the time stream of benefits and costs, comparison of short and long term investments, and synergistic affects of ITS and other "systems".
  - The need to address cost allocation between public and private entities.
  - Inclusion of additional stakeholders.

For the purpose of this Guidebook, the word "evaluation" refers to a variety activities that support decisions on a transportation project – on what type of project to implement, on the design of that project, and on institutional and financial arrangements. The evaluation process uses the estimates of costs, benefits and impacts (see V.E) and organizes this information in ways that can support decision-making.

Evaluation occurs at many points in the process. At the state and regional level, there may be an evaluation of alternative policies, visions, scenarios, or future networks. At the corridor level there may be an evaluation of mode and location alternatives. Screening is a form of evaluation, in which a large number of alternatives is given a preliminary evaluation to arrive at a smaller set of the most promising alternatives. Once a project concept is defined, there may be an evaluation of design or implementation options.

Examples of evaluation involving ITS and operations include:

- Evaluating the merits of a specific project or technology
- Comparing alternative ITS solutions to a specific problem to identify the best ITS solution
- Comparing ITS with other capital investment options to identify the best solution or the best use of available funds.
- Comparing a capital investment option that includes ITS with other capital investment options that include ITS.

The word "evaluation" can also refer to the analysis of a completed project to determine its degree of success. Such evaluations may lead to decisions to modify the completed project, or to implement similar projects elsewhere.

V.F.1 CURRENT PRACTICE VERSUS AN INTEGRATED APPROACH

There are two standard approaches to evaluation – benefit cost analysis and multi-criteria analysis. Benefit cost analysis requires a full accounting of both costs and benefits, by year, appropriately discounted. Because of the difficulties inherent in putting a value on all transportation benefits and impacts, classic benefit cost analysis can be hard to apply.

In multi-criteria analysis, transportation alternatives are compared using criteria that reflect the problem to be solved. These criteria may include measures of effectiveness – i.e., how well each alternative solves the problem, compared with doing nothing or some other base case. The criteria may also include measures of cost effectiveness (capital and operating cost divided by some measure of benefit, such as travel time savings), financial feasibility, environmental impacts, equity (the distribution of costs and benefits), and public acceptance.

The integration of ITS and operations into planning complicates the evaluation process in several ways:

- The evaluation process must make use of a broader set of evaluation criteria.
- The methodology should be capable of dealing with uncertainty – in technology, in benefits, and in costs.
- Compared with traditional highway projects, operating costs are likely to take on greater significance in the evaluation. Life cycle costing approaches may be used to combine capital and operating costs.
- The analysis should recognize a time stream of benefits and costs, appropriately discounted.
- The analysis should compare short- and long-term investment options.
- The analysis should reflect the synergistic effects of system integration, including benefits across modes and jurisdictional boundaries.
- Where project costs are to be shared with other agencies or the private sector, decisions must be made on the costs to include in the evaluation – all costs to society in general, or agency costs only.
- The evaluation is likely to be shared with a broader range of stakeholders. It should be done in a way that makes sense to all decision-makers.

The evaluation process should utilize criteria that can be adequately addressed with existing tools and data. It should not be so complicated that it is onerous, excessively costly, or that the results cannot be explained clearly to decision-makers and lay people.

V.F.2 APPLICATION WITHIN THE INTEGRATED FRAMEWORK

Those considering the implementation of ITS should develop an evaluation methodology defining the criteria to be used, the kinds of information needed, and the sources of that information. Ideally, the methodology is developed at an early stage of the planning or engineering study so that it may guide the subsequent analysis process. Cost, benefit, and impact analyses should be conducted in such a way as to provide the specific data that is required to apply the evaluation methodology. Interested stakeholders should be involved in developing the methodology. This section identifies some of the technical and institutional factors to be considered when preparing the methodology.

V.F.2.1 Technical

Broader Set of Criteria.

Evaluating ITS requires a broader array of effectiveness measures than a more traditional evaluation of infrastructure alternatives. New criteria might include, for example, measures that relate to non-recurring congestion, safety, and customer service.

Virginia's I-64 MIS used measures of effectiveness that could be applied to all transportation modes and types of improvements – including measures that highlighted the performance of ITS strategies. Primary measures of performance were:

- Capacity enhancement
- Accident reduction
- Recurring delay reduction
- Non-recurring delay reduction
- Demand reduction (or diversion of trips to alternate modes)
- Peak period and peak hour travel time

Dealing with Uncertainty

Predicting the costs and benefits of ITS involves considerable uncertainty. Technology is advancing rapidly, and costs are dropping. The rate at which new technologies will be embraced by the marketplace, as well as how travelers will respond to technological innovation, may be difficult to predict. The economic life of a particular new technology will be hard to forecast as well. Strategies for dealing with uncertainty include:

- Acknowledge the uncertainty and document all assumptions.
- Use a range of estimates.
- Use conservative estimates.
- Rely on experts to verify assumptions.
- Identify all costs and benefits that cannot be estimated.
- Adjust assumptions and findings to match the level of uncertainty.

Life Cycle Costing

The operating costs of ITS can be significant, and over time may exceed the initial capital cost. The analytical process of factoring these costs into a benefit-cost or cost effectiveness framework is relatively straightforward. First the alternative, the project, or the program is defined in terms of its complete implementation schedule. The implementation of ITS may entail many separate steps, with elements that are deployed and become operational at various points in time. Second, the time stream of capital and operating costs is estimated. Then, the annual costs are discounted and summed to derive the net present value.

The Integrated Framework proposes that the planning process evaluate long-, mid-, and short-term needs and solutions. Ideally, this will lead to a multi-year program of projects in some logical sequence. The planning process identifies a not only projects, but also “paths” that lead incrementally over time to full implementation. Life cycle costing techniques can be used to compare different projects or alternatives that have different implementation schedules.

To evaluate ITS in terms of its financial feasibility, the time stream of capital and operating costs can be compared with projections of annual revenues.

Synergistic Effects

Many ITS benefits result from system integration. For example, development of the core ITS infrastructure by itself may have few in any benefits. It is only as other systems connect to this core infrastructure that benefits occur. If the core were evaluated as a stand alone project, it might not fare well in an evaluation. These synergies need to be appropriately reflected, although estimating the benefits may be difficult.

One way to accommodate this in planning is to develop packages of ITS improvements and analyze them as a group.

Cost Sharing

The costs of implementing an ITS strategy may be shared among multiple parties – State and local governments, highway and transit agencies, multiple jurisdictions, public and private sector, etc. The integration of related elements can reduce the cost and increases the benefits for all.

Morgan State University performed a benefit-cost analysis for commercial vehicle information systems and networks (CVISN) in Maryland. The analysis predicted the capital costs, operating costs, and benefits for nine state regulatory agencies and commercial motor carriers. The following costs and benefits were included:

- State CVISN investment costs (computer network and new inspection facilities)
- State maintenance and operating costs
- Motor carrier CVISN component costs (transponders, computers and software)
- Savings in agency time and costs
- Savings in motor carrier operating time and costs
- Net safety benefits (CVISN enhanced road-side inspection for out-of-service placement and identifying overweight vehicles)

A benefit-cost or cost effectiveness evaluation process may take a broad “societal perspective”, identifying all costs and benefits to society, or a narrow “agency perspective” that looks at only the costs and benefits to a particular agency. Both approaches have legitimacy under different circumstances. Using both approaches simultaneously may provide useful insights. To determine appropriate cost-sharing arrangements, it may be helpful to show how the benefits of an ITS deployment would be distributed among different user groups. Use of the agency perspective does not imply that an ITS deployment will not be integrated with other technology applications.

For a financial feasibility evaluation, it makes sense to identify the cost responsibilities of each participating entity and compare those costs with each entity's available resources.

V.F.2.2 Institutional

Stakeholder Involvement.

The process for evaluating ITS may involve a broader set of stakeholders. An ITS solution may cross jurisdictional boundaries, involve different modes, and include private sector participation. The evaluation methodology should be designed to meet the decision-making needs of each participating entity.

Since ITS strategies may not be well understood by study participants and decision-makers, educating them about ITS may be an important part of the evaluation effort. Obtaining stakeholder buy-in on the evaluation methodology and the assumptions can aid in reaching consensus on a preferred solution.

In Virginia's I-64 MIS, stakeholder involvement led to a team problem-solving approach through which the stakeholders helped the study team find data to use in the analysis and evaluation of ITS.

V.F.3 VARIATIONS BY SCALE, SETTING, AND INSTITUTIONS

Evaluation is local and case-specific. The criteria should always reflect local problems, issues, and the information needs of the decision-makers. The evaluation methodology should be tailored to the decision at hand, the information needs of those who will be making the decisions, the kinds of benefit and cost information that can reasonably be developed, and the range of alternatives being considered. Although there are generally accepted principles of benefit cost analysis, there is no one right set of criteria and thus no one correct analytical approach.

In most urban areas, the travel demand models and other analytical planning tools do not currently provide credible predictions of technology's potential impact on behavior and system performance. They may predict average peak period conditions, but be incapable of dealing with incidents and travel time reliability issues. Moreover, most parts of the country do not have the resources to develop new modeling tools for analyzing ITS. They may be unfamiliar with analytical approaches to evaluation, not trust the input data, or believe that the degree of uncertainty makes a definitive evaluation impossible.

Advances in the state-of-the-practice are more likely to occur incrementally, as part of broader model updates and advances in the state-of-the-art of modeling. Meanwhile, many analysts are likely to rely on simpler approaches for developing the input data for evaluation.

Lacking models that could predict the benefits of ITS strategies, the I-64 MIS in Virginia relied heavily upon the actual experiences of other jurisdictions and from evaluation findings realized in other ITS studies. The study team collected data by various means – database research, review of published sources, contacts with ITS professionals, Internet searches, and telephone calls to jurisdictions that have implemented or evaluated specific ITS strategies.

One low cost way to analyze and evaluate ITS is to look for look for analogous situations elsewhere in the country that have experience with implementing ITS. Ask questions of those who are familiar with the actual deployments, such as:

- Did the deployment function as expected?
- Are the agency and its customers satisfied with the deployment's performance? Why (or why not)?
- How large was the deployment?
- How much did the deployment cost to implement?
- How many people are required to operate the system, and what are their wage rates?
- What would you do differently next time?

Make use of the data resources identified in this Guidebook. Consult the U.S. DOT's ITS website (www.its.dot.gov).

V.F.4 SECTION REVIEW AND TRANSITION ASSESSMENT

This section described different approaches and issues concerning the evaluation of choices within integrated planning. Evaluation takes place at many levels within the integrated process. Choices must be made on the mix of ITS, operations, and traditional solutions within each planning cycle: short, mid, and long-term. These lead to the development of an alternative's full development path from today to the horizon year. Alternate development paths, or full alternatives, which reflect different policies, values and principals, or major investment choices can also be evaluated and compared.

Integrated planning complicates evaluation of future options in several ways. It introduces:

- A broader set of objectives, measures, and evaluation criteria.
- New uncertainties in technology, benefits, and costs
- The need to include operating or life cycle costs
- The need to address the time stream of benefits and costs, comparison of short and long-term investments, and synergistic affects of ITS and other "systems".
- The need to address cost allocation between public and private entities.
- Inclusion of additional stakeholders.

Table V-15 provides a set of self-assessment questions for your area's status regarding expanding evaluation to meet the needs of integrated planning. Mark your area's relative position on each question.

Table V-15 Alternative Evaluation Self-Assessment

Question	NO YES
Alternative Evaluation	
Does the evaluation process account for tradeoffs between near and far term improvements?	NO -------- YES
Does the evaluation process incorporate the new goals and objectives previously discussed?	NO -------- YES
Does the evaluation process provide for examining tradeoffs between ITS, operational, and system enhancement improvements, alone or in combination?	NO -------- YES

Mark the relative position of your area's advancement.

V.G PLANNING TO PROGRAMMING

Key Points of Section V.G

- Programming matches activities to available resources (budgets, funding sources, revenues)
- The planning to programming link is heightened in the Integrated Framework.
  - Focus on cycles of planning (short, mid, long)
  - Operations and Maintenance are significant costs of ITS and operations.
  - Crosses traditional funding categories and boundaries.
- In the past dedicated funding for ITS often bypassed many programming issues. This is no longer possible and ITS must compete with other demands for such CMAQ, NHS, STP, and local funds. As part of TEA-21 many Federal sources have become more flexible and can be applied to operations.
- Issues to address in expanding programming to the integrated process include:
  - Expand the criteria to include reliability, customer satisfaction, and other operationally oriented goals and objectives.
  - The indivisibility of ITS. It often can’t be done in pieces.
  - Enabling technologies and phasing.
  - System benefits and synergy of ITS systems.
- Options to assist in integrated programming include:
  - Assignment to specific funding categories (not recommended).
  - Lexicographic and hierarchical programming based upon maintaining and operating what you have first.
  - Development of new weights and criteria.
  - Combining ITS and traditional projects.
- Other activities include:
  - Bundling ITS projects in deployment packages.
  - Using current performance data.
  - Working towards flexible programming.
- Operations should also be linked to programming and new operations oriented stakeholders included.

Programming is the process of matching activities with available budgets, funding sources, and generated revenues. For a number of reasons, the link between programming and planning takes on a heightened importance in the Integrated Framework. First, the Integrated Framework focuses on what can be done with available resources to address existing problems first, in the short-term, then in the mid-term, and finally in the long-term. Consequently, programming is closely tied to the decisions that are made within each cycle and the problems that remain for the next cycle. Second, with ITS and operations, resources must be programmed to operate and maintain the systems after they are implemented. Thus, any decision made today may have long-term resource requirements. Third, by its very nature the integrated process is examining tradeoffs and implicit allocation decisions across funding boundaries that may have been previously fixed: operations versus capital, ITS versus traditional improvements

Within each planning cycle programming:

- Identifies priorities for implementation
- Allocates funds to activities (project development, operations, maintenance, and preservation) by funding source.
- Identifies implementation schedules for priority activities matching funding availability.

Programming is part of the implementation of the plan. Programming decisions should flow from a sound planning process that identifies needs, develops the strategies to be used for addressing those needs, and estimates the costs and benefits of the strategies. Note, that programming and short-range planning are different. Planning identifies strategies, whereas programming allocates funds to those strategies and schedules them based on funding flow.

In integrated planning programming is also not limited to the Federally mandated TIP and STIP process. Most government entities as well as private entities develop capital programs and budgets.

V.G.1 CURRENT PRACTICE VERSUS AN INTEGRATED APPROACH

Once the development path and overall integrated time stream of activities is defined projects and ongoing operations must still be programmed to match budget categories and availability of funds, implementation schedules, and areas of responsibility. In the traditional planning process this is the role of the TIP program, and operating/implementing agency operations, maintenance and capital budgeting. The integration of ITS and the integrated "systems" perspective that it brings raises new issues in these processes including:

- Incorporating operations and maintenance activities into the process. Once systems are implemented they must be maintained.
- Incorporating performance orientation, deficiency analysis and performance standards. The new measures of performance and reliability need to be included in the programming weights.
- How to capture system benefits and synergy of individual projects and how to program for incremental improvements (piecemeal vs. integrated systems)
- Enabling technologies and the phasing of interdependent ITS systems
- The indivisibility of many ITS systems, and the need to "bundle" components in order for them to function, or to obtain their full benefits.
- The impact of private sector involvement, resource sharing, and the leveraging of funds. Often, long-term guarantees are needed to minimize risks and obtain agreements that leverage public contributions. These are difficult to incorporate into an incremental budgeting process.

Whether funds are categorical, or general also plays a significant role. For example, in addition to state and local funding sources, ITS projects may also be funded under a wide range of federal highway and transit programs authorized in TEA-21. TEA-21 calls out funding for ITS in two major areas: the Intelligent Transportation Systems Act of 1998, and eligible Federal-Aid Highway Program (FAHP) categories and other infrastructure programs. APTS projects are eligible for capital funding under the Federal transit programs.

Federal funding for the ITS Integration Program (which has been appropriated discretionary for Congressionally designated earmarked projects) is specified in the ITS Act of 1998 for each fiscal year beginning 1998 and ending 2003. Approximately $1.3 billion in contract authority for ITS is provided, as follows:

Research, training and standards development	$603 million
Accelerated integration and interoperability	$482 million
Commercial vehicle infrastructure deployment	$184 million

The ITS-eligible Federal-aid programs include the National Highway System (NHS), the Surface Transportation Program (STP), and the Congestion Mitigation and Air Quality Improvement Program (CMAQ). NHS and STP specifically allow federal expenditures on infrastructure-based ITS capital improvements. CMAQ funding includes programs or projects that implement ITS strategies that improve traffic flow and reduce emissions. The operating costs for traffic monitoring, management, and control facilities and programs are potentially eligible under the Federal-aid highway program as well. In January 2000, the FHWA Operations Core Business Unit (CBU) issued a memo and guidance (http://ops.fhwa.dot.gov/Travel) to Resource Center Directors, Division Administrators, and Federal Lands Highway Division Engineers on federal-aid eligibility of operating costs for transportation management systems. The guidance contains interpretation of TEA-21 legislation for the eligibility of typical operating costs and expenses for traffic monitoring, management, and control under federal-aid funding. Examples include, but are not limited to the installation and integration of ITS infrastructure, labor and administration costs, management system hardware and software, as well as system maintenance and equipment replacement to assure peak operating performance.

The Advanced Regional Traffic Interactive Management and Information System (ARTIMIS) is a freeway management system operating in the Cincinnati/Northern Kentucky area. Kentucky DOT uses a combination of Federal and state funds for operations and maintenance, while Ohio DOT uses state-only funds.

To receive Federal funds, ITS projects must compete with other needs. Local agencies must present a supporting case for ITS projects that they want included in the TIP. Many agencies look for the best funding source to get a project accepted. Alternatively, ITS projects consistent with the transportation plan and initiated from activity such as a Congestion Management System (CMS) plan are good ways to introduce ITS strategies. Trade-offs between ITS and other projects are made through the State and regional programming processes.

Under the Integrated Framework, transportation agencies may wish to consider the need for several changes to their existing programming processes:

- Modifying the criteria used to set priorities, making them sensitive to system reliability, customer satisfaction, and other goals that reflect management and operations considerations
- Programming a package of inter-related ITS projects, rather than individual stand alone projects
- Incorporating ITS projects or elements with traditional construction projects
- Factoring in current data on system performance
- Increasing flexibility to insert new projects at the front of the queue
- Broadening the scope of the programming process to include funds for operations
- Strengthening the working relationships between planning, programming and operations
- Involving stakeholders in program decisions

The Washington Transportation Commission, the governing board of the Washington State DOT, has established five program areas – maintenance, traffic operations, preservation, safety improvement, and mobility improvement. ITS activities are included in all five.

Programming is also a political process. Funding for ITS and M&O requires a constituency of supporters for ITS, both within and outside transportation agencies.

The long-term vision plan for the Hampton Roads Planning District Commission includes a regional transportation system with ITS as the central link.

V.G.2 APPLICATION WITHIN THE INTEGRATED FRAMEWORK

V.G.2.1 Technical

There are several approaches that are being used to address these issues and developing an integrated ITS/M&O/infrastructure programming process. These include: assignment to specific funding categories; Developing a hierarchy of system needs and funding priorities; and incorporating new programming criteria and weights. They are discussed below.

Assignment to Specific Funding Categories

The selection and prioritization of projects is often tied to funding categories. Under ISTEA ITS was often funded using special ITS research and deployment funds including the ITS Priority Corridor and Metropolitan Model Deployment programs. This has changed under TEA-21, which aims at mainstreaming ITS projects, but also provides for more flexible funding. To allocate projects to funding different criteria and processes are used, depending on the category of funds, and different agencies may have decision-making responsibility. Often ITS is pre-allocated to a specific funding category. For example, in the past ITS projects for the Houston region were funded using CMAQ funds (Mitretek, 1998). Pre-allocating projects to funding categories may make programming easier, however, it may also limit opportunities, and tradeoffs/integration with other traditional improvements.

Hierarchy of System Needs and Funding Priorities

Some States and metropolitan areas use a “lexicographic programming process” through which top priority is given to keeping the system operational, second priority is given to system maintenance, and any remaining funds are available for system expansion. ITS projects that qualify as operational and maintenance-related could receive funding priority under such a process. This approach comes from "Asset Management" and the philosophy that existing systems must be maintained and preserved before new expansions are implemented. This approach establishes a hierarchy of system needs and funding priorities. Washington State provides and example where the Transportation Commission has established the following hierarchy of needs as guidelines for funding (Jacobsen, 1999).

- Maintenance
- Traffic Operations
- Preservation
- Safety Improvement
- Mobility Improvement

Funds are allocated first to maintenance needs, then traffic operations, etc. This ensures that the existing system will be maintained and operated efficiently. ITS services contribute to all of the categories. However, this may limit the kinds of funds that are available, especially through the transit programs.

Modifying the Programming Criteria

Most transportation agencies have established criteria for evaluating projects for inclusion in the program. Some use scoring techniques. Some rely on benefit-cost analysis. In order to fully integrate ITS into planning and programming, the measures used to rate or rank projects for funding should reflect management and operations considerations and non-average conditions. The programming process will also need to be able to accommodate and make trade-offs among projects that address very different goals.

Where benefit-cost analysis is used, it is appropriate to reflect life-cycle costs and benefits. Annual operating costs would be included, appropriately discounted, as well as a time stream of benefits.

TIP projects in a financially constrained environment are typically subject to some kind of evaluation process using common criteria. Such criteria typically include:

- Cost
- Urgency
- Impact on level of service or congestion
- Air quality impact
- Support of land-use

Scoring methods used often provide extra-credit for non-capacity improvements or projects with and efficiency impact. An important aspect of mainstreaming is to develop criteria that respond to the unique features of ITS and operations improvements such as their short-term, cost-effective implementation and their ability to respond to non-standard conditions. These include both quantitative and qualitative criteria sensitive to system reliability, customer satisfaction, and, and contribution to system management and performance. Quantitative measures should be based upon the system performance measures defined earlier in the process. Qualitative measures can include the contributions to the National Architecture Consistency requirements and system integration; the system versus local impacts, cost sharing opportunities, ability to operate and training needs for advanced systems, etc.

The Phoenix MPO has developed a rating point system for comparing ITS with non-ITS projects (as described in CUTR, 2000). As shown in Table V-16 the system is based on assessing five characteristics for each project. A maximum of 100 points is awarded to each project and the projects are then ranked.

Table V-16 Example of Programming Weights: Phoenix

Category and Measure	Points
Deployment Priority Addresses all needs of entire area = 30; most needs in at least ½ area = 20; a few needs in less than ½ area = 10. Plus 5 points if project addresses special event needs or high traffic generator	**35**
Congestion/Integration 0 to 25 points based on resulting VMT/lane-mile ratio (O for lowest, 25 for highest). Projects for which VMT estimates are unavailable are scored by ITS sub-committee	**25**
Cost Factor 0 to 15 points based on VMT/cost (0 for lowest and up to 15 for highest). Projects for which VMT estimates are unavailable will be scored based upon project cost only.	**15**
Jurisdiction Match 0 to 10 points based on extent of matching funds from Federal and/or State (O for no match and up to 10 points for highest Federal Match	**10**
ITS Steering Committee Ranking 0 to 15 points based upon subjective decision of the ITS Sub-committee.	**15**
Total	**100**

Incorporating ITS into Traditional Transportation Projects

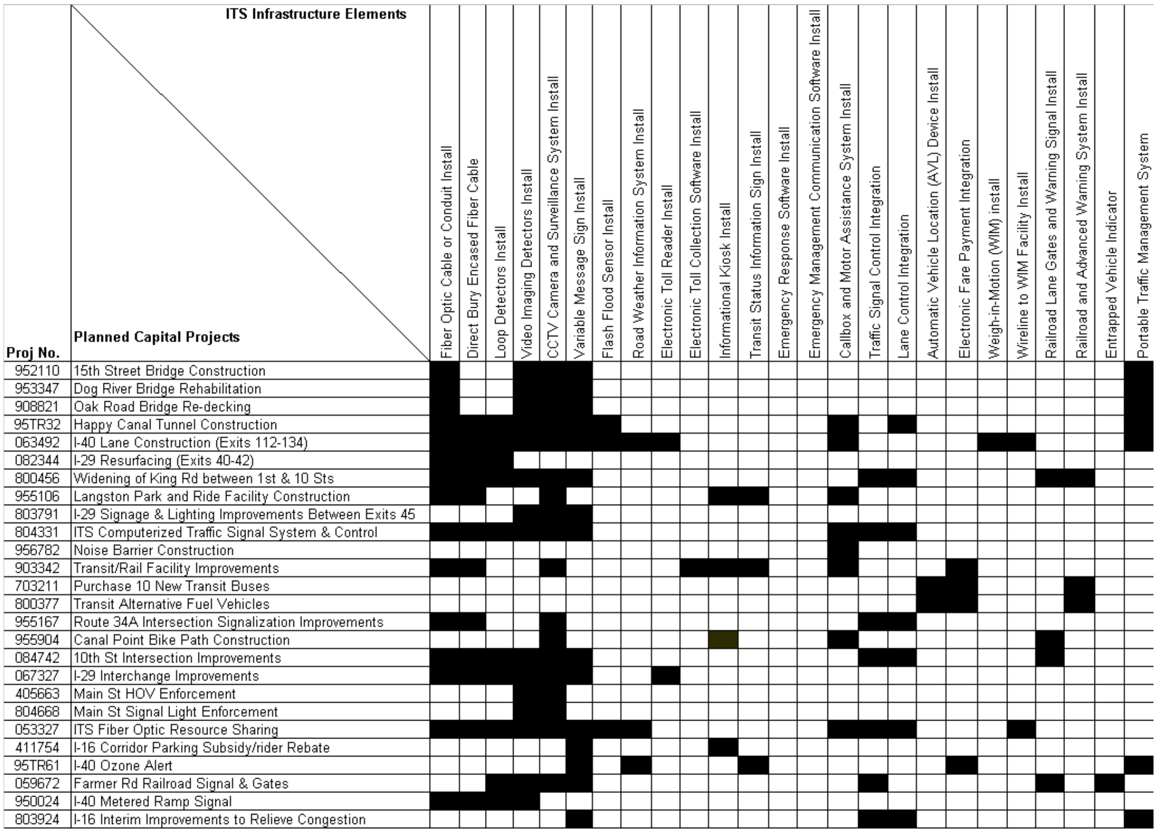
Another method for getting ITS projects to programming is to include tem or ITS components into traditional transportation projects. This has the advantage of bringing attention to solutions to needs and deficiencies that combine both ITS and traditional construction or other projects. It also can provide substantial efficiencies and costs savings.

The “Guidance on Including ITS Elements in Transportation Projects) released by the released by the FHWA Office of Travel Management in January 2001 (Staples, 2001) provides a recommended approach and helpful hints for following this approach.   The approach consists of a 3-step “ITS Site Assessment” The steps are:

1. **Develop an inventory of existing, planned, and future ITS infrastructure:** The inventory should be as site- or location-specific as possible. Identify particular corridors, intersections, freeway sections, etc. where ITS elements would improve congestion, safety, and incident management. This initial step should be done independent of any particular project and should be taken across the region or metropolitan area (This is already part of the Integrated Framework).
2. **Develop an “implementation plan”:** This step helps flesh out ITS priorities, needs, budgets, and timing/scheduling. Furthermore, it facilitates “mapping” ITS technologies to related traditional transportation projects. The implementation plan development includes: bundling inventory items into candidate improvements, development of timing and phasing schedules, and setting priorities and budgets. Each of the inventory items should be assessed to factor in technologies, location, public/private stakeholders, costs, and priorities. Regional ITS decisions related to system wide or common infrastructure items such as communication backbone, toll tag technology, and NTCIP standards, need to be considered and decided on. Information from the implementation plan can be used to coordinate deployment with capital projects. The implementation plan will probably go through several iterations and should be revised over time.
3. **Match related ITS improvements and traditional projects identified in the Transportation Improvement Plan (TIP) or other planning documents:** This includes coordinating any remaining planning, design, development, and deployment of these projects. Also, consider working ITS projects into private partnership projects such as installing CCTV cameras on cellular towers constructed by telecommunication companies via right-of-way agreements.

A matrix relating the planned capital improvements is prepared as part of the last step. Table V-17 some of the possible relationships between sample capital projects and ITS technologies. The objective is to identify which capital projects present good opportunities to implement items identified through the ITS site-specific assessment process.

Table V-17 Sample Matrix of Matching Capital Projects and ITS Infrastructure (Happy Valley)



Proj No.	ITS Infrastructure Elements Planned Capital Projects	Fiber Optic Cable or Conduit Install	Direct Bury Encased Fiber Cable	Loop Detectors Install	Video Imaging Detectors Install	CCTV Camera and Surveillance System Install	Variable Message Sign Install	Flash Flood Sensor Install	Road Weather Information System Install	Electronic Toll Reader Install	Electronic Toll Collection Software Install	Informational Kiosk Install	Transit Status Information Sign Install	Emergency Response Software Install	Emergency Management Communication Software Install	Callbox and Motor Assistance System Install	Traffic Signal Control Integration	Lane Control Integration	Automatic Vehicle Location (AVL) Device Install	Electronic Fare Payment Integration	Weigh-in-Motion (WIM) install	Wireline to WIM Facility Install	Railroad Lane Gates and Warning Signal Install	Railroad and Advanced Warning System Install	Entrapped Vehicle Indicator	Portable Traffic Management System
952110	15th Street Bridge Construction	■			■	■	■																			■
953347	Dog River Bridge Rehabilitation	■			■	■	■																			■
908821	Oak Road Bridge Re-decking	■			■	■	■																			■
95TR32	Happy Canal Tunnel Construction	■	■	■	■	■	■	■								■		■								■
063492	I-40 Lane Construction (Exits 112-134)	■	■	■	■	■	■	■	■	■						■					■	■				■
082344	I-29 Resurfacing (Exits 40-42)	■	■	■																						
800456	Widening of King Rd between 1st & 10 Sts	■	■	■	■	■	■										■	■					■	■		
955106	Langston Park and Ride Facility Construction	■	■			■						■	■			■										
803791	I-29 Signage & Lighting Improvements Between Exits 45				■	■	■																			
804331	ITS Computerized Traffic Signal System & Control	■	■	■	■	■	■									■	■	■								
956782	Noise Barrier Construction															■										
903342	Transit/Rail Facility Improvements	■	■			■					■	■	■			■				■						
703211	Purchase 10 New Transit Buses																		■	■				■		
800377	Transit Alternative Fuel Vehicles																		■	■				■		
955167	Route 34A Intersection Signalization Improvements	■	■			■											■	■								
955904	Canal Point Bike Path Construction					■						■				■							■			
084742	10th St Intersection Improvements	■	■	■	■	■	■										■	■					■			
067327	I-29 Interchange Improvements	■	■	■	■	■	■			■																
405663	Main St HOV Enforcement				■	■																				
804668	Main St Signal Light Enforcement				■	■																				
053327	ITS Fiber Optic Resource Sharing	■	■	■	■	■	■	■	■							■	■	■				■				
411754	I-16 Corridor Parking Subsidy/rider Rebate						■					■														
95TR61	I-40 Ozone Alert						■		■				■							■						■
059672	Farmer Rd Railroad Signal & Gates			■	■	■	■										■						■		■	
950024	I-40 Metered Ramp Signal	■	■	■	■																					
803924	I-16 Interim Improvements to Relieve Congestion						■										■	■								■

Source:(Staples, 2001)

Other Technical Programming Issues

Other technical issues to address include the packaging of interrelated projects, collecting current data on performance, and the need for flexible programming.

When evaluating ITS, consideration might be given to evaluating a package of inter-related ITS projects, rather than evaluating individual ITS elements. Core elements of the ITS infrastructure – i.e., the surveillance, communications and data processing capabilities – may not fare well in a benefit-cost analysis if they are evaluated as stand alone investments. The benefits of the core infrastructure start to accrue as other ITS elements are added. The benefit-cost methodology should reflect the synergistic effects of integrated program.

Integrated approach requires reliable data on current system performance. In setting priorities, greater attention is given to projects that address current problems. Thus, agencies need data on current needs a well as forecasts of future needs.

The Integrated Framework assumes that transportation agencies can be responsive to short-term needs. This requires flexibility in programming – the ability to advance projects more quickly or insert new projects into the program as conditions warrant. A multi-year program where projects can only enter at the out-year end does not lend itself to effective management of the system.

V.G.2.2 Institutional

Linking Operations with Programming

Most transportation agencies keep their capital programs and their operating budgets separate. In many agencies, the Integrated Framework may require a closer tie that highlights the relationships between the capital program and the operating budget.

A recent survey conducted by Volpe for the ITS JPO suggests that few metropolitan areas have operating projects in the TIP. The main reasons for the lack of these projects include: capital needs outweigh available funding; conscious decision by the MPO (MPOs expressed a lack of expertise in the are of operations, while that may be the case, programming for operations projects should not be overlooked), and CMAQ funds already a primary funding source.

Expenditures on the capital side may have significant implications for the operating budget:

- Federal aid highway funds can be spent on either capital or operations, forcing trade-offs between the two. Maintenance of ITS systems to ensure continuous operations (e.g., preventative computer maintenance, replacement of damaged traffic management equipment) also is eligible for federal funding.
- Capital investments in ITS bring with them a continuing requirement for operations and maintenance.
- Transportation agencies may need to acquire new skills in information technologies. Operating budgets should recognize the cost of training existing employees and/or attracting and retaining new high tech. employees.

ITS capital projects, while often a fraction of the cost of traditional construction projects, require funding for the continual operation and maintenance long after the system has been installed. The type of operation and maintenance for an ITS project or program is quite different from that of a traditional highway or bridge project. ITS projects, because of their systems and management nature, require staff and management on a daily basis. Funds to operate the transportation asset must now be considered -- bringing a new meaning to operations. The frequency of maintenance is greater for ITS projects and is exacerbated increased frequency of upgrades to software and hardware inherent in ITS technologies. An important point to remember is as more ITS programs are implemented within a region or state, the total amount of funds needed to support operations and maintenance will continue to grow. Resource sharing and reuse of non-proprietary software are just a few strategies to employ when investigating funding options for O&M.

This all suggests that, within transportation agencies, there needs to be a close working relationship among the staff involved in planning, programming, and operations.

Involving stakeholders

The development of an integrated ITS program requires the cooperation of many parties. Some aspects of the program may have shared funding. Other elements of the program, while funded by one agency, may depend upon or connect with another component provided by others. Stakeholders need to collaborate on timing, staging, and the sharing of risk. Programming and budgeting decisions must be done in partnership.

Another reason for stakeholder involvement is that programming is in part a political process. There needs to be a constituency for ITS and M&O if they are to compete successfully for funding. Engaging stakeholders in the establishment of priorities can help develop support for the program.

V.G.3 VARIATIONS BY SCALE, SETTING, AND INSTITUTIONS

The programming procedures and priority-setting criteria and methodologies differ considerably from place to place. Rural areas may give priority to projects that enhance safety, encourage tourism, or promote growth, while urban areas may favor projects that reduce congestion or encourage the use of transit and ridesharing.

Where resources are constrained, the competition for funding may be more acute. Options to consider might include:

- ITS phasing and staging – building the core infrastructure first, or some piece that can later be integrated with larger whole
- More aggressive efforts to create partnerships and share resources stakeholders

V.G.4 SECTION REVIEW AND TRANSITION ASSESSMENT

This section examined the impact of the Integrated Framework on Programming. Programming matches activities to available resources (budgets, funding sources, revenues). In the Integrated Framework the planning to program link is heightened due to:

- Its focus on cycles of planning (short, mid, long)
- Operations and Maintenance are significant costs of ITS and operations
- Integrated planning crossing traditional funding categories and boundaries

In the past dedicated funding for ITS often bypassed many programming issues. This is no longer possible and ITS must compete with other demands for such CMAQ, NHS, STP, as well as local funds. As part of TEA-21 many Federal sources have also become more flexible and can be applied to operations.

Issues to address in expanding programming to the integrated process include:

- Expanding the criteria to include reliability, customer satisfaction, and other operationally oriented goals and objectives
- The indivisibility of ITS. It often can’t be done in pieces
- Enabling technologies and the need to implement them even if they provide little benefits themselves. They allow other more beneficial ITS to be deployed
- System benefits and synergy of ITS systems

Options and other activities to carry out in integrated programming include:

- Assignment to specific funding categories (not recommended)
- Lexicographic and hierarchical programming based upon maintaining and operating what you have first
- Development of new weights and criteria
- Combining ITS and traditional projects
- Bundling ITS projects in deployment packages
- Using current performance data
- Working towards flexible programming

It is also critical to link operations to programming and include new operations oriented stakeholders in the process.

Table V-18 provides a set of self-assessment questions for your area’s status regarding expanding evaluation to meet the needs of integrated planning. Mark your area’s relative position on each question.

Table V-18 Planning to Programming Self-Assessment

Question	NO YES
Are extended programming criteria which incorporate ITS, and operations, system performance, and system preservation used?	NO - - - - - - - - YES
Are the system characteristics and need to bundle inter-related projects included in the programming process?	NO - - - - - - - - YES
Are continued operations and system maintenance/preservation included in the programming process?	NO - - - - - - - - YES
Are opportunities to combine ITS and other operational improvements with traditional construction and service expansion projects part of the programming process?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

V.H ITS DATA AND PLANNING DECISION-MAKING

Key Points of Section V.H

- ITS data provides the information needed for performance feedback in the Integrated Framework
  - New ways to collect traditional measures
  - New information on variability, reliability, and customer satisfaction
  - Data on ITS impacts
- It also creates new issues
  - Data coverage and usefulness to planners requires coordination in design
  - Presentation and visualization of complex information
  - Sheer quantity of information requires new methods of analysis, cleaning, and storage
  - Data control and error checking
  - Access, ownership, and privacy must be resolved
  - Roles and responsibilities must be determined
- The ADUS User Service and its Market Packages provide assistance. The Market Packages are:
  - ITS Data Mart
  - ITS Data Warehouse
  - Virtual ITS Data Warehouse
- Data process should be developed as part of the overall integrated planning

This last activity/function in the Integrated Framework provides for the data and performance based feedback within the process. Here, the data collection system is defined and developed. This includes identifying:

- The data to be collected
- The collection methods
- How it should be processed; stored; and maintained
- What measures to draw from it
- How/who should have access to it.

Performing the continual exercise of collecting the data, converting it into information that can be used to monitor the system performance, and providing the feedback to the cycles within the Integrated Framework also falls within this topic. In recognition of the importance of ITS data and feedback to planning and other "secondary" uses the Archived Data User Service (ADUS) was added to the ITS User Services and its Market Packages added in the National ITS Architecture in 1999 (USDOT, 1999).

Unless the data exists to support the performance based measures and the continual monitoring and feedback, integrating the management and operations focus brought by ITS into the planning process becomes difficult. Data is needed to assess the impact of the ITS systems as well as the performance of the overall system and its response to conditions. Obtaining the information from traditional data collection methods, however, is costly if not impossible. This was highlighted continually in the discussion forums carried out throughout the U.S. for this project where the lack of data on system operations and variation in conditions, and the difficulties in collecting it was a recurring theme. A recent U.S. DOT strategy paper also placed "collection and use of data" as one of three key conditions in bringing ITS solutions into the metropolitan transportation planning process (Deblasio, et.al. 1998).

Feedback of the continual performance of the system into planning and decision making allows the system to evolve through small steps and mid-course corrections rather than discontinuous major investments. Feedback through monitoring the performance of the system also allows the decision making process to see the impacts of the decisions made and then respond. This is in marked contrast with traditional planning and its focus on the long-range forecasts of conditions and developing major investments to meet these conditions. ITS provides a source of continuous data which must be transformed into the "information" and performance measures used in the feedback process. ITS data also helps:

- **Monitor traditional measures in a cost-effective way:** ITS can provide volume and speed data on specific locations, travel times, vehicle classifications, transit passenger counts, fare and toll revenues, etc.
- **Provide new measures for capturing system variability, reliability, and customer satisfaction:** variation in volumes and speeds by time of day, incidents and their duration, weather impacts, recurrent and non-recurrent system/link delay, frequency of high

acceleration and deceleration events (for air quality), Information system requests and usage, etc.

- **Provide the information for developing, calibrating, and validating new travel forecasting models and analytic tools:** Network simulation tools such as CORSIM and INTEGRATION need data only available through ITS collection, the new TRANSIMS travel forecasting suite, the IDAS ITS impact sketch planning tool, modal emission models, new accident forecasting tools, etc. all require time sensitive data that only ITS can provide in a cost/effective manner.

V.H.1 CURRENT PRACTICE VERSUS AN INTEGRATED APPROACH

ITS data has the potential to supplement or replace many of the data needs found in both the traditional planning process and Integrated Framework. Table V-19 provides some examples of the use of ITS data and comparison with current data sources for both planning and management and operations functions found in the Integrated Framework. Roadway surveillance and probe data become important sources to monitor the volumes and speeds in the system and how they change under varying conditions. They can be used in CMS plans long-range plan development, and corridor analyses. They can also be used to define travel patterns and provide critical information for developing new transportation models such as TRANSIMS and in calibrating traffic simulations. Transit data such as automatic passenger counters, computer aided dispatch systems, and automatic vehicle locator systems provide similar functions for transit planning. Since ISTEA, Freight and intermodal planning also is part of the overall planning requirements and ITS provides a source for tracking truck travel patterns, and goods movements information that was previously unobtainable.

ITS also provides a source of information for the shorter range management and operations functions of the Integrated framework. It provides a means to evaluate both ITS and non-ITS programs and their combinations. The usefulness of incident management and freeway surveillance data is shown in the table. ITS data can also provide key information for maintenance scheduling and asset management (pavement, bridge and other infrastructure conditions).

In spite of its potential the majority of ITS data now generated is not saved for use in planning and other applications. Pioneers are, however, beginning to save and use some ITS data in areas across the country. Some examples of the use of ITS data and its feedback are provided below.

- *Freeway Performance Evaluation in Puget Sound Region*, Washington. Loop detector data have been used to monitor congestion patterns, including variability in speeds and travel times.
- *Evaluation of HOV Lanes in Houston, Texas.* Probe vehicle data were used to compare travel times for HOV and Non-HOV lanes. Surveillance data are also used to monitor HOV performance by time-of-day and adjust HOV operations accordingly.
- *Minneapolis – St. Paul, Minnesota Traffic Management Center Database.* Reports of travel in the AM peak, and volumes by time of day for freeway segments. This data is available through a data management system and is used extensively by planners. The data is also used to adjust ramp meters ..
- *Traffic Statistics in Chicago, Illinois*. Freeway management system data is archived and has been used to produce an “atlas” of traffic statistics for the Chicago area, and other summary reports on system performance. While the electronic version of the data is still not user friendly, planners at the MPO and throughout the region use the reports extensively.
- *Transit system management in Portland Oregon*. Portland’s Tri-Met uses Passenger Count, vehicle location, and event data to assist in updating schedules, set transit priority, and system planning. Caused a 62% to 77% change in on time performance, and 36% in bus spacing (reliability).
- *Phoenix Arizona System Performance*. The freeway management system data is being used to track the start and duration of congestion, HOV versus main-lane use, truck volumes, and to develop volume-delay relationships.

Sources: Mergel, 1998; Flannery, 2000; TRB 2000 ADUS presentations

Table V-19 Uses of ITS Data For Planning, Management & Operations

Stakeholder Group	Application	Method or Function	Collection and Use of:	
			Current Data	**ITS-Generated Data**
MPO and State Transportation Planners	Congestion Management Systems	Congestion Monitoring	Travel times collected by "floating cars": usually only a few runs (small samples) on selected routes. Speeds and travel times synthesized with analytic methods (e.g., *HCM*, simulation) using limited traffic data (short counts). Effect of incidents missed completely with synthetic methods and minimally covered by floating cars.	Roadway surveillance data (e.g., loop detectors) provide continuous volume counts and speeds. Variability can be directly assessed. Probe vehicles provide similar travel times as "floating cars" but greatly increase sample size and area wide coverage. The effect of incidents is imbedded in surveillance data and Incident Management Systems provide details on incident conditions.
	Long-Range Plan Development	Travel Demand Forecasting Models	Short-duration traffic counts used for model validation. O/D patterns from infrequent travel surveys used to calibrate trip distribution. Link speeds based on speed limits or functional class. Link capacities usually based on functional class.	Roadway surveillance data provide continuous volume counts, truck percents, and speeds. Probe vehicles can be used to estimate O/D patterns without the need for a survey. The emerging TDF models (e.g., TRANSIMS) will require detailed data on network (e.g., signal timing) that can be collected automatically via ITS. Other TDF formulations that account for variability in travel conditions can be calibrated against the continuous volume and speed data.
	Corridor Analysis	Traffic Simulation Models	Short-duration traffic counts and turning movements used as model inputs. Other input data to run the models collected through special efforts (signal timing). Very little performance data available for model calibration (e.g., incidents, speeds, delay).	Most input data can be collected automatically and models can be directly calibrated to actual conditions.
Traffic Management Operators	ITS Technology	Program and Technology Evaluations	Extremely limited; special data collection efforts required.	Data from ITS provide the ability to evaluate the effectiveness of both ITS and non-ITS programs. For example, data from an Incident Management System can be used to determine changes in verification, response, and clearance times due to new technologies or institutional arrangements. Freeway surveillance data can be used to evaluate the effectiveness of ramp meters or HOV restrictions.
	Operations Planning	Pre-Determined Control Strategies	Short-duration traffic counts and "floating car" travel time runs. A limited set of pre-determined control plans is usually developed mostly due to the lack of data.	Continuous roadway surveillance data makes it possible to develop any number of pre-determined control strategies.
		Predictive Traffic Flow Algorithms	Extremely limited.	Analysis of historical data forms the basis of predictive algorithms: "What will traffic conditions be in the next 15 minutes?" (Bayesian approach).

Stakeholder Group	Application	Method or Function	Collection and Use of:	
			Current Data	ITS-Generated Data
Transit Operators	Operations Planning	Routing and Scheduling	Manual travel demand and ridership surveys; special studies.	Electronic Fare Payment System and Automatic Passenger Counters allow continuous boardings to be collected. Computer-aided dispatch systems allow O/D patterns to be tracked. AVI on buses allows monitoring of schedule adherence and permits the accurate setting of schedules without field review.
Air Quality Analysts	Conformity Determinations	Analysis with the MOBILE Model	Area wide speed data taken from TDFs. VMT and vehicle classifications derived from short counts.	Roadway surveillance provides actual speeds, volumes, and truck mix by time of day. Modal emission models will require these data in even greater detail and ITS is the only practical source.
MPO/State Freight and Intermodal Planners	Port and Intermodal Facilities Planning	Freight Demand Models	Data collected through rare special surveys or implied from national data (e.g., Commodity Flow Survey).	Electronic credentialing and AVI allows tracking of truck travel patterns, sometimes including cargo. Improved tracking of congestion through the use of roadway surveillance data leads to improved assessments of intermodal access.
Safety Planners and Administrators	Safety Management Systems	Area wide Safety Monitoring; Studies of Highway and Vehicle Safety Relationships	Exposure (typically VMT) derived from short-duration traffic and vehicle classification counts; traffic conditions under which crashes occurred must be inferred. Police investigations, the basis for most crash data sets, performed manually.	Roadway surveillance data provide continuous volume counts, truck percents, and speeds, leading to improved exposure estimation and measurement of the actual traffic conditions for crash studies. Incident management can identify unreported crashes. ITS technologies also offer the possibility of automating field collection of crash data by police officers (e.g., GPS for location).
Maintenance Personnel	Pavement and Bridge Management	Historical and Forecasted Loadings	Volumes, vehicle classifications, and vehicle weights derived from short-duration counts (limited number of continuously operating sites).	Roadway surveillance data provide continuous volume counts, vehicle classifications, and vehicle weights, making more accurate loading data and growth forecasts available.
Transportation Researchers	Model Development	Travel Behavior Models	Mostly rely on infrequent and costly surveys: stated preference and some travel diary efforts (revealed preference).	Traveler response to system conditions can be measured through system detectors, probe vehicles, or monitoring in-vehicle and personal device use. Travel diaries can be imbedded in these technologies as well.
		Traffic Flow Models	Detailed traffic data for model development must be collected through special efforts.	Roadway surveillance data provide continuous volume counts, densities, truck percents, and speeds at very small time increments. GPS-instrumented vehicles can provide second-by second performance characteristics for microscopic model development and validation.

Source: Selected rows from Table 2.1 in "ITS as a Data Resource: Preliminary Requirements for a User Service" (Margiotta, 1998)

The pioneering efforts in the use of ITS data (those shown as well as others) have begun to provide some insights on the use of ITS data and its comparison with traditional data sources (See Table V-20). Due to their labor intensive nature traditional data collection activities tend to be expensive separate efforts, easily cut during times when budgets are lean. They are also infrequent, often occurring only once a year (traffic count and system inventory updates, ridership surveys, etc.), or even at greater intervals (regional origin-destination surveys, or census data collection every ten years). Because of their cost they are typically based on taking samples, by time, or by location. On the other hand they usually are designed for broad geographic coverage of the area in question. In contrast, ITS data offers a continuous data stream that is produced for operations and other ITS system management purposes. Once the ITS systems are deployed the data creation is free or comes at very low cost. The information is available for all time periods but usually the facility coverage is limited to the few locations/facilities where ITS surveillance is installed. Because of the continuous nature the amount of ITS data may be enormous and storage and aggregation strategies are needed to keep costs and maintenance of the data reasonable.

Table V-20 Traditional versus ITS Data Comparison

Traditional Data Activities	ITS as a Data Source
Infrequent	Continuous
Labor Intensive, Expensive Separate Efforts	Automated, Collected for Operations
Time Sample, Large Geographic Coverage	All Time Periods Limited Facility Coverage
Relatively high reliability, Errors often visible/caught during inspections	Must provide reliability checks. Amount of data hides errors
Data is concise, small storage requirements	Vast amount of information, large storage requirements

As shown ITS as a data source provides new opportunities, and also raises issues as performance monitoring and feedback of the information are implemented. Because of unfamiliarity and lack of experience these issues are often perceived as barriers, or hurdles, to the use of ITS data versus traditional means of data collection. The issues and how to overcome some of the perceived hurdles are discussed below (see Mergel, 1998, Margiotta, 1998, Turner et.al, 1997,1999).

Data Content and Coverage: Usefulness to Planners.

Planners may not be aware of the existence or potential uses of ITS data, or the data being collected (location of surveillance, types of information, frequency and classifications) for operational purposes may not meet planner's needs. Early in the development of the ITS services and data collection/storage strategies an ongoing dialog should be established between the data collectors (ITS operators), data providers, and data users. Often existing regional data and ITS committees can provide a home for this interaction. One must be sure, however, to include not only regional planners and their needs but also others that provide planning functions or use the data in other fashions (transit route planners, public works, fire and safety services, etc.)

In San Antonio, the automatic vehicle identification system is provides travel times for the regional congestion management system (CMS). However portions of the CMS network are not covered because the MPO was not consulted on where the field detectors would be located.

In Michigan the MDOT planners would like to obtain vehicle classification data from the Michigan ITS (MITS) system. The cost of using MITS as a data source, however, was found to be prohibitive because the need was raised late in the design process. It might have been economically feasible if the requirements were considered at the beginning of the process.

In Minneapolis, the TMC will be able to collect and archive 30-second detector data at locations across the region. Yet, when requested ramp meter delays could not be provided to the MPO in a timely fashion because the loop detectors required were not part of the original system design.

(Source: Mergel, 1998)

A good place to start the dialog is by educating planners and other potential users on the existing and planned ITS data sources in the region. The earlier this takes place in the development of the ITS regional architecture and ADUS components (see next section) the better. The potential for using ITS data to provide feedback on regional goals and objectives and performance measures can then be assessed. A collaborative process can also begin to consider users needs on: statistical significance (precision), frequency of information, location and coverage, needed aggregation, and classification schemes. If users would like to bring disparate ITS together for analysis this should also be considered here. For example, it is almost impossible to bring traffic, accident/incident, transit, and condition (weather) data together unless some forethought is used at the data design and collection phase to ensure some commonalties exist.

Users also need to be trained on the issues and use of ITS data and information. For example, loop detector data may provide a continuous source of volume information at a location, however, it should also have error trapping routines built in to check for sensor malfunctions. After collection, validity checks also need to be performed. In traditional data collection malfunctions when they do occur are many times manually caught in the field. More and better information on average and variable conditions can be obtained from ITS sources but different procedures and interpretation may be warranted once the information is stored.

Data versus Information: Visualization.

Planners and other users don’t want raw data. They want information on both how the system performs under average conditions and how it varies. Detailed 24 hour per day traffic data by lane and half-mile intervals in 20-second increments is voluminous, difficult to work with, and difficult to understand in the best of cases. Data must be mapped to humanly understandable locations, aggregated, cleaned, and compared with other information to provide useful information to the planning process. In many applications determining patterns in variability, trends, and relative use for the entire system are what is desired.

ITS data does provide more information than conditions on an average day and is a critical part of the causal analysis described in Section V.B. However, this must also be communicated and explained to be useful. Thought should therefore be given on how the ITS data will be summarized, and displayed to show both average and variable conditions in the system (see Ishimaru & Hallenbeck, 1999, Winick, 1998).

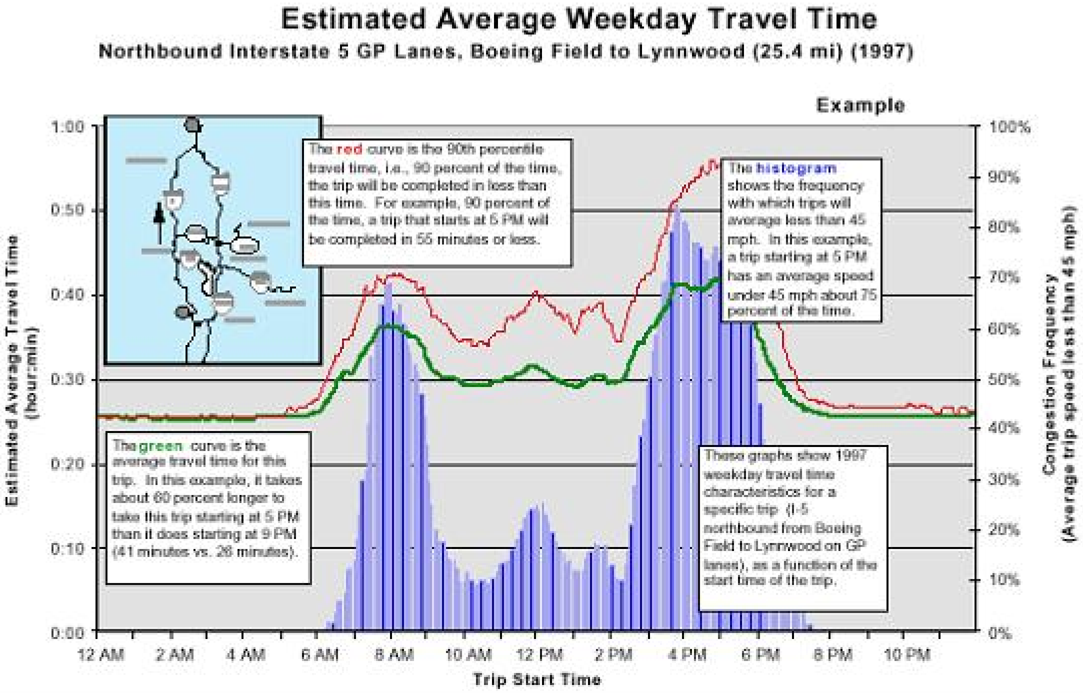
The Seattle area has been using the FLOW system to measure the performance of its Freeway System for a number of years. The Washington State Transportation Center (TRAC) has developed the CDR Analyst system to summarize the detailed volume counts and a number of different visualization techniques to make the variation in system conditions understandable to decision makers and the public. Two examples are shown below. Figure V-13 Shows the variation in average weekday travel time by time of day along the I-5 Freeway corridor. The peaks and duration of congestion are clearly visible. The 90th percentile travel time also gives an indication of variation and reliability of travel time depending upon when the trip starts. Figure V-14 shows how the congestion varies by location along the corridor during the day (Ishimaru & Hallenbeck, 1999).

Other displays can also show the likelihood of an incident or unusual congestion occurring, weather, and variations in volumes or travel times throughout the year. The importance of being able to bring disparate data together and analyze it for relationships and patterns (data mining) is discussed next.

Data Management and Storage.

ITS data collected for 24hours a day 360 days a year can take up megabytes of storage for a single locations. Data management issues relate to how much of this data should be kept, at what cycles, how it

Figure V-13 Example of Travel Time Variation along A Corridor



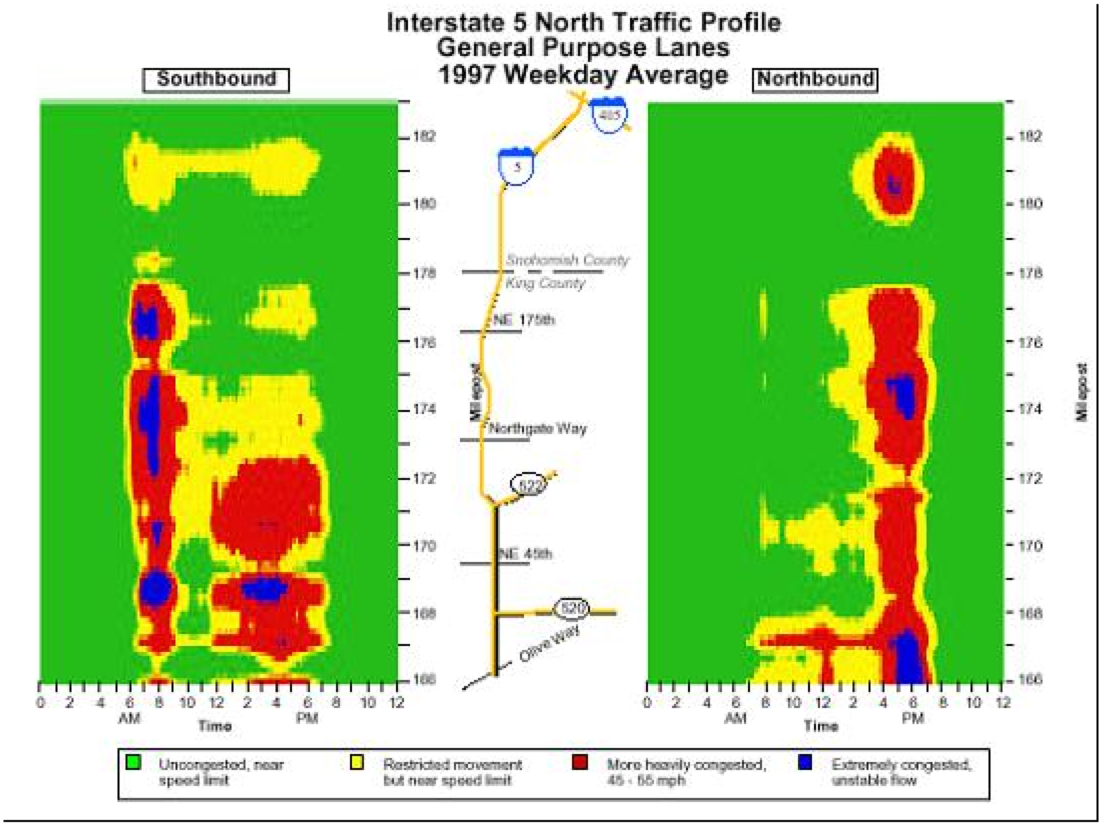
The red curve is the 90th percentile travel time, i.e., 90 percent of the time, the trip will be completed in less than this time. For example, 90 percent of the time, a trip that starts at 5 PM will be completed in 55 minutes or less.

The histogram shows the frequency with which trips will average less than 45 mph. In this example, a trip starting at 5 PM has an average speed under 45 mph about 75 percent of the time.

The green curve is the average travel time for this trip. In this example, it takes about 60 percent longer to take this trip starting at 5 PM than it does starting at 9 PM (41 minutes vs. 26 minutes).

These graphs show 1997 weekday travel time characteristics for a specific trip (I-5 northbound from Boeing Field to Lynnwood on GP lanes), as a function of the start time of the trip.

Figure V-14 Example of Congestion Contours



should be aggregated and summarized, the ability to retrieve analyze and merge it with other sources, and its maintenance. In dealing with these issues the needs of different users, which can vary greatly, and the costs must be kept in mind. These issues are dealt with in depth elsewhere and summarized here (Margiotta, 1998, Brydia et. al. 1997, Turner et. al. 1999,).

Data storage requirements for San Antonio’s Phase 1 TransGuide loop detector data (26 freeway miles) were 12 megabytes per day in compressed ASCII Format (120 MB/day uncompressed), or 43.2 GB per year. Phase II will more than double the coverage and storage requirements.

(Source: Turner, et. al., 1997).

Whether all of the ITS data, aggregation/summaries, or both are stored; the length of storage and data retention cycles (all data for a year, daily summaries for 5 years, monthly and annual information permanent), and the information about the data (meta-data) are all important issues that impact how the data can be used and by whom. What data is saved routinely, and what capabilities are added to save additional information by special request also needs to be addressed. Different users have very different needs and wants that must be taken into account. For example, planners may want hourly volumes on a roadway by day and also annual weekday statistics (both by hour and daily) while traffic simulators would like 20 second or smaller “occupancy” and volume data by lane for specific days to validate their models. How these questions are answered impact the costs of maintaining the information and is one of the main functions of the dialog between stakeholders to resolve.

Different systems and ways of organizing the information also impact the ability to retrieve and analyze the data and turn it into useful information. Texas Transportation Institute has defined four management functions increasing in sophistication: Data storage/management; Data query (browse summarize/report); Exploration/integration; and On-line Analytic Processing (OLAP) (Eisele, B, 2000). The most sophisticated OLAP provides data mining capabilities, what if scenarios and real time simulation and feedback. Easy access to data can be catalyst to new and unforeseen uses. However, the advanced data systems require specialized expertise and consultant assistance is recommended. The data providers, users, and collectors should work closely together to determine what retrieval and analysis is needed, how it impacts the data storage, and where the analysis should take place (as part of the data system, or in the users systems). At a minimum good planning is key to allow for potential integration of information in the future (common keys, reference systems, definitions) even if it is not done at present.

It is very important that database maintenance and upkeep also be addressed and budgeted for as plans for using ITS data are being developed. This includes maintaining past archives and backups, updating formats, keeping relationships and file locations current, etc. In large systems this may require one or more dedicated staff. In smaller systems it still needs to be accounted for.

Data quality control and error checking.

One of the main concerns raised by planners regarding the use of ITS data is the lack of reliability and comparability with traditional sources for the average annual values of traffic, and passengers, or survey data that they are used too. This stems from two sources: 1. Data collected for operational use is often concerned more about detecting existing conditions and unusual events in the system rather than the accuracy of any one numerical measure; and 2. Users don’t recognize that the data is in a rawer form than they are used and requires additional quality control analyses, error trapping, and possibly imputation of missing values. Detectors are often down for brief periods, or report suspicious information.

Traffic detector data from San Antonio’s TRANSTAR for October 1998 showed that “good” data was provided 76.5%, “suspect” data 1.0%, and missing data 22.5% of the time across all detectors. Missing data during some portion of each day for each detector was the more notable issue. They also found that where you install the detectors is important. Areas with high weaving movements and other variations in flow should be avoided.

(Turner, 2000)

Recommendations to address quality control issues include (See, Turner 1999, Ishimaru & Hallenbeck, 1999).:

- Understand the data accuracy and precision requirements of your users.
- Provide ongoing error checking and loop maintenance
- Report a reliability indicator on the information that is provided rather than leaving it blank or providing no information on its quality;
- Develop algorithms and plans for accounting for missing data in the data streams (imputation, adjustment of averages etc.)

At a minimum the nature and extent of missing and suspicious data should be reflected in the design and implementation of any data or analysis system.

Access, Ownership, and Privacy

These issues must be resolved and can become flash points in the use or perceived use of ITS data. Who should have access to the raw and/or processed and summarized information? Should the access be through the web, special on-line connections, or by special request? Will the archives be provided on electronic medium such as CDs, or only through queries to the central system? Ownership issues become extremely important as private sector partnerships are developed and independent service providers obtain and re-package the information. The public sector should be extremely careful not to give away their rights to information that they collect without careful study. Likewise, who is responsible for insuring that the data is maintained and used in a responsible manner is intrinsically linked to ownership issues. Last, privacy of individuals and firms information must be assured as part of the process. This is especially true when individuals probe, toll, and electronic fare data may be part of the ITS system, and for commercial carriers and other private enterprises. All of these issues should be part of the data dialog and how they are dealt with clearly established through memorandum of understandings and other agreements.

Roles and Responsibilities.

Many of the issues regarding the use of ITS data for planning boil down to establishing the roles and responsibilities of continuous and ongoing data collection, maintenance, analysis and distribution activities raised in the above issues. This is especially true since the collection and archiving of ITS data will often be performed by ITS operators or others that do not necessarily share the need for the information that planners require. How costs are shared and who has access at what price (will the information be sold?), and the relationships with the private sector are also important issues. These should be addressed in the dialog of stakeholders and included in the ITS regional architecture’s Concept of Operations as part of the ADUS implementation. Implementing ADUS is discussed next in the Application section.

V.H.2 APPLICATION WITHIN THE INTEGRATED FRAMEWORK

The above discussion provided the importance and potential use of ITS Data to provide the needed feedback to the Integrated Framework, and also meet traditional data needs. This section discusses the implementation of ITS Data Collection to meet these needs through the use of the newest ITS User Service: Archived Data User Service(ADUS). ADUS’ purpose is to provide the technical foundation within the National ITS Architecture on the use of ITS data for secondary sources such as feedback to transportation planning and management and operation of the system within the Integrated Framework. Implementation of ADUS and the ITS data used for planning should therefore be considered as part of the development of the Regional Integration Strategy and Regional ITS Architecture to meet TEA-21’s architecture consistency requirements. Highlights of ADUS are provided below.

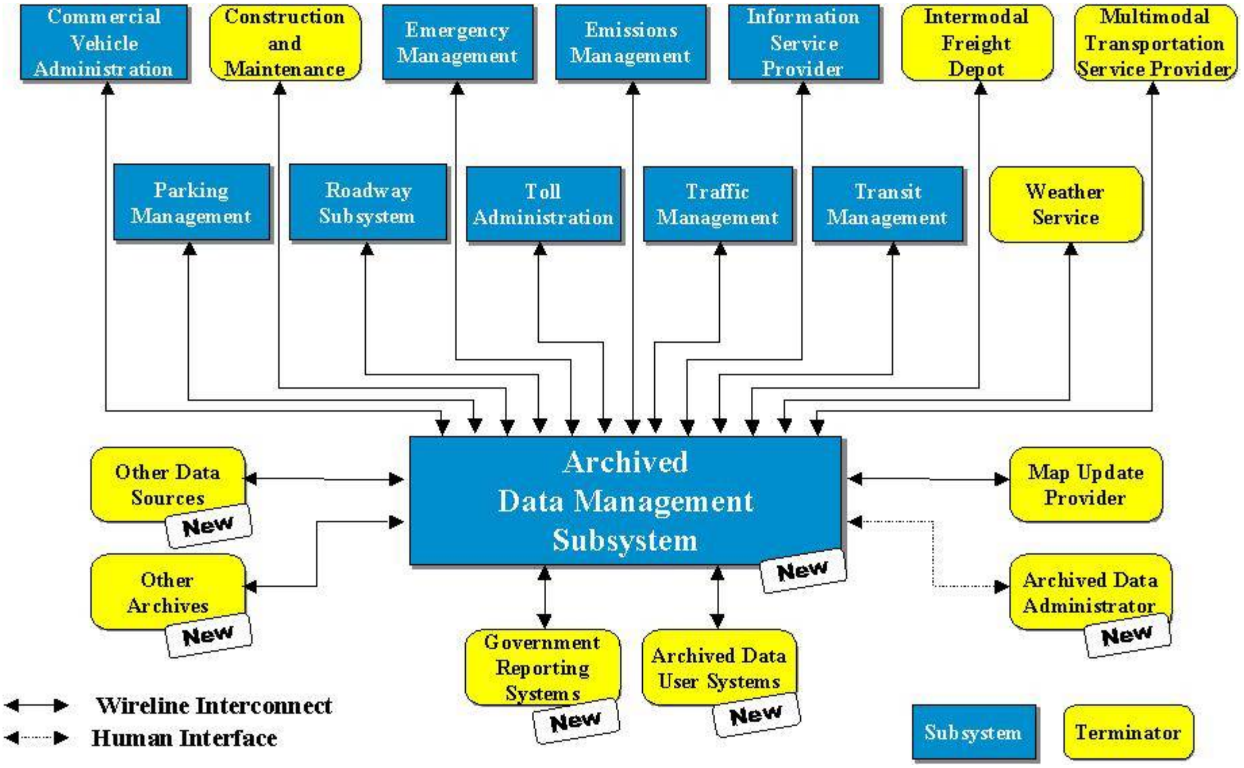
Within the National ITS Architecture ADUS defines the information flows and functions required when someone is considering saving and using ITS data. A new Center Subsystem, Archived Data Management System (ADMS), has been defined as part of ADUS. Figure V-15 shows the potential information flows and interfaces to and from the ADMS. Note, that while the Architecture defines the flows it does not define the location of the ADMS. In fact, depending on the needs several ADMS centers may be developed in a region (e.g. a traffic center, a transit center, and a CVO center), and the ability to share/merge data center to center and archive to archive preserved.

Five major functions are defined that are carried out as part of ADUS. These are:

1) Operational Data Control function to manage operations data integrity
2) Data Import and Verification function to acquire historical data from the Operational Data Control function
3) Automatic Data Historical Archive function for permanently archiving the data
4) Data Warehouse Distribution function, which integrates the planning, safety, operations, and research communities into ITS and processes data products for these communities
5) ITS Community Interface which provides the ITS common interface to all ITS users for data products specification and retrieval.

Within the functions the Architecture now has defined many sub-functions and details to help areas think through their specific applications. It is therefore a very useful resource to use when planning for the use of ITS data.

Figure V-15 ADUS Information Flows and Interfaces



The organization and implementation of the ADMS can also be implemented in several different ways. At its simplest the data from a single source is simply collected and stored in its own database (a data mart). At its most complex the data from many different sources is brought together and merged for analysis of multi-dimensional issues (a data warehouse). "Data mining", or the exploration of large amounts of information for new relationships and trends, is often part of the latter. To allow an area to tailor ADUS to meet its needs the Architecture provides three different "market packages" to choose from for implementing the local ADUS systems. These are:

ITS Data Mart (Market Package): This market package provides a focused archive that houses data collected and owned by a single agency, district, private sector provider, research institution, or other organization. This focused archive typically includes data covering a single transportation mode and one jurisdiction that is collected from an operational data store and archived for future use. It provides the basic data quality, data privacy, and meta- data management common to all ITS archives and provides general query and report access to archive data users.

ITS Data Warehouse (Market Package): This market package includes all the data collection and management capabilities provided by the ITS Data Mart, and adds the functionality and interface definitions that allow collection of data from multiple agencies and data sources spanning across modal and jurisdictional boundaries. It performs the additional transformations and provides the additional meta-data management features that are necessary so that all this data can be managed in a single repository with consistent formats. The potential for large volumes of varied data suggests additional on-line analysis and data mining features that are also included in this market package in addition to the basic query and reporting user access features offered by the ITS Data Mart.

ITS Virtual Data Warehouse (Market Package): This market package provides the same broad access to multimodal, multidimensional data from varied data sources as in the ITS Data Warehouse Market Package, but provides this access using enhanced interoperability between physically distributed ITS archives that are each locally managed. Requests for data that are satisfied by access to a single repository in the ITS Data Warehouse Market Package are parsed by the local archive and dynamically translated to requests to remote archives which relay the data necessary to satisfy the request.

The steps for implementing an ADUS and providing feedback to the all cycles of the should be carried out as part of the integrated process. They include:

1. **Gather Stakeholders**. Bring the ITS operators and data collectors, data providers, and users together.
2. **Determine needs and measures and attributes**. From the stakeholder dialog and the previously defined performance measures develop a list of information needs that ITS data may be able to address. This is more than simply a list of measures and should include collection and storage frequency, aggregation levels, accuracy, access/privacy and other requirements. Determining how the information should be provided and feedback occur (reports, graphic displays, on-line queries) should also be part of this
3. **Define architecture and operational design.** This step determines which market packages to use (data marts, data warehouse, virtual data warehouse), and the basic structure of the ITS data collection and storage system. It must also plan for the ability to integrate and merge data when needed. Data validation, storage, and maintenance functions also need to be defined.
4. **Develop concept of operations.** Who should do what? Who is responsible for cleaning and providing the data? Who has access? How should the costs be shared? These are all part of the concept of operations. A general rule is to maximize “ownership” of functions and issues where those performing the functions are the same ones that they are important too. Where this is not possible some ongoing interaction between the collector and user(s) should be incorporated.
5. **Develop phasing plan.** An important observation is to keep it simple at the beginning, start slow and add functions. If the ultimate plan is to develop a virtual data warehouse integrating traffic, transit, and accident data the first step maybe to implement data marts for each designed with the final integration in mind. A phasing plan shows how the systems will ultimately come together and may help obtain cooperation of users, especially for functions/data that do not directly meet their needs.
6. **Obtain agreements.** Agreements and memorandum of understanding are essential for the long-term continued success of any data management system. They should include both sharing of responsibilities and costs. Where possible common goals and objectives associated with the performance measures should become part of each stakeholders own performance evaluation. Equally important they should clearly establish ownership and access rights, and privacy

procedures. This is important both for working between agencies and in interactions with the public, the private sector, and potential liability concerns.

7. **Implement and provide ongoing feedback.** Data can now be collected, stored and fed back to the decision processes. Questions to ask as this process continues include; is the information continuing to be reliable? Are the reports and other communications remaining useful? Are participants performing their functions? Long-term continuing functions such as ITS data storage are new to many transportation groups and feedback on the process itself is needed to insure that it remains viable.
8. **Update.** As new components are added, and new knowledge gained the processes for collection and feedback of ITS data will need to be updated. It is therefore very important that continual involvement of stakeholders be included in the overall plan.

V.H.3 VARIATIONS BY SCALE, SETTING, AND INSTITUTIONS

How systems for ITS data collection and distribution vary can depend upon a number of different factors. Primary among these are resources and institutional relationships. Other important factors include the sources of information and modes within a region, and the complexity of the issues that decision makers are trying to address.

The collection, validation, maintenance, and communication of ITS data is not free. While it has the potential to be a rich data source and save overall resources it often places different burdens on different participants than traditional data collection. This must be addressed and the system designed so it can be maintained on a continual basis. Whether saved by individual agencies in data marts, or in a data warehouse, on-line or off-line, raw or aggregated, the resource requirements need to be tailored to local capabilities.

Historical institutional arrangements and capabilities also play an important role. Virginia Department of Transportation is developing an integrated data management system and warehouse as part of its decision support system. Because it is department wide it is able to integrate many individual data sources. On the other hand, in a region with many transit and other operating agencies a physically integrated data warehouse may be impossible. MPOs may also be the logical data repositories for these new sources of information. One of the main functions of an MPO is to provide a forum for collaboration and liaison between participants in the planning process. Also, MPOs often have historically provided the data repository for planning functions. Each area must assess, who is best able to perform the data maintenance functions, and the level of integration needed to answer their questions.

The number of modes and sources of ITS data will impact the overall ITS data system that should be implemented for a region. More modes may or may not lead to more complex systems. Weather the systems are complex, or simple, physical or virtual, planning still needs to take place to allow for integration of information. This may require new and non-traditional interactions across modes especially between transit and traffic operations staff.

Last, the complexity of issues and problems facing the region will be an important factor. Areas with heavy congestion, multiple modes, and resource limitations may need to able to assess multiple relationships in a policy environment that requires very quick response to questions. Complex decision support systems such as OLAP may thus be called for. Other areas may have more persistent issues and problems that can be addressed by separate data marts and off-line merging of information when necessary.

The key to the many different variations that can be implemented for ITS data storage and feedback is matching needs to resources. Thus, the first two steps discussed above in defining the data system are critical: bringing stakeholders together, and defining needs and measures.

V.H.4 SECTION REVIEW AND TRANSITION ASSESSMENT

This section described the importance of performance feedback and the use of ITS data within the Integrated Framework. ITS data has provides the opportunity to monitor traditional measures in a cost effective way, provide new measurement of system variation, reliability, and customer satisfaction, and collect information for ITS benefits and costs and new analysis tools.

However, ITS data also brings its own set of issues. These include: the quantity of data generated through 24/7 collection, the need for developing data cleaning and error checking processes to ensure that quality information is stored, how to store the information, and how to analyze the volume of data that is provided once it is stored. Also data cannot simply be stored once. The costs of data management and maintenance must also be accounted for.

If it is to be useful to planners the data content, location of detectors, and coverage must also be considered. It is therefore very important to bring in potential data users as the ITS data collection system is being developed.

Likewise, there is also almost too much information to be understood and useful to the decision making process as information. Data presentation and visualization must processes must also be developed as part of the feedback process.

Other issues include access, ownership, and privacy concerns, and defining the roles and responsibilities within the overall concept of operations.

The Archived Data User Service provides three Market Packages for the implementation of a data archiving system. These are: 1) ITS Data Mart; 2) ITS Data Warehouse; and 3) Virtual ITS Data Warehouse. Which to use should be determined as part of the overall integrated planning process.

Table V-21 provides some self-assessment questions regarding ITS data and feedback. Mark where you think your area's relative position is for each question.

Table V-21 ITS Data, Performance Monitoring, and Feedback Self-Assessment

Question	NO YES
Is ITS data currently being collected and archived for highway, arterial, or transit system performance? Is it being analyzed to assist in operational or other planning activities?	NO - - - - - - - - YES
Is system performance being continually monitored and used in the transportation decision process? Is ITS data being used in this process?	NO - - - - - - - - YES
Is there a data quality control and management program for ITS data?	NO - - - - - - - - YES
Are the costs for ITS data collection, maintenance of surveillance equipment, and maintenance and cleaning being accounted for in system plans?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

VI CONTINUING CHALLENGES AND SOURCES FOR STAYING CURRENT

VI.A CONTINUING CHALLENGES

There are a number of remaining challenges that must be overcome as the standard practice evolves toward the integrated framework. These include:

Final Planning Level Policy on and Guidance ITS Architecture Conformity: The Joint FHWA/FTA Planning Rule for Metropolitan and Statewide Planning update to incorporate the new requirements of TEA-21 including planning level ITS Architecture Conformity is still under review and comment. Experience with implementing the project level Final Rule and Policy is also being gained. Consequently, what constitutes good practice and how to address all situations is still being determined. Yet, the Rule and Policy are the first actual regulations calling for mainstreaming ITS. Case studies, “model” efforts, and dissemination of good practice are needed as lessons are learned and specific issues resolved.

New Organizations and public-private partnerships: New organizations aimed at managing the overall transportation system, integrating and coordinating ITS services, developing ITS architectures are developing which carry out many near-to-mid-term planning and programming functions. As we move to the integrated planning process how these organizations interact with traditional planning and the roles and responsibilities of both the new and old, organizations are evolving. Likewise, actual working models of sustainable public-private partnerships and the role of the private sector in future transportation is still undetermined. The National ITS Program Plan’s vision assumes a growing role of Independent Service Providers (ISPs), and the market in provision of services. What remains to be seen is whether these services will actually develop, and if they develop will they do so in a way that is consistent with the overall management of the transportation system, and fulfillment of a region’s goals and objectives.

Data Revolution (costs, models, and uses): New technology is revolutionizing the storage and analysis of data. The new Archived Data User Service (ADUS) has been developed in response. However, there are virtually no cases of integrating ITS data, and the new techniques for data warehousing, fusion, and mining into the standard practices of planning. Questions remain, regarding how to maintain the volume of data and its quality over time, the costs of different ADUS market packages, and the comparability between ITS collected data and data collected from traditional means. More important, ITS data provides new information on variability of the system, and customer satisfaction. New uses of the continuous information and how it may transform the planning/decision process remain to be seen.

Predicting Technology: Predicting the new innovations in technology and its costs will be a perennial issue if ITS is to be fully incorporated into mid-long-range planning. Equally important, are predictions of market penetrations of technologies and services once they are deployed. Most ITS specialists are hesitant to predict the future beyond 5 to 7 years. Yet, 20 year forecasts are needed. In order to provide consistency in regional forecasts, and avoid duplication of effort by local and state agencies across the country a national base-line forecast may be needed.

Synergies of Integrated Systems: While examples of individual ITS implementations, their costs and benefits and analysis methods are growing rapidly, little is known still about the impacts of integrated systems. These may defy simple sketch methods, and require incorporating the use of information and response to variability and non-recurrent incidents in the overall regional travel forecasting tools. The US DOT Metropolitan Model Deployment Initiative has provided a beginning on collecting and analyzing information on integrated deployments. However, this is only a beginning, and more information and tools for evaluating integrated ITS, as well as combined ITS and traditional solutions are needed.

Putting it all together (no one is there yet): There are a growing number of areas that are beginning to incorporate ITS into their planning processes, and have included various aspects of the integrated planning process described here in their procedures. San Francisco, Chicago, Washington D.C., Houston, Albany, and others all are on their way in the evolution. However, no area has fully re-focused their process on management and operations and the development path, or incorporated variation and ITS into their analysis techniques. This will come with time. There are, however, a number of initial actions that can be taken which are discussed next.

VI.B SOURCES FOR CURRENT INFORMATION

Since the development of this Guidebook began in April, 1998, significant changes have taken place in both the requirements for planning, the generally accepted principals of planning, and the practice of planning and ITS. TEA-21 was enacted including requirements for conformity to the National ITS Architecture, and the Management and Operations Planning Factor. Deployments of ITS systems have continued to grow and its benefits become more accepted. New methods for analysis have also appeared.

With re-authorization of TEA-21 rapidly approaching, new guidance being developed on incorporating operations into planning, and shifting public priorities brought on by September 11, 2002, this change will only continue to occur. Consequently, a number of sources are provided below to help keep abreast of the continued evolution towards integrated planning.

VI.B.1 ITS, OPERATIONS, AND THE CHANGING REQUIREMENTS AND PRACTICE FOR INTEGRATED PLANNING.

Joint Program Office ITS Resource Guide:	http://www.its.dot.gov/guide.html
FHWA Planning For Operations	http://plan2op.fhwa.dot.gov/
FHWA Planning	http://www.fhwa.dot.gov/environment/index.htm
FTA Planning	http://www.fta.dot.gov/office/planning/index.html
ITS America's Regional Planning	http://www.itsa.org/metro.html
National Dialogue on Transportation Operations	http://ops.fhwa.dot.gov/nat_dialogue.htm
Association of Metropolitan Planning Organizations (AMPO)	http://www.ampo.org/
National Associations ITS Working Group (NAWGITS) Resource site	http://www.nawgits.com/its_res1.html

VI.B.2 INSTITUTIONAL AND ORGANIZATIONAL ISSUES.

Association of Metropolitan Planning Organizations (AMPO)	http://www.ampo.org/
ITE Regional Operating Organizations Site	http://www.ite.org/library/Reg_Trans_Ops.htm

VI.B.3 VISIONS, GOALS, OBJECTIVES AND PERFORMANCE MEASURES.

ITS Decision Support and Planning	http://www.path.berkeley.edu/%7Eleap/itsdecision_resources/decision.html
FHWA Operations site on Performance Measures	http://www.ops.fhwa.dot.gov/Travel/Deployment_Task_Force/perf_measures.htm
National Dialogue on Operations	http://ops.fhwa.dot.gov/nat_dialogue.htm

VI.B.4 ESTIMATING BENEFITS, COSTS, AND IMPACTS

USDOT JPO ITS Benefits and Unit Costs Database	http://www.benefitcost.its.dot.gov/its/benecost.nsf/
FTA Transit ITS Impacts Matrix	http://web.mitretek.org/its/aptsmatrix.nsf
Transit Capacity and Quality of Service site	http://transit.kittelson.com/
FHWA Planning For Operations web site	http://plan2op.fhwa.dot.gov/
ITS Decision Support and Planning	http://www.path.berkeley.edu/%7Eleap/itsdecision_resources/decision.html
USDOT JPO ITS Evaluation web site	http://www.its.dot.gov/EVAL/eval.htm
Screening for ITS web site	http://www.fhwa.dot.gov/steam/scrits.htm
Cambridge Systematics IDAS web site	http://idas.camsys.com/
McTrans IDAS web site	http://www-mctrans.ce.ufl.edu/featured/idas/
FHWA Quick Zone Work Zone Analysis Tool	http://www.tfhrc.gov/its/quickzon.htm.
FHWA Operations Traffic Analysis Tools site	http://ops.fhwa.dot.gov/Travel/Traffic_Analysis_Tools/traffic_analysis_tools.htm
FHWA Traffic Software Integrated System (TSIS) for simulation	http://www.fhwa-tsis.com.
Travel Model Improvement Program Clearinghouse	http://tmip.fhwa.dot.gov/
FHWA Dynamic Traffic Assignment web site	http://www.dynamictrafficassignment.org/
TRANSIMS	http://tmip.fhwa.dot.gov/transims/

VI.B.5 ITS ARCHITECTURE'S AND STANDARDS

National ITS Architecture Conformity	www.its.dot.gov/aconform/aconform.htm
National ITS Architecture ITS site:	http://www.its.dot.gov/arch/arch.htm
Online version of the National ITS Architecture	http://www.iteris.com/itsarch/
McTrans Site for The Turbo Architecture	http://www-mctrans.ce.ufl.edu/featured/turbo/
ITS America System Architecture Committee	http://www.itsa.org/architecture.html
ITSA Library of Regional Architectures (Click on link from site on the right)	http://www.itsa.org/architecture.html
ITS Standards and their development	www.its-standards.net

VI.B.6 ITS DATA AND ADUS.

ITS JPO Travel Management ADUS Site	http://www.its.dot.gov/TravelManagement/adus.htm
ITS America ADUS Resources Page	:www.itsa.org/resources.nsf/urls/adusr.html

VI.B.7 ITS AND PLANNING TRAINING

USDOT JPO ITS Training web site	http://www.its.dot.gov/pcb/pcb.htm
ITS Professional Capacity Building web site	http://www.pcb.its.dot.gov/
National Highway Institute Courses on Planning and ITS	http://www.nhi.fhwa.dot.gov/coursec.html
National Transit Institute Courses on Planning and ITS	http://www.ntionline.com/Training.asp
ITS Standards Training (Click on Training Tab)	http://www.its-standards.net/

For additional information on the NCHRP Project 8-35 “Incorporating ITS Into the Transportation Planning Process” and its products please visit the Transportation Research Board web site and go to the NCHRP All Projects Tab (http://www4.trb.org/trb/crp.nsf/NCHRP+projects). The up to date project description is kept under Topic 8: Forecasting.

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APPENDIXES

Appendix A:	Glossary.
Appendix B:	User Services to Market Packages
Appendix C:	Self-Assessments On Regional Progress Towards Integrated Planning

APPENDIX A GLOSSARY OF ITS AND PLANNING TERMS

Terms Related to Planning, Evaluation, and General Transportation	
Term	**Definition**
AASHTO	American Association of State Highway and Transportation Officials. One of five standards development organizations with which US DOT is working to establish standards for integrated, interoperable ITS deployment.
Arterial	A class of street serving major traffic movement that is not designated as a highway.
Bus Lane	A lane reserved for bus use only. Sometimes also known as a "diamond lane." See also "HOV".
CMAQ	Congestion Management and Air Quality program
CMS	Congestion Management System
Conformity	Process to assess the compliance of any Federally funded or approved transportation plan, program, or project with air quality implementation plans. The conformity process is defined by the Clean Air Act.
Conformity lapse	The conformity determination for a transportation plan or TIP has expired, and thus there is no currently conforming transportation plan and TIP.
Conformity rule	The EPA Transportation Conformity Rule, as amended, 40 CFR parts 51 and 93.
Congestion Management and Air Quality program (CMAQ)	Congestion Management and Air Quality program. Funding category in the Intermodal Surface Transportation Efficiency Act that targets efforts to reduce metropolitan air pollution. ITS technologies that contribute to improving air quality are eligible for CMAQ funds.
Congestion Management System (CMS)	A systematic process for managing congestion that provides information on transportation system performance and on alternative strategies for alleviating congestion and enhancing the mobility of persons and goods to levels that meet State and local needs. ISTEA required that each Transportation Management Area (see definition of TMA) develop a CMS that provides for effective management of new and existing transportation facilities through the use of travel demand reduction and operational management strategies.
Consultation	One party confers with another party, in accordance with an established process, about an anticipated action and then keeps that party informed about actions taken.
Cooperation	The parties involved in carrying out the planning and/or project development processes work together to achieve a common goal or objective.
Coordination	The comparison of the transportation plans, programs, and schedules of one agency with related plans, programs and schedules of other agencies and adjustment of plans, programs and schedules to achieve general consistency.
Demand Response	Segment of public transit designed to efficiently move persons not able to access regular, fixed transit routes. This form of transit is utilized especially for persons with disabilities and senior citizens.
Department of Transportation (D0T)	Department of Transportation. When used alone, indicated U.S. Department of Transportation. In conjunction with a place name, indicates State, city, or county transportation agency (e.g., Illinois DOT, Los Angeles DOT).
Design concept	The type of facility identified by the project, e.g., freeway, expressway, arterial highway, grade-separated highway, reserved right-of-way rail transit, mixed-traffic rail transit, exclusive busway, etc.
Design scope	The design aspects which will affect the proposed facility's impact on regional emissions, usually as they relate to vehicle or person carrying capacity and control, e.g., number of lanes or tracks to be constructed or added, length of project, signalization, access control including approximate number and location of interchanges, preferential treatment for high-occupancy vehicles, etc.
DOT	Department of Transportation
Environmental Justice	Requirement that Federal actions do not place disproportionate burdens on minority and low-income population groups. It was defined by Executive Order 12898 signed by President Clinton in February 1994 that requires each Federal Agency to "make environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations".

Terms Related to Planning, Evaluation, and General Transportation

Term	Definition
Expressway	A controlled access, divided arterial highway for through traffic, the intersections of which are usually separated from other roadways by differing grades.
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
Federal Communications Commission (FCC)	The Federal agency, which regulates telecommunications in the United States.
Federal Highway Administration (FHWA)	An agency of the U.S. Department of Transportation that funds highway planning and programs.
Federal Railroad Administration (FRA)	The agency of the U.S. Department of Transportation that funds rail planning and deployment programs.
Federal Transit Administration (FTA)	An agency of the U.S. Department of Transportation that funds transit planning and deployment programs.
Federally funded non-emergency transportation services	Transportation services provided to the general public, including those with special transport needs, by public transit, private non-profit service providers, and private third-party contractors to public agencies.
FHWA	Federal Highway Administration
Financial Capacity	Refers to the ISTEA requirement that an adequate financial plan for funding and sustaining transportation improvements be part of the plan and TIP.
Financial estimate	A projection of Federal and State resources that will serve as a basis for developing plans and /or TIPs.
FRA	Federal Railroad Administration
Freeway	A divided arterial highway designed for the unimpeded flow of large traffic volumes. Access to a freeway is rigorously controlled and intersection grade separations are required.
FTA	Federal Transit Administration
High Occupancy Vehicles (HOVs)	Vehicles carrying two or more people (bus, carpool). The number that constitutes an HOV for the purposes of HOV highway lanes may be designated differently by different transportation agencies.
Highway	Term applies to roads, streets, and parkways, and also includes rights of way, bridges, railroad crossings, tunnels, drainage structures, signs, guardrails, and protective structures in connection with highways.
HOV	High Occupancy Vehicle
IEEE	Institute of Electrical and Electronics Engineers
Illustrative project	A transportation improvement that would be included in a financially constrained transportation plan and program if reasonable additional financial resources were available to support it.
Institute of Electrical and Electronics Engineers (IEEE)	Institute of Electrical and Electronics Engineers. One of five standards development organizations with which US DOT is working to establish standards for integrated, interoperable ITS deployment.
Institute of Traffic Engineers (ITE)	Institute of Traffic Engineers. One of five standards development organizations with which US DOT is working to establish standards for integrated, interoperable ITS deployment.
Interim plan	A plan composed of projects eligible to proceed under a conformity lapse (as defined in 40 CFR parts 51 and 93) and otherwise meeting all other provisions of this part including adoption by the MPOs.
Interim transportation improvement program	A TIP composed of projects eligible to proceed under a conformity lapse (as defined in 40 CFR parts 51 and 93) and otherwise meeting all other provisions of this part including approval by the Governor.
Intermodal	The ability to connect, and make connections between modes of transportation.
Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA)	Intermodal Surface Transportation Efficiency Act of 1991. Federal law providing primary federal funding for highway and other surface transportation programs in the United States through 1997. ISTEA contains the Intelligent Vehicle-Highway System Act. Directs the establishment of a National ITS program that is to include: a strategic plan for ITS in the United States, implementation and evaluation of ITS technologies, development of standards protocols, an

Terms Related to Planning, Evaluation, and General Transportation	
Term	**Definition**
	information clearinghouse, the use of advisory committees (one of which is ITS America), and funding for ITS research, development, and testing in such efforts as the corridors program. ISTEA authorized increased levels of highway and transportation funding and an increased role for regional planning commissions/MPOs in funding decisions. The Act also requires comprehensive regional and Statewide long-term transportation plans and places an increased emphasis on public participation and transportation alternatives.
Intermodalism	Seamless integration of multiple travel modes.
Interstate Highway System	The system of highways that connects the principal metropolitan areas, cities, and industrial centers of the United States. The Interstate System also connects the U.S. to internationally significant routes in Mexico and Canada.
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Traffic Engineers
Local Street	A street intended solely for access to adjacent properties.
Long Term	In transportation planning, refers to a time span of, generally, twenty years.
LRP	A long range metropolitan transportation plan for a region
Maintenance area	Any geographic region of the United States previously designated nonattainment pursuant to the Clean Air Act Amendments of 1990 (CAA) and subsequently redesignated to attainment subject to the requirement to develop a maintenance plan under section 175A of the CAA, as amended.
Management and operation	Actions and strategies aimed at improving the person, vehicle and/or freight carrying capacity, safety, efficiency and effectiveness of the existing and future transportation system to enhance mobility and accessibility in the area served.
Metropolitan planning area	The geographic area in which the metropolitan transportation planning process required by 23 U.S.C. 134 and 49 U.S.C. 5303-5306 must be carried out.
Metropolitan planning organization (MPO)	The forum for cooperative transportation decision making for the metropolitan planning area pursuant to 23 U.S.C. 134 and 49 U.S.C. 5303. Regional policy body that is responsible in cooperation with the state and other transportation providers for carrying out the metropolitan transportation planning requirements of federal highway and transit guidelines.
Metropolitan transportation plan (LRP)	The official intermodal transportation plan that is developed and adopted through the metropolitan transportation planning process for the metropolitan planning area, in accordance with 23 U.S.C. 134 and 135 and 49 U.S.C. 5303.
Mode	A form of transportation such as an automobile, bus or bicycle.
MPO	Metropolitan Planning Organization.
Multi Modal	The availability of transportation options using different modes within a system or corridor.
National Highway System (NHS)	The transportation system designated by Congress that includes Interstate Highways and nationally significant roads for interstate travel, national defense, Intermodal connections, and international commerce.
National Highway Traffic Safety Administration (NHTSA)	The agency in the U.S. Department of Transportation that is charged with overseeing transportation safety research and standards.
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
Nonattainment area	Any geographic region of the United States that has been designated as nonattainment under section 107 of the CAA for any pollutant for which a national ambient air quality standard exists.
Non-metropolitan local official	Elected or appointed officials of general purpose local government, outside metropolitan planning areas, with jurisdiction/responsibility for transportation or other community development actions that impact transportation and elected officials for special transportation and planning agencies, such as economic development districts and land use planning agencies.
Paratransit	A variety of smaller often flexibly scheduled and routed transportation services using low capacity vehicles, such as vans, to operate within normal urban transit corridors or rural areas. These services usually serve the needs of persons that standard mass transit services would serve with difficulty, or not at all. Often, the patrons include the elderly and persons with disabilities.

Terms Related to Planning, Evaluation, and General Transportation	
Term	**Definition**
Public Participation	The active and meaningful involvement of the public in the development of transportation plans and programs.
Purpose and need	The intended outcome and sustaining rationale for a proposed transportation improvement, including, but not limited, to mobility deficiencies for identified populations and geographic areas.
R&D	Research and Development
Regionally significant project	A transportation project (other than an exempt project) that is on a facility which serves regional transportation needs (such as access to and from the area outside of the region, major activity centers in the region, major planned developments such as new retail malls, sports complexes, etc., or transportation terminals as well as most terminals themselves) and would normally be included in the modeling of a metropolitan area's transportation network, including at a minimum all principal arterial highways and all fixed guide way transit facilities that offer an alternative to regional highway travel.
RSPA	Research and Special Programs Administration of the US Department of Transportation.
SIP	State Implementation Plan (for air quality)
Society of Automotive Engineers (SAE)	Society of Automotive Engineers. One of five standards development organizations with which US DOT is working to establish standards for integrated, interoperable ITS deployment.
State Implementation Plan (SIP)	The implementation plan which contains specific strategies for controlling emissions of and reducing ambient levels of pollutants in order to satisfy Clean Air Act (CAA) requirements for demonstrations of reasonable further progress and attainment (CAA secs. 182(b)(1), 182(c)(2)(A), 182(c)(2)(B), 187(a)(7), 189(a)(1)(B), and 189(b)(1)(A); and secs.192 (a) and 192(b), for nitrogen dioxide of the CAA); or The implementation plan under section 175A of the CAA as amended.
Statewide transportation improvement program (STIP)	A staged, multi-year, statewide, intermodal program of transportation projects which is consistent with the statewide transportation plan and planning processes and metropolitan plans, TIPs and processes pursuant to 23 U.S.C. 135.
Statewide Transportation Plan	The official, statewide intermodal transportation plan that is developed through the statewide transportation planning process pursuant to 23 U.S.C. 135.
STIP	Statewide Transportation Improvement Plan
STIP extension	The lengthening of the scheduled duration of an existing STIP, including the component metropolitan TIPs included in the STIP, beyond two years by joint administrative action of the FHWA and the FTA. STIP extensions are not allowed for metropolitan TIP portions of the STIP that are in nonattainment or maintenance areas as well as for those portions of the STIP containing projects in rural nonattainment or maintenance areas.
TCM	Transportation Control Measure
TDM	Transportation Demand Management
TEA - 21	The Transportation Equity Act for the 21st Century
The Transportation Equity Act for the 21st Century (TEA - 21)	TEA - 21 was enacted June 9, 1998 as Public Law 105-178. TEA-21 authorizes the Federal surface transportation programs for highways, highway safety, and transit for the 6-year period 1998-2003. The TEA 21 Restoration Act, enacted July 22, 1998, provided technical corrections to the original law. Significant provisions of TEA - 21 regarding ITS and planning include: The definition of a new "Management and Operations" planning factor; inclusion of formal requirements that all ITS projects funded from the U.S. Highway Trust Fund conform to the National ITS Architecture; mainstreaming of ITS into the transportation decision process; definition of new planning factors; streamlining the environmental review and Federal decision process including eliminating the requirement for separate Major Investment Studies (MIS); and strengthening many of the ISTEA processes including flexible financing, environmental justice, and public participation.
TIP	Transportation Improvement Program
TIP update	The periodic re-examination and revision of TIP contents, including, but not limited to, non-exempt projects, on a scheduled basis, normally at least every two years. The addition or deletion of a non-exempt project or phase of a non-exempt project to a TIP shall be based on a comprehensive update of the TIP.
TMA	Transportation Management Area
Transit	Generally refers to passenger service provided to the general public along established routes with

Terms Related to Planning, Evaluation, and General Transportation	
Term	**Definition**
	fixed or variable schedules at published fares. Related terms include: public transit, mass transit, public transportation, urban transit and paratransit.
Transportation Control Measure (TCM)	Any measure that is specifically identified and committed to in the applicable implementation plan that is either one of the types listed in section 108 of the CAA, or any other measure for the purpose of reducing emissions or concentrations of air pollutants from transportation sources by reducing vehicle use or changing traffic flow or congestion conditions. These may include HOV lanes, provision of bicycle facilities, ridesharing, telecommuting, etc. Notwithstanding the above, vehicle technology-based, fuel- based, and maintenance-based measures that control the emissions from vehicles under fixed traffic conditions are not TCMs.
Transportation Demand Management (TDM)	Programs designed to reduce demand for transportation through various means such as the use of high occupancy vehicles, alternative work hours, transit and telecommuting.
Transportation Improvement Program (TIP)	A staged, multi- year, intermodal program of transportation projects in the metropolitan planning area that is consistent with the metropolitan transportation plan. This is a document prepared by metropolitan planning organizations listing projects to be funded with FHWA/FTA funds for the next one to three year period (can cover up to 6 years).
Transportation Management Area (TMA)	An urbanized area with a population over 200,000 (as determined by the latest decennial census) or other area when TMA designation is requested by the Governor and the MPO (or affected local officials), and officially designated by the Administrators of the FHWA and the FTA. The TMA designation applies to the entire metropolitan planning area(s).
Transportation plan update	The periodic review, revision or reaffirmation of plan content, normally every three years in nonattainment and maintenance areas and five years in attainment areas or the update period for State plans as determined by the State.
Transportation Research Board (TRB)	Part of the National Academy of Science, National Research Council. Serves to stimulate, correlate, and make known the findings of transportation research.
Transportation System Management (TSM)	The element of a TIP that proposes non capital intensive steps toward the improvement of a transportation system, such as refinement of system and traffic management, the use of bus priority or reserved lanes, and parking strategies. It includes actions to reduce vehicle use, facilitate traffic flow, and improve internal transit management.
TRB	Transportation Research Board
TSM	Transportation System Management
Twenty year planning horizon	A forecast period covering twenty years from the date of plan adoption, reaffirmation or modification in attainment areas and subsequent Federal conformity finding at the time of adoption in nonattainment and maintenance areas. The plan must reflect the most recent planning assumptions for current and future population, travel, land use, congestion, employment, economic activity and other related statistical measures for the metropolitan planning area.
U.S. Department of Transportation (U.S. DOT)	The principal direct Federal funding agency for transportation facilities and programs. Includes the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), and others.
Urbanized area (UZA)	A geographic area with a population of at least 50,000 as designated by the U.S. Department of Commerce, Bureau of the Census based on the latest decennial census or special census as appropriate.
UZA	Urbanized area
Vehicle Miles of Travel (VMT)	A standard area wide measure of travel activity. The most conventional VMT calculation is to multiply average length of trip by the total number of trips.
VMT	Vehicle Miles of Travel
WWW	World Wide Web
Zone	The smallest geographically designated area for analysis of transportation activity. A zone can be from one to 10 square miles in area. Average zone size depends on the total size of study area.

Terms Related to Intelligent Transportation Systems and the National ITS Architecture

Term	Definition
ACN	Automated Collision Notification system.
Advanced Public Transportation Systems (APTS)	Advanced Public Transportation Systems. Collection of technologies to increase efficiency of public transportation systems and offer users greater access to information on system operation. Now using ITS-Transit
Advanced Rural Transportation Systems (ARTS)	Advanced Rural Transportation Systems. ITS technologies aimed at addressing the specific needs of rural communities, particularly the issues of mobility and road safety.
Advanced Traffic Management Systems (ATMS)	Advanced Traffic Management Systems. An array of institutional, human, hardware and software components designed to monitor, control and manage traffic on streets and highways. ATMS technologies apply surveillance and control strategies to improve traffic flow on highways and streets.
Advanced Traveler Information Systems (ATIS)	Advanced Traveler Information Systems. ATIS technologies provide travelers and transportation professionals with the information they need to make decisions, from daily individual travel decisions to larger scale decisions that affect the entire system, such as those concerning incident management.
Advanced Vehicle Collision and Safety Systems (AVCSS)	Advanced Vehicle Collision and Safety Systems. These systems employ mostly in-vehicle technologies to help drivers avoid collisions, monitor driver performance, and automatically signal for emergency aid immediately upon collision.
Advanced Vehicle Control Systems (AVCS)	Vehicle and/or roadway based electromechanical and communications devices that enhance the control of vehicles by facilitating and augmenting driver performance. Of particular importance are collision avoidance or warning systems to prevent accidents.
American Society of Testing and Materials (ASTM)	American Society of Testing and Materials. One of five standards development organizations with which US DOT is working to establish standards for integrated, interoperable ITS deployment.
APTS	Advanced Public Transportation Systems
Architecture	An overarching framework that allows individual ITS services and technologies to work together, share information, and yield synergistic benefits.
ARTS	Advanced Rural Transportation Systems
ATIS	Advanced Traveler Information Systems
ATMS	Advanced Traffic Management Systems
Automated Vehicle Identification (AVI)	A system that transmits signals from an on board tag or transponder to a roadside receiver for the automated identification of vehicles. AVI systems are used in automated toll collection, incident management, and Commercial Vehicle Operations systems, among others.
Automated Vehicle Location (AVL)	A computerized system that tracks the current location of trucks, buses, emergency vehicles etc., enabling fleet manager to coordinate activities more efficiently. AVL also is installed on vehicles to locate help located them accurately and quickly in emergencies.
AVCS	Advanced Vehicle Control Systems
AVCSS	Advanced Vehicle Collision and Safety Systems
AVI	Automated Vehicle Identification
AVL	Automatic Vehicle Location System
Beacons	Short range roadside transceivers for communicating between vehicles and the traffic management infrastructure. Common transmission technologies include microwave and infrared
CAD	Computer Aided Dispatch
Changeable Message Signs	Electronic signs that can change the message it displays. Often used on highways to warn and redirect traffic. Also referred to as variable or electronic message signs.
Commercial Vehicle Information Systems and Networks (CVISN)	The communications and information systems component of CVO. A network that connects existing federal, state, and private-sector information systems to improve commercial vehicle movement. The national CVISN project is developing protocols to ensure the compatibility of systems that collect and exchange electronic information on commercial vehicles, including state registration, fuel tax requirements, weight and safety inspection information, cargo type etc. The intent is to streamline and simplify commercial vehicle application and clearance processes across the states.

Terms Related to Intelligent Transportation Systems and the National ITS Architecture

Term	Definition
Commercial Vehicle Operations (CVO)	Commercial Vehicle Operations. ITS program to apply advanced technologies to commercial vehicle operations, including commercial vehicle electronic clearance; automated roadside safety inspection; electronic purchase of credentials; automated mileage and fuel reporting and auditing; safety status monitoring; communication between drivers, dispatchers and intermodal transportation providers; and immediate notification of incidents and descriptions of hazardous materials involved.
Computer Aided Dispatch (CAD)	Uses advanced communications to coordinate and relay information efficiently to vehicle fleets, such as transit buses, patrol cars, emergency response vehicles and private carriers.
Concept of Operations	Component of a Regional Architecture which describes the roles and responsibilities of participating agencies and existing or required agreements for operations and resources required to support the project in order to implement the ITS strategy.
Conceptual Design	Component of a Regional Architecture describing the functions, information flows, and services sufficient to support subsequent project design regarding the following: (i) System functional requirements; (ii) Interface requirements and information exchanges with planned and existing systems and subsystems (for example, subsystems and architecture flows as defined in the National ITS Architecture); (iii) Identification of key standards supporting regional and national interoperability, including uniformity and compatibility of equipment, practices and procedures to deliver ITS services; (iv) A prioritization of phases or steps required in implementation.
CVISN	Commercial Vehicle Information System and Networks
CVO	Commercial Vehicle Operations
Dedicated Short-Range Communications (DSRC)	Dedicated Short-Range Communications. Wireless, short-range digital communications. Uses electronic readers, tags, and software.
DGPS	Differential Global Positioning System
Differential Global Positioning System (DGPS)	Differential Global Positioning System. A technique that can be applied by civilian GPS users to improve GPS accuracy to 1-10 meters.
DSRC	Dedicated Short-Range Communications
EDI	Electronic Data Interchange.
EDP	Early Deployment Plan
Electronic Fare Payment	Systems that allow electronic debit or credit processing of transit fares.
Emergency Management Services (EMS)	Emergency Management Services. Services designed to optimize the response time to incidents.
EMS	Emergency Management Services
Enabling Research	Applied research that advances existing technologies to enable them to support ITS applications. This research has refined technology for eventual field testing, developed evaluation methods to determine potential benefits and cost effectiveness, developed human factors guidelines, and established performance specifications and criteria.
ENTERPRISE	Evaluating New Technologies for Roads Program Initiative in Safety and Efficiency. North American ITS cooperative initiative to facilitate the rapid development and deployment of ITS technologies. A consortium of public and private organizations with compatible ITS goals which will identify and exploit opportunities for cooperative ventures. Participants include Arizona DOT, Arizona State University, Castle Rock Consultants, Colorado DOT, FHWA, Ford, Iowa DOT, Lockheed, Marconi Electronic Devices, Minnesota DOT, New York DOT, Nissan, Ontario Ministry of Transportation, and Transport Canada.
ETC	Electronic Toll Collection
Fiber (optical fiber)	A medium used to transmit information via light impulses rather than through the movement of electrons. A single strand of optical fiber, the approximate size of a human hair, can carry thousands of digital voice conversations or data transmissions at the same time.
FMS	Freeway Management Systems

Terms Related to Intelligent Transportation Systems and the National ITS Architecture

Term	Definition
Freeway Management Systems (FMS)	Freeway Management Systems. Network systems that allows transportation managers the capability to monitor highway and environmental conditions on the freeway system, identify recurring and non-recurring flow impediments, implement appropriate control and management strategies, and provide collection and dissemination of critical real-time information to travelers.
Geographic Information Systems (GIS)	Computerized data management system designed to capture store, retrieve, analyze, and report on geographic/demographic information.
GIS	Geographic Information Systems
Global Positioning Systems (GPS)	A system that determines the real time position of vehicles using communications with a satellite. Also, refers more specifically to a government owned system of 24 Earth orbiting satellites that transmit data to ground based receivers and provides extremely accurate latitude/longitude ground positions.
GPS	Global Positioning Systems
Human Factors	Research done to understand the impact of automated technology on human decision making and driving behavior. For instance, studies are being done to investigate whether the use of cellular phones while driving distracts drivers to the extent that more accidents occur with their use.
ICC	Intelligent Cruise Control
IMS	Incident Management Systems
Intelligent Cruise Control (ICC)	Intelligent Cruise Control. A crash avoidance technology that automatically adjusts vehicle cruise speed to maintain safe following distances.
Intelligent Transportation Infrastructure (ITI)	Core infrastructure (The computer, communications, and control systems) that combines conventional and advanced technologies to integrate essential ITS services so that they are interoperable and intermodal.
Intelligent Transportation Society of America (ITS America)	Intelligent Transportation Society of America. A nonprofit, public/private scientific and educational corporation that works to advance a national program for safer, more economical, more energy efficient and environmentally sound highway travel in the United States. Federal advisory committee used by the US Department of Transportation.
Intelligent Transportation Systems (ITS)	Electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system. (ITS Architecture and Standards Final Rule, 2001)
Intelligent Vehicle-Highway Systems (IVHS)	Intelligent Vehicle-Highway Systems. Now known as intelligent transportation systems.
Interim Guidance for National ITS Architecture Conformity	Released in October 1998, it is the interim policy for implementing the TEA-21 language requiring conformance with the National ITS Architecture and standards. It recommends the development of an ITS Regional Architecture, and requires that ITS projects that affect regional integration which receive Highway Trust Funds be analyzed to:(a) Engage a wide range of stakeholders; (b) Enable the appropriate electronic information sharing between shareholders; (c) Facilitate Future ITS expansion and (d) Consider the use of applicable ITS standards. It also provides relevant definitions, a recommended approach, responses to frequently asked questions, and a TEA-21 legislative excerpt.
Internet	A collection of computer networks, all connected using a common set of protocols and rules on sharing and directing messages.
Interoperability	The ability to integrate the operation of diverse networks and systems. The vision of the intelligent transportation infrastructure is a seamless interoperable network from coast to coast that allows drivers and information to flow through the system without barriers.
In-vehicle navigation	Technology that allows drivers to access route guidance information while en-route. Includes location referencing technology, in-vehicle display units, map information, and audio/text delivery technology.
ITI	Intelligent Transportation Infrastructure
ITS	Intelligent Transportation Systems
ITS America	Intelligent Transportation Society of America
ITS Integration Strategy	A systematic approach for coordinating and implementing intelligent transportation system investments funded with Federal highway trust funds to achieve an integrated regional

Terms Related to Intelligent Transportation Systems and the National ITS Architecture	
Term	**Definition**
	transportation system.
ITS project	Any project that in whole or in part funds the acquisition of technologies or systems of technologies that provide or significantly contribute to the provision of one or more ITS User Services as defined in the National ITS Architecture. (ITS Architecture and Standards Final Rule, 2001)
ITS Project that Affects Regional Integration	In the Interim Guidance for Architecture Consistency, an ITS project that can serve as a catalyst in achieving regional ITS integration. Generally, those ITS projects with the potential to support electronic data sharing between transportation stakeholders, projects with substantial software design, projects involving major upgrades of central transportation management functions, and projects involving significant communications would be considered ITS projects that affect regional integration.
ITS Regional Architecture	A regional framework for ensuring institutional agreement and technical integration of technologies for the implementation of projects or groups of projects under an ITS Integration Strategy.
IVHS	Intelligent Vehicle-Highway Systems
Joint Program Office (JPO)	The office of the U.S. Department of Transportation established to oversee and guide the multimodal National ITS program.
JPO	Joint Program Office for ITS.
Kiosk	In the transportation context, an interactive computer center for traffic or travel related information. Usually located in shopping malls, hotels, airports, businesses, and transit terminals, kiosks provide pre recorded and real time information using text, sound, graphics, and video clips.
Location referencing	Technology that more precisely identifies locations of vehicles, locations, and travelers. Used with GPS, AVL technologies. Supports User Services such as Mayday, EMS, CVO, ATMS, ATIS, and AVCSS.
Loop Detectors	Sensors embedded below the surface of roads and highways that monitor the flow of vehicles and help authorities manage traffic and incidents.
Mainstreaming	The act of brining ITS technology into everyday use by travelers and transportation professionals.
Major ITS project	Any ITS project that implements part of a regional ITS initiative that is multijurisdictional, multi-modal, or otherwise affects regional integration of ITS systems. (ITS Architecture and Standards Final Rule, 2001)
Market Package	The 75 Market Packages serve as the "building blocks" of the National ITS Architecture. Some of the 32 User Services are too broad in scope to be convenient in planning actual deployments, don’t translate easily into existing institutional environments, or distinguish between major levels of functionality. Derived from the User Services, the Market Packages provide a finer grained breakdown tailored to fit - separately or in combination - real world transportation problems and needs. Many Market Packages are also incremental allowing initial systems to be deployed first and advanced packages to be efficiently implemented based on earlier deployments as needs (and capabilities) grow. The 75 Market Package descriptions follow the User Service descriptions below.
Mayday	An ITS program designed to link travelers in trouble with transportation officials in real-time. Uses location referencing technologies and communications systems.
MDI	Model Deployment Initiative
Model Deployment Initiative (MDI)	Model Deployment Initiative. A program designed to develop model sites demonstrating integrated intelligent transportation infrastructure and successful jurisdictional and organizational working relationships. The program is also designed to demonstrate the benefits of integrated transportation management systems that feature strong regional, multimodal traveler information services.
National ITS Architecture (also “national architecture”)	A common framework for ITS interoperability. The National ITS Architecture comprises the logical architecture and physical architecture that satisfy a defined set of User Services. The National ITS Architecture is maintained by the United States Department of Transportation (DOT) and is available on the DOT web site at *http://www.its.dot.gov*. (ITS Architecture and Standards Final Rule, 2001)
National Transportation Communications for ITS Protocol (NTCIP)	National Transportation Communications for ITS Protocol. Required for traffic management operations. Allowing for wireline communications between traffic management centers and field equipment.
NTCIP	National Transportation Communications for ITS Protocol.

Terms Related to Intelligent Transportation Systems and the National ITS Architecture

Term	Definition
Open System	A vendor independent computer system that is designed to interconnect with a variety of commonly available technology products.
Operation Timesaver	Federal initiative aimed at reducing congestion by building an intelligent transportation infrastructure in 75 of the Nation's largest metropolitan areas within 10 years. The goal is to reduce travel times by 15 percent be the year 2005.
PCB	Professional Capacity Building program.
Priority Corridor	One of the first "deployment" programs established by ISTEA. Originally designed to showcase technology and hardware, it has created communication channels and organization frameworks among the numerous agencies that must coordinate to successfully implement ITS.
Project level ITS architecture	A framework that identifies the institutional agreement and technical integration necessary to interface a major ITS project with other ITS projects and systems. (ITS Architecture and Standards Final Rule, 2001)
Protocol	Envelopes used to package data for interoperable flow of ITS information. Protocols can include information on addressing, security, priority and other handling information.
Public-Private Partnerships	Agreements with private sector companies to participate in the deployment of ITS through commitment of time, services, products, or capital investment. These partnerships are the foundation of the ITS strategic plan's financial strategy for ITS deployment. The plan assumes that private sector companies will contribute up to 20 percent of testing and deployment costs.
Ramp Metering	Traffic sensitive regulation of vehicle entry to a freeway, typically via sensor controlled freeway ramp stoplights.
Region (For ITS Architecture Consistency)	The geographical area that identifies the boundaries of the regional ITS architecture and is defined by and based on the needs of the participating agencies and other stakeholders. In metropolitan areas, a region should be no less than the boundaries of the metropolitan planning area. (ITS Architecture and Standards Final Rule, 2001)
Regional ITS architecture	A regional framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects. (ITS Architecture and Standards Final Rule, 2001)
RT-TRACS	Real-Time Traffic-Adaptive Control System. Next-generation traffic and transit management system. An advanced dynamic control strategy that uses state-of-the-art traffic signal control based on real-time demand.
SDO	Standards Development Organization.
Smart Card	Electronic information systems that use plastic cards (similar to credit or debit cards) to store and process information. Used in fare payment and parking applications.
Standard	Specifications that are established to address the need for various technologies, products, and components from different vendors to work together.
Standards Development Organization (SDO)	Standards Development Organization. US DOT is working with five organizations to develop standards in areas relevant to intelligent transportation: state-level participation and roadside infrastructure (AASHTO), dedicated short-range communication systems (ASTM), electronics and communication message sets and protocols (IEEE), traffic management and transportation planning systems (ITE), and in-vehicle and traveler information (SAE).
Systems engineering	A structured process for arriving at a final design of a system. The final design is selected from a number of alternatives that would accomplish the same objectives and considers the total life-cycle of the project including not only the technical merits of potential solutions but also the costs and relative value of alternatives. (ITS Architecture and Standards Final Rule, 2001)
Telecommuting	The substitution, either partially or completely, of transportation to a conventional office through the use of computer and telecommunications technologies (e.g., telephones, personal computers, modems, facsimile machines, electronic mail).
TMC	Traffic Management Center
TMDD	Traffic Management Data Dictionary
Traffic Management Data Dictionary (TMDD)	Traffic Management Data Dictionary. A source of standardized information that defines how data is exchanged and how it flows between ITS devices and systems. The TMDD standardizes message sets for national interoperability.
Traffic Signal Control Systems	Traffic Signal Control Systems. Advanced systems that adjust the amount of green time for each

Terms Related to Intelligent Transportation Systems and the National ITS Architecture

Term	Definition
(TSCS)	street and coordinate operation between each signal to maximize traffic flow and minimize delay based on real-time changes in demand.
Transponder	Electronic device designed to store information. Electronic readers access the information stored on these devices for such functions as toll collection and trucking activities.
TSCS	Traffic Signal Control Systems
User Services	Services available to users of ITS (drivers, passengers, system operators) as set forth by ITS America. The 32 User Services are arranged in 8 categories as follows: 1. Travel and Traffic Management 2. Public Transportation Management 3. Electronic Payment 4. Commercial Vehicle Operations 5. Emergency Management 6. Advanced Vehicle Safety Systems 7. Information Management 8. Maintenance And Construction Management See the separate listing of User Services which follows the general ITS terms.
Variable Message Sign (VMS)	Electronic highway sign that can change the message it displays. Used with traffic management systems. Also referred to as changeable or electronic message signs.
VMS	Variable Message Sign
WAN	Wide Area Network.
Wide Area Network (WAN)	A method of connecting several computers together in a wide geographic area using fiber optic cables.
WIM	Weigh-In-Motion

National ITS Program ITS User Services

User Service	Description
Archived Data Function	National ITS Program User Service: This User Service will provide an ITS Historical Data Archive for all relevant ITS data and will incorporate the planning, safety, operations, and research communities into ITS. It will provide the data collection, manipulation, and dissemination functions of these groups, as they relate to data generated by ITS. The ITS Historical Data Archive will function as a data warehouse or repository to support stakeholder functions.
Automated Highway Systems	National ITS Program User Service: Provides a fully automated, “hands-off, ” operating environment.
Automated Roadside Safety Inspection	National ITS Program User Service: Facilitates roadside inspections of commercial vehicles.
Automated Vehicle Operation	National ITS Program User Service: Provides a partially or fully automated vehicle operating environment.
Commercial Fleet Management	National ITS Program User Service: Provides communications between drivers, dispatchers, and inter-modal transportation providers.
Commercial Vehicle Administrative Processes	National ITS Program User Service: Provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing.
Commercial Vehicle Electronic Clearance	National ITS Program User Service: Facilitates domestic and international border clearance, minimizing stops.
Electronic Payment Services	National ITS Program User Service: Allows travelers to pay for transportation services electronically.
Emergency Notification and Personal Security	National ITS Program User Service: Provides immediate notification of an incident and an immediate request for assistance.
Emergency Vehicle Management	National ITS Program User Service: Reduces the time it takes emergency vehicles to respond to an incident.

National ITS Program ITS User Services

User Service	Description
Emissions Testing and Mitigation	National ITS Program User Service: Provides information for monitoring air quality and developing air quality improvement strategies.
En-Route Driver Information	National ITS Program User Service: Driver advisories and in-vehicle signing for convenience and safety during travel.
En-Route Transit Information	National ITS Program User Service: Provides information to travelers using public transportation after they begin their trips.
Hazardous Material Incident Response	National ITS Program User Service: Provides immediate description of hazardous materials to emergency responders.
Highway-Rail Intersection (HRI)	National ITS Program User Service: Integrates ITS technology into already existing HRI warning systems to enhance their safety effectiveness and operational efficiency. At railroad grade crossings, HRI technologies located both in-vehicle and along the roadside ensure that train movements are coordinated with traffic signals and that drivers are alerted to approaching trains.
Incident Management	National ITS Program User Service: Helps public and private organizations quickly identify incidents and implement a response to minimize their effects on traffic.
Intersection Collision Avoidance	National ITS Program User Service: Helps prevent collisions at intersections.
Lateral Collision Avoidance	National ITS Program User Service: Helps prevent collisions when vehicles leave their lane of travel.
Longitudinal Collision Avoidance	National ITS Program User Service: Helps prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.
Maintenance and Construction Operations	National ITS Program User Service: This User Service will integrate key activities to ensure that roadways, associated infrastructure, and available resources are coordinated in the best possible manner. Generally, key activities include monitoring, operating, maintaining, improving, and managing the physical condition of the roadway.
On-Board Safety Monitoring	National ITS Program User Service: Senses the safety status of a commercial vehicle, cargo, and driver.
Personalized Public Transit	National ITS Program User Service: Flexibly routed transit vehicles offer more convenient service to customers.
Pre-Crash Restraint Deployment	National ITS Program User Service: Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.
Pre-Trip Travel Information	National ITS Program User Service: Provides information for selecting the best transportation mode, departure time, and route.
Public Transportation Management	National ITS Program User Service: Automates operations, planning, and management functions of public transit systems.
Public Travel Security	National ITS Program User Service: Creates a secure environment for public transportation patrons and operators.
Ride Matching and Reservation	National ITS Program User Service: Makes ride sharing easier and more convenient.
Route Guidance	National ITS Program User Service: Provides travelers with simple instructions on how to best reach their destinations.
Safety Readiness	National ITS Program User Service: Provides warnings about the condition of the driver, the vehicle, and the roadway.
Traffic Control	National ITS Program User Service: Manages the movement of traffic on streets and highways.
Travel Demand Management	National ITS Program User Service: Supports policies and regulations designed to mitigate the environmental and social impacts of traffic congestion.
Traveler Services Information	National ITS Program User Service: Provides a business directory, or “yellow pages,” of service information.
Vision Enhancement for Crash Avoidance	National ITS Program User Service: Improves the driver’s ability to see the roadway and objects that are on or along the roadway.

National ITS Architecture ITS Market Packages

Market Package	Description
Advanced Railroad Grade Crossing	National ITS Architecture Market Package that manages highway traffic at highway-rail intersections (HRIs) where operational requirements demand advanced features (e.g., where rail operational speeds are greater than 80 miles per hour). It includes all capabilities from the Standard Railroad Grade Crossing Market Package and augments these with additional safety features to mitigate the risks associated with higher rail speeds. The active warning systems supported by the Advanced Railroad Grade Crossing Market Package include positive barrier systems that preclude entrance into the intersection when the barriers are activated. In this market package, additional information about the arriving train is also provided by the wayside interface equipment so that the train's direction of travel, its estimated time of arrival, and the estimated duration of closure may be derived.
Advanced Vehicle Lateral Control	National ITS Architecture Market Package that automates the steering control on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to control the steering. It requires on-board sensors to measure lane position and lateral deviations and a processor for controlling the vehicle steering.
Advanced Vehicle Longitudinal Control	National ITS Architecture Market Package that automates the speed and headway control functions on board the vehicle. It utilizes safety sensors and collision sensors combined with vehicle dynamics processing to control the throttle and brakes. It requires on-board sensors to measure longitudinal gaps and a processor for controlling the vehicle speed.
Automated Highway System (AHS)	National ITS Architecture Market Package that enables “hands-off” operation of the vehicle on the automated portion of the highway system. Implementation requires lateral lane holding, vehicle speed and steering control, and Automated Highway System check-in and checkout. This market package currently supports a balance in intelligence allocation between infrastructure and the vehicle pending selection of a single operational concept by the AHS consortium.
Autonomous Route Guidance	National ITS Architecture Market Package that relies on in-vehicle sensory, location determination, computational, map database, and interactive driver interface equipment to enable route planning and detailed route guidance based on static, stored information. No communication with the infrastructure is assumed or required. Identical capabilities are available to the traveler outside the vehicle by integrating a similar suite of equipment into portable devices.
Broadcast Traveler Information	National ITS Architecture Market Package that provides the user with a basic set of ATIS services; its objective is early acceptance. It involves the collection of traffic conditions, advisories, general public transportation, toll and parking information, incident information, air quality and weather information, and the near real time dissemination of this information over a wide area through existing infrastructures and low cost user equipment (e.g., FM subcarrier, cellular data broadcast). Different from the Traffic Information Dissemination Market Package, which provides the more basic HAR and DMS information capabilities, the Broadcast Traveler Information Market Package provides the more sophisticated digital broadcast service. Successful deployment of this market package relies on availability of real-time traveler information from roadway instrumentation, probe vehicles or other sources.
CV Administrative Processes	National ITS Architecture Market Package that provides for electronic application, processing, fee collection, issuance, and distribution of CVO credential and tax filing. Through this process, carriers, drivers, and vehicles may be enrolled in the electronic clearance program provided by a separate market package that allows commercial vehicles to be screened at mainline speeds at commercial vehicle checkpoints. Through this enrollment process, current profile databases are maintained in the Commercial Vehicle Administration Subsystem and snapshots of this database are made available to the commercial vehicle check facilities at the roadside to support the electronic clearance process.
CVO Fleet Maintenance	National ITS Architecture Market Package that supports maintenance of CVO fleet vehicles through close interface with on-board monitoring equipment and AVLS capabilities with in the Fleet and Freight Management Subsystem. Records of vehicle mileage, repairs, and safety violations are maintained to assure safe vehicles on the highway.
Demand Response Transit Operations	National ITS Architecture Market Package that performs automatic driver assignment and monitoring as well as vehicle routing and scheduling for demand response transit services. This package uses the existing AVL database to monitor current status of the transit fleet and supports allocation of these fleet resources to service incoming requests for transit service while also considering traffic conditions. The Transit Management Subsystem provides the necessary data processing and information display to assist the transit operator in making optimal use of the transit fleet.

National ITS Architecture ITS Market Packages	
Market Package	**Description**
Drawbridge Management	National ITS Architecture Market Package that supports systems that manage drawbridges at rivers and canals and other multimodal crossings. (other than railroad grade crossings that are specifically covered by other market packages). The equipment managed by this market package includes control devices (e.g., gates, warning lights, dynamic message signs) at the draw bridge as well as the information systems that keep travelers appraised of current and forecasted draw bridge status.
Driver Safety Monitoring	National ITS Architecture Market Package that will determine the driver's condition, and warn the driver of potential dangers. On-board sensors will determine the driver's condition and performance, determine on-board safety data and display information.
Driver Visibility Improvement	National ITS Architecture Market Package that will enhance driver visibility using an enhanced vision system. On-board display hardware is needed
Dynamic Ridesharing	National ITS Architecture Market Package that enhances the Interactive Traveler Information package by adding an infrastructure provided dynamic ridesharing/ride matching capability.
Dynamic Route Guidance	National ITS Architecture Market Package that offers the user advanced route planning and guidance which is responsive to current conditions. The package combines the autonomous route guidance user equipment with a digital receiver capable of receiving real-time traffic, transit, and road condition information that is considered by the user equipment in provision of route guidance.
Electronic Clearance	National ITS Architecture Market Package that provides for automated clearance at roadside check facilities. The roadside check facility communicates with the Commercial Vehicle Administration subsystem to retrieve infrastructure snapshots of critical carrier, vehicle, and driver data to be used to sort passing vehicles. This package allows a good driver/vehicle/carrier to pass roadside facilities at highway speeds using transponders and dedicated short-range communications to the roadside. The roadside check facility may be equipped with AVI, weighing sensors, transponder read/write devices, computer workstation processing hardware, software, and databases.
Electronic Toll Collection (ETC)	National ITS Architecture Market Package that provides toll operators with the ability to collect tolls electronically and detect and process violators. Variations in the fees that are collected enable implementation of demand management strategies. Dedicated short-range communication between the roadway equipment and the vehicle is required as well as wireline interfaces between the toll collection equipment and transportation authorities and the financial infrastructure that supports fee collection.
Emergency Response	National ITS Architecture Market Package that provides the computer-aided dispatch systems, emergency vehicle equipment, and wireless communications that enable safe and rapid deployment of appropriate resources to an emergency. Coordination between Emergency Management Subsystems supports emergency notification and coordinated response between agencies. Existing wide area wireless communications would be utilized between the Emergency Management Subsystem and an Emergency Vehicle to enable an incident command system to be established and supported at the emergency location. The Emergency Management Subsystem would include hardware and software for tracking the emergency vehicles. Public safety, traffic management, and many other allied agencies may each participate in the coordinated response managed by this package.
Emergency Routing	National ITS Architecture Market Package that supports automated vehicle location and dynamic routing of emergency vehicles. The service also supports coordination with the Traffic Management Subsystem, collecting detailed road network conditions and requesting special priority or other specific emergency traffic control strategies on the selected route(s). The Emergency Management Subsystem provides the routing for the emergency fleet based on real-time traffic conditions. The Emergency Vehicle may also be equipped with dedicated short-range communications for local signal preemption. The service provides for information exchange between care facilities and both the Emergency Management Subsystem and emergency vehicles.
Emissions Monitoring and Management	National ITS Architecture Market Package that monitors individual vehicle emissions and provides general air quality monitoring using distributed sensors to collect the data. The collected information is transmitted to the emissions management subsystem for processing. Both individual detection and identification of vehicles that exceed emissions standards and general area-wide monitoring of air quality are supported by this market package.
Fleet Administration	National ITS Architecture Market Package that keeps track of vehicle location, itineraries, and fuel usage at the Fleet and Freight Management Subsystem using a cell based or satellite data link and the pre-existing wireless infrastructure. The vehicle has a processor to interface to its sensor (e.g., fuel gauge) and to the cellular data link. The Fleet and Freight Management Subsystem can provide the vehicle with dispatch instructions, and can process and respond to requests for assistance and general information from the vehicle via the cellular data link. The market package also provides

National ITS Architecture ITS Market Packages	
Market Package	**Description**
	the Fleet Manager with connectivity to intermodal transportation providers using the existing wireline infrastructure.
Freeway Control	National ITS Architecture Market Package that provides the communications and roadside equipment to support ramp control, lane controls, and interchange control for freeways. Coordination and integration of ramp meters are included as part of this market package. This package is consistent with typical urban traffic freeway control systems. This package incorporates the instrumentation included in the Network Surveillance Market Package to support freeway monitoring and adaptive strategies as an option. The Freeway Control Market Package also includes the capability to utilize surveillance information for detection of incidents.
Freight Administration	National ITS Architecture Market Package that tracks cargo and the cargo condition. This information is communicated with the Fleet and Freight Management Subsystem via the existing wireless infrastructure. Interconnections are provided to intermodal shippers and intermodal freight depots for tracking the cargo from source to destination.
HAZMAT Management	National ITS Architecture Market Package that integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of HAZMAT material and incidents. HAZMAT tracking is performed by the Fleet and Freight Management Subsystem. The Emergency Management subsystem is notified by the Commercial Vehicle if an incident occurs and coordinates the response. The response is tailored based on information that is provided as part of the original incident notification or derived from supplemental information provided by the Fleet and Freight Management Subsystem. The latter information can be provided prior to the beginning of the trip or gathered following the incident depending on the selected policy and implementation.
HOV Lane Management	National ITS Architecture Market Package that manages HOV lanes by coordinating freeway ramp meters and connector signals with HOV lane usage signals. Preferential treatment is given to HOV lanes using special bypasses, reserved lanes, and exclusive rights-of-way that may vary by time of day. Vehicle occupancy detectors may be installed to verify HOV compliance and to notify enforcement agencies of violations.
In Vehicle Signing	National ITS Architecture Market Package that supports distribution of traffic and travel advisory information to drivers through in-vehicle devices. It includes short-range communications between roadside equipment and the vehicle and wireline connections to the Traffic Management Subsystem for coordination and control. This market package also informs the driver of both highway-highway and highway-rail intersection status.
Incident Management System (IMS)	National ITS Architecture Market Package that manages both unexpected incidents and planned events so that the impact to the transportation network and traveler safety is minimized. The market package includes incident detection capabilities through roadside surveillance devices (e.g. CCTV) and through regional coordination with other traffic management, maintenance and construction management and emergency management centers as well as weather service entities and event promoters. Information from these diverse sources are collected and correlated by this market package to detect and verify incidents and implement an appropriate response. This market package supports traffic operations personnel in developing an appropriate response in coordination with emergency management, maintenance and construction management, and other incident response personnel to confirmed incidents. The response may include traffic control strategy modifications or resource coordination between center subsystems. Incident response also includes presentation of information to affected travelers using the Traffic Information Dissemination Market Package and dissemination of incident information to travelers through the Broadcast Traveler Information or Interactive Traveler Information Market Packages. The roadside equipment used to detect and verify incidents also allows the operator to monitor incident status as the response unfolds. The coordination with emergency management might be through a CAD system or through other communication with emergency field personnel. The coordination can also extend to tow trucks and other allied response agencies and field service personnel.
Integrated Transportation Management/Route Guidance	National ITS Architecture Market Package that allows a traffic management center to continuously optimize the traffic control strategy based on near-real time information on intended routes for a proportion of the vehicles within their network while offering the user advanced route planning and guidance which is responsive to current conditions. It would utilize the individual and ISP route planning information to optimize signal timing while at the same time providing updated signal timing information to allow optimized route plans. The use of predictive link times for this market package are possible through utilizing the Traffic Forecast and Demand Management market package at the traffic management center.
Interactive Traveler Information	National ITS Architecture Market Package that provides tailored information in response to a traveler request. Both real-time interactive request/response systems and information systems are

National ITS Architecture ITS Market Packages

Market Package	Description
	included. The traveler can obtain current information regarding traffic conditions, transit services, ride share/ride match, parking management, and pricing information. A range of two-way wide-area wireless and wireline communications systems may be used to support the required digital communications between traveler and the information service provider. A variety of interactive devices may be used by the traveler to access information prior to a trip or en-route to include phone, kiosk, Personal Digital Assistant, personal computer, and a variety of in-vehicle devices. Successful deployment of this market package relies on availability of real-time transportation data from roadway instrumentation, probe vehicles or other means.
International Border Electronic Clearance	National ITS Architecture Market Package that provides for automated clearance specific to international border crossings. This package augments the electronic clearance package by allowing interface with customs related functions and permitting NAFTA required entry and exit from the US to Canada and Mexico.
Intersection Collision Avoidance	National ITS Architecture Market Package that will determine the probability of an intersection collision and provide timely warnings to approaching vehicles so that avoidance actions can be taken. This market package builds on the Intersection Collision Warning infrastructure and in-vehicle equipment and adds equipment in the vehicle that can take control of the vehicle in emergency situations. The same monitors in the roadway infrastructure are needed to assess vehicle locations and speeds near an intersection. This information is determined and communicated to the approaching vehicle using a short-range communications system. The vehicle uses this information to develop control actions that alter the vehicle's speed and steering control and potentially activate its pre-crash safety system.
Intersection Safety Warning	National ITS Architecture Market Package that will determine the probability of a collision in an equipped intersection (either highway-highway or highway-rail) and provide timely warnings to drivers in response to hazardous conditions. Monitors in the roadway infrastructure assess vehicle locations and speeds near an intersection. Using this information, a warning is determined and communicated to the approaching vehicle using a short-range communications system. Information can be provided to the driver through the In-Vehicle Signing Market Package.
ISP Based Route Guidance	National ITS Architecture Market Package that offers the user advanced route planning and guidance which is responsive to current conditions. Different from the Dynamic Route Guidance market package, the ISP Based Route Guidance Market Package moves the route planning function from the user device to the information service provider. This approach simplifies the user equipment requirements and can provide the infrastructure better information on which to predict future traffic and appropriate control strategies to support basic route planning with minimal user equipment. The package includes both turn-by-turn route guidance as might be used in a vehicle, as well as pre-trip routes. The package includes two-way data communications and optionally also equips the vehicle with the databases, location determination capability, and display technology to support turn-by-turn route guidance.
ITS Data Mart	National ITS Architecture Market Package that provides a focused archive that houses data collected and owned by a single agency, district, private sector provider, research institution, or other organization. This focused archive typically includes data covering a single transportation mode and one jurisdiction that is collected from an operational data store and archived for future use. It provides the basic data quality, data privacy, and meta data management common to all ITS archives and provides general query and report access to archive data users.
ITS Data Warehouse	National ITS Architecture Market Package that includes all the data collection and management capabilities provided by the ITS Data Mart, and adds the functionality and interface definitions that allow collection of data from multiple agencies and data sources spanning across modal and jurisdictional boundaries. It performs the additional transformations and provides the additional meta data management features that are necessary so that all this data can be managed in a single repository with consistent formats. The potential for large volumes of varied data suggests additional on-line analysis and data mining features that are also included in this market package in addition to the basic query and reporting user access features offered by the ITS Data Mart.
ITS Virtual Data Warehouse	National ITS Architecture Market Package that provides the same broad access to multimodal, multidimensional data from varied data sources as in the ITS Data Warehouse Market Package, but provides this access using enhanced interoperability between physically distributed ITS archives that are each locally managed. Requests for data that are satisfied by access to a single repository in the ITS Data Warehouse Market Package are parsed by the local archive and dynamically translated to requests to remote archives which relay the data necessary to satisfy the request.
Lateral Safety Warning	National ITS Architecture Market Package that allows for lateral warning. It utilizes safety sensors and collision sensors. It requires on-board sensors to monitor the areas to the sides of the vehicle

National ITS Architecture ITS Market Packages	
Market Package	**Description**
	and present warnings to the driver about potential hazards.
Longitudinal Safety Warning	National ITS Architecture Market Package that allows for longitudinal warning. It utilizes safety sensors and collision sensors. It requires on-board sensors to monitor the areas in front of and behind the vehicle and present warnings to the driver about potential hazards.
Maintenance and Construction Activity Coordination	National ITS Architecture Market Package that supports the dissemination of maintenance and construction activity to centers which can utilize it as part of their operations, or to the Information Service Providers who can provide the information to travelers.
Maintenance and Construction Vehicle Maintenance	National ITS Architecture Market Package that performs vehicle maintenance scheduling and manages both routine and corrective maintenance activities on vehicles and other maintenance and construction equipment. It includes on-board sensors capable of automatically performing diagnostics for maintenance and construction vehicles, and the systems that collect this diagnostic information and use it to schedule and manage vehicle maintenance.
Maintenance and Construction Vehicle Tracking	National ITS Architecture Market Package that will track the location of maintenance and construction vehicles and other equipment to ascertain the progress of their activities. These activities can include ensuring the correct roads are being plowed and work activity is being performed at the correct locations.
Mayday Support	National ITS Architecture Market Package that allows the user (driver or non-driver) to initiate a request for emergency assistance and enables the Emergency Management Subsystem to locate the user and determine the appropriate response. The Emergency Management Subsystem may be operated by the public sector or by a private sector provider. The request from the traveler needing assistance may be manually initiated or automated and linked to vehicle sensors. The data is sent to the Emergency Management subsystem using wide area wireless communications with voice as an option. Providing user location implies either a location technology within the user device or location determination within the communications infrastructure.
Multi-modal Coordination	National ITS Architecture Market Package that establishes two way communications between multiple transit and traffic agencies to improve service coordination. Intermodal coordination between transit agencies can increase traveler convenience at transfer points and also improve operating efficiency. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network. More limited local coordination between the transit vehicle and the individual intersection for signal priority is also supported by this package.
Network Surveillance	National ITS Architecture Market Package that includes traffic detectors, other surveillance equipment, the supporting field equipment, and wireline communications to transmit the collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g., when a CCTV system sends data back to the Traffic Management Subsystem). The data generated by this market package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Information Service Provider Subsystem.
On-board CVO Safety	National ITS Architecture Market Package that provides for on-board commercial vehicle safety monitoring and reporting. It is an enhancement of the Roadside CVO Safety Market Package and includes roadside support for reading on-board safety data via tags. Safety warnings are provided to the driver as a priority with secondary requirements to notify the Commercial Vehicle Check roadside elements. This market package allows for the Fleet and Freight Management subsystem to have access to the on-board safety data.
Parking Facility Management	National ITS Architecture Market Package that provides enhanced monitoring and management of parking facilities. The included equipment assists in the management of parking operations, coordinates with transportation authorities, and supports electronic collection of parking fees. This is performed by sensing and collecting current parking facilities status, sharing the data with information service providers and traffic operations, and automatic fee collection using short-range communications with the same in-vehicle equipment utilized for electronic toll collection.
Pre-Crash Restraint Deployment	National ITS Architecture Market Package that provides in-vehicle sensors to monitor the vehicle's local environment, determine collision probability and deploy a pre-crash safety system. It will include on-board sensors to measure lateral and longitudinal gaps and together with weather and roadway conditions will determine lateral and longitudinal collision probability. It will have the mechanism to deploy a pre-crash safety system.

National ITS Architecture ITS Market Packages

Market Package	Description
Probe Surveillance	National ITS Architecture Market Package that provides an alternative approach for surveillance of the roadway network. Two general implementation paths are supported by this market package: 1) wide-area wireless communications between the vehicle and Information Service Provider is used to communicate current vehicle location and status, and 2) dedicated short range communications between the vehicle and roadside is used to provide equivalent information back to the Traffic Management Subsystem. The market package enables traffic managers to monitor road conditions, identify incidents, analyze and reduce the collected data, and make it available to users and private information providers.
Railroad Operations Coordination	National ITS Architecture Market Package that provides an additional level of strategic coordination between rail operations and traffic management centers. Rail operations provide train schedules, maintenance schedules, and any other forecast events that will result in highway-rail intersection (HRI) closures. This information is used to develop forecast HRI closure times and durations that may be used in advanced traffic control strategies or to enhance the quality of traveler information.
Regional Parking Management	National ITS Architecture Market Package that supports coordination between parking facilities to enable regional parking management strategies.
Regional Traffic Control	National ITS Architecture Market Package that advances the Surface Street Control and Freeway Control Market Packages by adding the communications links and integrated control strategies that enable integrated interjurisdictional traffic control. This market package provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. This package relies principally on roadside instrumentation supported by the Surface Street Control and Freeway Control Market Packages and adds hardware, software, and wireline communications capabilities to implement traffic management strategies that are coordinated between allied traffic management centers. Several levels of coordination are supported from sharing of information through sharing of control between traffic management centers.
Reversible Lane Management	National ITS Architecture Market Package that provides for the management of reversible lane facilities. In addition to standard surveillance capabilities, this market package includes sensory functions that detect wrong-way vehicles and other special surveillance capabilities that mitigate safety hazards associated with reversible lanes. The package includes the field equipment, physical lane access controls, and associated control electronics that manage and control these special lanes. It also includes the equipment used to electronically reconfigure intersections and manage right-of-way to address dynamic demand changes and special events.
Road Weather Data Collection	National ITS Architecture Market Package that collects current road and weather conditions using data collected from environmental sensors deployed on and about the roadway (or guide way in the case of transit related rail systems). In addition to fixed sensor stations at the roadside, sensing of the roadway environment can also occur from sensor systems located on Maintenance and Construction Vehicles and on-board sensors provided by auto manufacturers. The collected environmental data is used by the Weather Information Processing and Distribution Market Package to process the information and make decisions on operations.
Roadside CVO Safety	National ITS Architecture Market Package that provides for automated roadside safety monitoring and reporting. It automates commercial vehicle safety inspections at the Commercial Vehicle Check roadside element. The capabilities for performing the safety inspection are shared between this market package and the On-Board CVO Safety Market Package, which enables a variety of implementation options. The basic option, directly supported by the Roadside CVO Safety Market Package, facilitates safety inspection of vehicles that have been pulled in, perhaps as a result of the automated screening process provided by the Electronic Clearance Market Package.
Roadway Automated Treatment	National ITS Architecture Market Package that automatically treats a roadway section based on environmental or atmospheric conditions. Treatments include fog dispersion, anti-icing chemicals, etc. The market package includes the environmental sensors that detect adverse conditions, the automated treatment system itself, and driver information systems (e.g., dynamic message signs) that warn drivers when the treatment system is activated.
Roadway Maintenance and Construction	National ITS Architecture Market Package that supports numerous services for scheduled and unscheduled maintenance and construction on a roadway system or right-of-way. Maintenance services would include landscape maintenance, hazard removal (roadway debris, dead animals), routine maintenance activities (roadway cleaning, grass cutting), and repair and maintenance of both ITS and non-ITS equipment on the roadway (e.g., signs, traffic controllers, traffic detectors, dynamic message signs, traffic signals, CCTV, etc.). Environmental conditions information is also

National ITS Architecture ITS Market Packages

Market Package	Description
	received from various weather sources to aid in scheduling maintenance and construction activities.
Roadway Service Patrols	National ITS Architecture Market Package that supports roadway service patrol vehicles that monitor roads that typically have incidents, offering rapid response to minor incidents (flat tire, accidents, out of gas) to minimize disruption to the traffic stream. If problems are detected, the roadway service patrol vehicles will provide assistance to the motorist (e.g., push a vehicle to the shoulder or median).
Speed Monitoring	National ITS Architecture Market Package that monitors the speeds of vehicles traveling through a roadway system. If the speed is determine to be excessive, roadside equipment can suggest a safe driving speed. Environmental conditions may be monitored and factored into the safe speed advisories that are provided to the motorist. This service can also support notifications to an enforcement agency to enforce the speed limit on a roadway system.
Standard Railroad Grade Crossing	National ITS Architecture Market Package that manages highway traffic at highway-rail intersections (HRIs) where operational requirements do not dictate more advanced features (e.g., where rail operational speeds are less than 80 miles per hour). Both passive (e.g., the crossbuck sign) and active warning systems (e.g., flashing lights and gates) are supported. (Note that passive systems exercise only the single interface between the roadway subsystem and the driver in the architecture definition.) These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train.
Surface Street Control	National ITS Architecture Market Package that provides the central control and monitoring equipment, communication links, and the signal control equipment that support local surface street control and/or arterial traffic management. A range of traffic signal control systems are represented by this market package ranging from static pre-timed control systems to fully traffic responsive systems that dynamically adjust control plans and strategies based on current traffic conditions and priority requests. Additionally, general advisory and traffic control information can be provided to the driver while en-route. This market package is generally an intra-jurisdictional package that does not rely on real-time communications between separate control systems to achieve area-wide traffic signal coordination.
Traffic Forecast and Demand Management	National ITS Architecture Market Package that includes advanced algorithms, processing, and mass storage capabilities that support historical evaluation, real-time assessment, and forecast of the roadway network performance. This includes the prediction of travel demand patterns to support better link travel time forecasts. In addition to short-term forecasts, this market package provides longer-range forecasts that can be used in transportation planning.
Traffic Information Dissemination	National ITS Architecture Market Package that allows traffic information to be disseminated to drivers and vehicles using roadway equipment such as dynamic message signs or highway advisory radio. This package provides a tool that can be used to notify drivers of incidents; careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information. This package also covers the equipment and interfaces that provide traffic information from a traffic management center to the media (for instance via a direct tie-in between a traffic management center and radio or television station computer systems), transit management center, emergency management center, and information service provider.
Transit Fixed-Route Operations	National ITS Architecture Market Package that performs automatic driver assignment and monitoring, as well as vehicle routing and scheduling for fixed-route services. This service uses the existing AVL database as a source for current schedule performance data, and is implemented through data processing and information display at the transit management subsystem. This data is exchanged using the existing wireline link to the information service provider where it is integrated with that from other transportation modes (e.g. rail, ferry, air) to provide the public with integrated and personalized dynamic schedules.
Transit Maintenance	National ITS Architecture Market Package that supports automatic maintenance scheduling and monitoring. On-board condition sensors monitor critical system status and transmit critical status information to the Transit Management Subsystem. Hardware and software in the Transit Management Subsystem processes this data and schedules maintenance activities.
Transit Passenger and Fare Management	National ITS Architecture Market Package that allows for the management of passenger loading and fare payments on-board vehicles using electronic means. The payment instrument may be either a stored value or credit card. This package is implemented with sensors mounted on the vehicle to permit the driver and central operations to determine vehicle loads, and readers located either in the infrastructure or on-board the transit vehicle to allow fare payment.

National ITS Architecture ITS Market Packages

Market Package	Description
Transit Security	National ITS Architecture Market Package that provides for the physical security of transit passengers. An on-board security system is deployed to perform surveillance and warn of potentially hazardous situations. Public areas (e.g. stops, park and ride lots, stations) are also monitored. Information is communicated to the Transit Management Subsystem using the existing or emerging wireless (vehicle to center) or wireline (area to center) infrastructure. Security related information is also transmitted to the Emergency Management Subsystem when an emergency is identified that requires an external response. Incident information is communicated to the Information Service Provider.
Transit Traveler Information	National ITS Architecture Market Package that provides transit users at transit stops and on-board transit vehicles with ready access to transit information. The information services include transit stop annunciation, imminent arrival signs, and real-time transit schedule displays that are of general interest to transit users. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this market package.
Transit Vehicle Tracking	National ITS Architecture Market Package that provides for an Automated Vehicle Location System to track the transit vehicle's real time schedule adherence and updates the transit system's schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A two-way wireless communication link with the Transit Management Subsystem is used for relaying vehicle position and control measures. Fixed route transit systems may also employ beacons along the route to enable position determination and facilitate communications with each vehicle at fixed intervals. The Transit Management Subsystem processes this information, updates the transit schedule and makes real-time schedule information available to the Information Service Provider Subsystem via a wireline link.
Vehicle Safety Monitoring	National ITS Architecture Market Package that will diagnose critical components of the vehicle and warn the driver of potential dangers. On-board sensors will determine the vehicle's condition and performance, determine on-board safety data and display information.
Virtual TMC and Smart Probe Data	National ITS Architecture Market Package that provides for special requirements of rural road systems. Instead of a central TMC, the traffic management is distributed over a very wide area (e.g., a whole state or collection of states). Each locality has the capability of accessing available information for assessment of road conditions. The package uses vehicles as smart probes that are capable of measuring road conditions and providing this information to the roadway for relay to the Traffic Management Subsystem and potentially direct relay to following vehicles (i.e., the automated road signing equipment is capable of autonomous operation). In-vehicle signing is used to inform drivers of detected road conditions.
Weather Information Processing and Distribution	National ITS Architecture Market Package that processes and distributes the environmental information collected from the Road Weather Data Collection Market Package. This market package uses the environmental data to detect environmental hazards such as icy road conditions, high winds, dense fog, etc. so system operators and decision support systems can make decision on corrective actions to take. The continuing updates of road condition information and current temperatures can be used by system operators to more effectively deploy road maintenance resources, issue general traveler advisories, issue location specific warnings to drivers using the Traffic Information Dissemination Market Package, and aid operators in scheduling work activity.
Weigh-In-Motion (WIM)	National ITS Architecture Market Package that provides for high speed weigh-in-motion with or without Automated Vehicle Identification (AVI) capabilities. This market package provides the roadside equipment that could be used as a stand-alone system or to augment the Electronic Clearance Market Package.
Winter Maintenance	National ITS Architecture Market Package that supports winter road maintenance including snow plow operations, roadway treatments (e.g., salt spraying and other anti-icing material applications), and other snow and ice control activities. This package monitors environmental conditions and weather forecasts and uses the information to schedule winter maintenance activities, determine the appropriate snow and ice control response, and track and manage response operations.
Work Zone Management	National ITS Architecture Market Package that directs activity in work zones, controlling traffic through portable dynamic message signs (DMS) and informing other groups of activity (e.g., ISP, TM, other maintenance and construction centers) for better coordination management. Work zone speeds and delays are provided to the motorist prior to the work zones.
Work Zone Safety Monitoring	National ITS Architecture Market Package that includes systems that improve work crew safety and reduce collisions between the motoring public and maintenance and construction vehicles. This market package detects vehicle intrusions in work zones and warns crew workers and drivers of

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Market Package	**Description**
	imminent encroachment or other potential safety hazards. Crew movements are also monitored so that the crew can be warned of movement beyond the designated safe zone. The market package supports both stationary and mobile work zones. The intrusion detection and alarm systems may be collocated or distributed, allowing systems that detect safety issues far upstream from a work zone (e.g., detection of over-dimension vehicles before they enter the work zone).
Yellow Pages and Reservation	National ITS Architecture Market Package that enhances the Interactive Traveler Information package by making infrastructure provided yellow pages and reservation services available to the user. The same basic user equipment is included. This market package provides multiple ways for accessing information either while en-route in a vehicle using wide-area wireless communications or pre-trip via wireline connections.

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APPENDIX B NATIONAL ITS ARCHITECTURE MARKET PACKAGES VERSUS ITS USER SERVICES.

Table B-1 Market Packages versus ITS 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 Service 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 Service	4.1 - Commercial Vehicle Electronic Clearance	4.2 - Automated Roadside Safety Inspection	4.3 - On-Board Safety Monitoring	4.4 - Commercial Vehicle Admin. Process	4.5 - Hazardous Material Incident Response	4.6 - Commercial Fleet Management	5.1 - Emergency Notif. 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	7.1 - Archived Data Function	8.1 – Maintenance and Construction Operations
ATMS	Network Surveillance						✓																										
	Probe Surveillance						✓																										
	Surface Street Control						✓	✓			✓																						
	Freeway Control						✓	✓	✓																								
	HOV Lane Management						✓		✓																								
	Traffic Information Dissemination						✓				✓																						
	Regional Traffic Control						✓																										
	Incident Management System							✓																									
	Traffic Forecast and Demand Management						✓		✓																								
	Electronic Toll Collection								✓							✓																	
	Emissions Monitoring and Management									✓																							
	Virtual TMC and Smart Probes		✓				✓	✓																									✓
	Standard Railroad Grade Crossing										✓																						
	Advanced Railroad Grade Crossing										✓																						
	Railroad Operations Coordination										✓																						
	Parking Facility Management								✓							✓																	
	Regional Parking Management								✓							✓																	
	Reversible Lane Management						✓	✓																									
	Speed Monitoring						✓																										✓
	Drawbridge Management						✓	✓																									
APTS	Transit Vehicle Tracking											✓	✓	✓	✓																		
	Transit Fixed-Route Operations											✓	✓																				
	Demand Response Transit Operations											✓	✓	✓																			
	Transit Passenger and Fare Management												✓			✓																	
	Transit Security											✓			✓																		
	Transit Maintenance											✓																					
	Multi-modal Coordination						✓		✓			✓																					
	Transit Traveler Information											✓	✓			✓																	

Source: Market Packages, ITS National Architecture Verson 4.0 (US DOT, April 2002)

Table B-1 Market Packages versus ITS User Services Continued

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 Service 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 Service	4.1 - Commercial Vehicle Electronic Clearance	4.2 - Automated Roadside Safety Inspection	4.3 - On-Board Safety Monitoring	4.4 - Commercial Vehicle Admin. Process	4.5 - Hazardous Material Incident Response	4.6 - Commercial Fleet Management	5.1 - Emergency Notif. 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	7.1 - Archived Data Function	8.1 – Maintenance and Construction Operations
ATIS	Broadcast Traveler Information	✓	✓										✓																				
	Interactive Traveler Information	✓	✓		✓	✓							✓	✓		✓																	
	Autonomous Route Guidance		✓	✓																													
	Dynamic Route Guidance		✓	✓		✓		✓					✓																				
	ISP Based Route Guidance	✓	✓	✓												✓																	
	Integrated Transp. Management/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 Management							✓													✓	✓											

Source: Market Packages, ITS National Architecture Verson 4.0 (US DOT, April 2002)

Table B-1 Market Packages versus ITS User Services Continued

	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 Service 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 Service	4.1 - Commercial Vehicle Electronic Clearance	4.2 - Automated Roadside Safety Inspection	4.3 - On-Board Safety Monitoring	4.4 - Commercial Vehicle Admin. Process	4.5 - Hazardous Material Incident Response	4.6 - Commercial Fleet Management	5.1 - Emergency Notif. 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	7.1 - Archived Data Function	8.1 – Maintenance and Construction Operations
EM	Emergency Response																						✓	✓									
	Emergency Routing						✓																	✓									
	Mayday Support																						✓	✓									
	Roadway Service Patrols							✓															✓	✓									✓
AD	ITS Data Mart																															✓	✓
	ITS Data Warehouse																															✓	✓
	ITS Virtual Data Warehouse																															✓	
MCO	Maintenance and Construction Vehicle Tracking																																✓
	Maintenance and Construction Vehicle Maintenance																																✓
	Road Weather Data Collection																																✓
	Weather Information Processing and Distribution	✓																															✓
	Roadway Automated Treatment																																✓
	Winter Maintenance							✓																									✓
	Roadway Maintenance and Construction							✓																									✓
	Work Zone Management							✓																									✓
	Work Zone Safety Monitoring							✓																									✓
	Maintenance and Construction Activity Coordination	✓																															✓

Source: Market Packages, ITS National Architecture Verson 4.0 (US DOT, April 2002)

APPENDIX C SELF-ASSESSMENTS ON REGIONAL PROGRESS TOWARDS INTEGRATED PLANNING

C.1 INTRODUCTION

The self-assessments provided at the end of each chapter of the Incorporating ITS into the Transportation Planning Process follow. Please take a moment to mark where you feel your area/region falls between absolute “NO”, and absolute ”YES” with regards to each question. YES represents the need for and/or progress towards an integrated planning/decision making process.

C.2 THE CHANGING CONTEXT OF PLANNING AND DECISION MAKING: FORCES LEADING TO INTEGRATED PLANNING.

Table C-1 Context For Integrated Planning: World 1/World 2 Self-Assessment

Question	World I World II
Are congestion and transit overloading a serious problem in your area causing extended peak periods, peak hour factors close to 1.0 and significant delays ?	NO - - - - - - - - - - YES
Do accidents and other incidents that cause cascading impacts over large portions of the transportation system occur frequently (daily)? Do the effects remain long after the incident is cleared?	NO - - - - - - - - - - YES
Do customers (travelers) complain frequently about unusual delays, or missed connections due to irregular service ?	NO - - - - - - - - - - YES
Is the area already built and densely populated with little or no room for additional road or transit right of way and expansion?	NO - - - - - - - - - - YES
Has there been significant opposition to transportation projects in the recent past?	NO - - - - - - - - - - YES
Is the transportation system complete and connected? Do the facilities exist for travelers to get to where they would like to go without significant diversion?	NO - - - - - - - - - - YES
Is the transportation system (roads, bridges, transit vehicles and facilities) in poor condition requiring an ever increasing portion of the transportation resources to maintain?	NO - - - - - - - - - - YES
Does the area have air quality or other environmental problems?	NO - - - - - - - - - - YES
Is the region experiencing rapid increases in travel (trips and VMT) due to population and employment growth and starting to experience congestion on some facilities?	NO - - - - - - - - - - YES

Mark the relative position of your area’s advancement.

Table C-2 Applicability of National ITS Architecture Conformity Requirements Self-Assessment

Question	NO YES
Are the National ITS Architecture Conformity Requirements Applicable ?	
Is the area currently operating or planning to implement ITS?	NO - - - - - - - - YES
Were any of the existing ITS systems implemented after June 9, 1998?	NO - - - - - - - - YES
Do planned ITS projects use funds from the U.S. Highway Trust Fund?	NO - - - - - - - - YES
Are any “Major ITS” projects (multi-modal, multi-jurisdictional, multi-agency) planned for implementation?	NO - - - - - - - - YES
If The Requirements Are Applicable? (Yes to any of the above questions)	
Are the area’s ITS systems included in and consistent with the appropriate Long Range Plan and Transportation Improvement Programs (both Metropolitan and Statewide)?	NO - - - - - - - - YES
Have a wide range of stakeholders including all ITS operators and major users participated in the development of the area’s ITS plans?	NO - - - - - - - - YES
Have the major information sharing requirements between stakeholders been identified?	NO - - - - - - - - YES
Have the needs for future ITS expansion been identified?	NO - - - - - - - - YES
Does a Regional ITS Architecture exist, or is one being developed?	NO - - - - - - - - YES
Has a region for the regional ITS architecture been defined which encompasses the boundaries of it’s major ITS systems?	NO - - - - - - - - YES
Does the development and continued maintenance of the regional ITS architecture include the required participating agencies and stakeholders?	NO - - - - - - - - YES
Has an operational concept been defined that identifies the roles and responsibilities of the stakeholders to implement, operate, and maintain the ITS system?	NO - - - - - - - - YES
Have the other required components of a regional ITS architecture been developed? (system functional and interface requirements, standards, phasing)	NO - - - - - - - - YES
Are agreements in place that ensure that the ITS system can be operated and maintained?	NO - - - - - - - - YES
Have the roles and responsibilities for maintaining and updating the regional ITS architecture been established?	NO - - - - - - - - YES

Mark the relative position of your area’s advancement.

C.3 AN INTEGRATED DECISION-MAKING FRAMEWORK

Table C-3 Questions on Region's Progress Towards An Integrated Framework

Question	NO YES
Does your planning process extend beyond current Federal requirements and consider all components and strategies that are part of the transportation system and operations?	NO - - - - - - - - YES
As part of the planning process, does the region include consideration of ITS, management and operations, system preservation, and traditional infrastructure capacity improvements in an integrated process?	NO - - - - - - - - YES
As part of the planning process, has the region set short and mid-term goals focused on operations and system performance in addition to the 20-year horizon of the typical long-range plan?	NO - - - - - - - - YES
Does the region's plan accommodate short and mid-term initiatives that focus on other than traditional infrastructure capacity?	NO - - - - - - - - YES
Do plans for all time frames define operational strategies and concepts ?	NO - - - - - - - - YES
Is there a process whereby short-term planning results can be fed into mid-term planning results, mid-term results into long-term results, and back to short-term? In other words, is there a "cycling" process whereby planning occurs along a continuum and is not only directed at a 20-year horizon?	NO - - - - - - - - YES
Have elected and senior officials enunciated their support and interest in short and mid-term operations and system performance as well as in capacity improvements?	NO - - - - - - - - YES
Are stakeholders from both the planning and management and operations communities represented in the regional planning process?	NO - - - - - - - - YES
Have most key transportation and related organizations in your region developed internal structures that enable cooperation between planning and operations elements?	NO - - - - - - - - YES
Have key transportation and related organizations in your region collectively developed a structure(s) that enables cooperation between the several agencies, and specifically cooperation between planning and operations staffs in the different agencies?	NO - - - - - - - - YES
Is the region able to effectively measure and make tradeoffs between ITS, management and operations, and traditional infrastructure-type improvements or expansions?	NO - - - - - - - - YES
Has the planning process expanded its view of system performance to include other than average or peak-hour conditions? Is the region effectively able to measure system performance? Are performance measures used to evaluate progress towards goals, and to make changes in current plans and programs when warranted?	NO - - - - - - - - YES
Does the inventory of transportation facilities and services include the ITS and communications components and operating rules/strategies that are part of an integrated alternative ?	NO - - - - - - - - YES
Does the region have a data collection and analysis program that includes varying system performance from throughout the day, between days, and under unusual events?	NO - - - - - - - - YES
Has the region completed an ITS architecture?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

C.4 INSTITUTIONAL RELATIONSHIPS, ACTIVITIES, AND FUNCTIONS

Table C-4 Institutional Relationships, Activities, and Functions Self-Assessment

Question	NO YES
Redefine Institutional /Organizational Relationships	
Do agencies within your area include development/construction, operations, maintenance, and other departmental staff in decisions on service provision, development, or ongoing performance?	NO - - - - - - - - YES
Do agencies with your area have separate budgets for operations, maintenance, preservation, and capital expansion, making it difficult to examine tradeoffs, or develop life cycle approaches? Do other restrictions such as procurement practices or work rules inhibit within agency coordination?	NO - - - - - - - - YES
Have agencies within your area adopted a customer service orientation? Has this new mission been promoted throughout their organizations?	NO - - - - - - - - YES
Is there a current forum for area-wide cooperative decision-making concerning transportation operations and management? Is this carried out through the MPO?	NO - - - - - - - - YES
Do inter-jurisdictional or agency agreements exist for ITS systems, or other system operations? Are they informal “virtual” organizations, or they formal legal entities?	NO - - - - - - - - YES
Has a Concept of Operations been developed as part of a Regional ITS Architecture? Is one now being developed?	NO - - - - - - - - YES
Expand Stakeholder Involvement	
Are transportation operators/providers included in the regional transportation planning process (freeway and traffic operations, transit, public safety and incident management)?	NO - - - - - - - - YES
Are other Stakeholders/Users also part of the process (Motorists, transit riders, commercial shippers, taxi and shuttle operators)?	NO - - - - - - - - YES
Have new forums for operations been created by the MPO or others that provide for the exchange of information between planning and operations?	NO - - - - - - - - YES
Are these stakeholders also participating in the development of a Regional ITS Architecture?	NO - - - - - - - - YES
Is a process in place for continual review and update of stakeholders that need to participate in the decision/planning process?	NO - - - - - - - - YES
Are private sector transportation and ITS providers also participants?	NO - - - - - - - - YES

Table C-4 Institutional Relationships, Activities, and Functions Self-Assessment Continued

Question	NO YES
Determine Public-Private Sector Roles and Relationships	
Do private-public sector partnerships for ITS or other transportation services currently exist in your area? Do the private sector partners participate in planning and operational decisions?	NO - - - - - - - - YES
Are their procurement or other barriers to developing new extended relationships with private sector partners?	NO - - - - - - - - YES
Have clear principals for private public sector agreements been established regarding responsibilities, liability, ownership of intellectual property, privacy, and/or confidentiality been established?	NO - - - - - - - - YES
Have the ITS and other services that are candidates for private sector provision or partnerships been determined? Are the assumptions on each participant's roles clearly defined? Does each party benefit?	NO - - - - - - - - YES
Factors: Leaders and Champions	
Have leaders and champions for ITS and operations already been established in your area?	NO - - - - - - - - YES
Is this through the MPO, the state, an operating agency, or regional operating organization?	NO - - - - - - - - YES
Do they have the necessary resources and technical skills?	NO - - - - - - - - YES
Is training and outreach to political and other decision makers being carried out to help them understand the benefits of ITS and Operational improvements?	NO - - - - - - - - YES
Factors: Alignment of Systems, Influence Areas, and Jurisdictions	
Do the ITS or other transportation systems or their influence area's in your region cross multiple MPO, state, or other significant jurisdictional boundaries?	NO - - - - - - - - YES
Is there a potential lead organization whose boundaries align with the above? Does it have the legal authority or mandate to provide leadership in ITS and operations?	NO - - - - - - - - YES
Are there ongoing operational partnerships between existing entities that could evolve into new joint leadership for ITS and operations?	NO - - - - - - - - YES
Factors: Historical Relationships	NO - - - - - - - - YES
Is there a history and precedence for cooperation between agencies and organizations in your area?	NO - - - - - - - - YES
Are there historical issues with cooperation due to political differences (suburbs-inner city), or professional perspectives (transit-highway). Have these created barriers to cooperation in the past?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

Table C-4 Institutional Relationships, Activities, and Functions Self-Assessment Continued

Question	NO YES
Factors: Transportation Environmental and Other Issues	
Is your area primarily part of World I, or World II (see earlier self-assessment)?	NO - - - - - - - - YES
Is part of your area in World I, and part in World II? This may lead to separate programs and agendas for each.	NO - - - - - - - - YES
Is your area a air quality non-attainment area? Are their other environmental issues and concerns that could limit transportation solutions, or introduce new stakeholders?	NO - - - - - - - - YES
Are there special events or activities that may act as a catalyst for ITS and operational considerations (festivals, severe weather)? Do these introduce additional stakeholders?	NO - - - - - - - - YES
Is the transportation system in need of extensive rehabilitation and /or maintenance?	NO - - - - - - - - YES
Factors: Agency Resources/Skills	
Does the MPO have available resources ITS and operations? Do staff understand ITS technologies, system engineering, and architectural development?	NO - - - - - - - - YES
Does the MPO currently operate any ITS or other services (ride-share, traveler information)?	NO - - - - - - - - YES
Is there significant disparity between jurisdictions/agencies in your region with regards to resource levels/budgets, staffing, or staff capabilities?	NO - - - - - - - - YES
Is training on ITS and operational issues ongoing or being considered for both staff within organizations, and public policy decision makers?	NO - - - - - - - - YES
Factors: Authorizing Environment	
Are they multiple operating agencies and political jurisdictions in your area? Does your area cross state boundaries?	NO - - - - - - - - YES
Do states own and operate the freeway and arterial systems in your area? Is this a city, or county function?	NO - - - - - - - - YES
Is the transit agency an independent regional authority? Does it cross jurisdictional boundaries?	NO - - - - - - - - YES
Are there specific legal and legislative barriers that inhibit regional operations and/or coordinated decision making?	NO - - - - - - - - YES
Are funding sources available and flexible to be used for combined alternatives (ITS, operations, and capital).	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

C.5 TECHNICAL ACTIVITIES AND FUNCTIONS

Table C-5 Cross-Cutting Technical Issues Self-Assessment

Question	NO YES
Are there neighboring regions, states, or inter-city corridors with ITS systems that overlap your area? Are they developing ITS plans and architectures that you need to coordinate with?	NO -------- YES
Has the region for an ITS architecture been defined? Does it encompass all current and planned ITS systems and their impact areas?	NO -------- YES
Is the use of ITS Standards being explored ?	NO -------- YES
Has a technology forecast been carried out or considered? Does it include uncertainty/sensitivity analyses on key assumptions ?	NO -------- YES

Mark the relative position of your area's advancement.

Table C-6 Vision, Goals, Objectives and Measures Self-Assessment

Question	NO YES
Is there a "Vision" of the region/area's future that includes an integrated perspective of system development, operations, and asset management, in a sustainable way?	NO -------- YES
Do the area's goals and objectives include emerging issues of reliability, system preservation, sustainability, and efficient system management?	NO -------- YES
Have new customer oriented performance measures been defined? Do they include measures of reliability and variation throughout the day, month, year? Do they apply to all alternatives? Do they include operational issues such as incident response, or accident frequency/location?	NO -------- YES

Mark the relative position of your area's advancement.

Table C-7 Needs/Deficiencies Analysis Self-Assessment

Question	NO YES
Needs/Deficiencies Analysis	
Does the system inventory include ITS facilities, equipment, and services? Does it capture how the system operates? Communication, traffic, and surveillance networks? Does it include operating rules and concepts ?	NO -------- YES
Does the analysis include operational issues and problems throughout the day? Does it include all stakeholders' points of view (incident response)? Does it include both recurrent and non-recurrent conditions within the peak and non-peak travel periods?	NO -------- YES
Is causal analysis performed on the identified needs and deficiencies to determine why they exist (lack of capacity, high accidents, poor signal timing, etc.)?	NO -------- YES

Mark the relative position of your area's advancement.

Table C-8 Integrated Alternative Definition Self-Assessment

Question	NO YES
Do short, mid, and long range plans exist? Are they developed incrementally with feedback between each cycle to create a path of development?	NO - - - - - - - - YES
Does alternative development include the new elements for integrated alternatives (ITS and operational equipment and facilities, ITS services, concept of operations, ITS Architecture, operating concepts, and performance relationships, public private assumptions) FOR ALL FUTURE TIME PERIODS?	NO - - - - - - - - YES
Does alternative development include participation of all stakeholders from both the planning and operations worlds?	NO - - - - - - - - YES
Do alternatives combine ITS, operational, and system enhancement improvements to address the identified needs and problems?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

Table C-9 Estimating Impacts, Benefits, and Costs Self-Assessment

Question	NO YES
Estimating Impacts, Benefits, and Costs	
Are the area's professionals aware of the US.DOT ITS benefits and costs databases and ITS Resource Guide? Have they used them to help determine potential ITS impacts?	NO - - - - - - - - YES
Is system variability and congestion accounted for in the analysis of alternatives?	NO - - - - - - - - YES
Is the IDAS sketch planning tool for ITS, or other methods, used to estimate impacts of ITS in the planning process?	NO - - - - - - - - YES
Are the time streams (life cycle) of benefits and costs estimated? Do these include all costs to operate and maintain each component of the system in a sustainable way?	NO - - - - - - - - YES
Are operational simulations or other analyses performed during system development?	NO - - - - - - - - YES
Is data collection and performance measurement used to continually make incremental service and other adjustments?	NO - - - - - - - - YES
Are plans underway to update the area's forecasting processes and assumptions to include operational assumptions and ITS (advanced traffic signal control, Transit Signal Priority, Transit AVL, etc.)	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

Table C-10 Alternative Evaluation Self-Assessment

Question	NO YES
Alternative Evaluation	
Does the evaluation process account for tradeoffs between near and far term improvements?	NO - - - - - - - - YES
Does the evaluation process incorporate the new goals and objectives previously discussed?	NO - - - - - - - - YES
Does the evaluation process provide for examining tradeoffs between ITS, operational, and system enhancement improvements, alone or in combination?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

Table C-11 Planning to Programming Self-Assessment

Question	NO YES
Are extended programming criteria which incorporate ITS, and operations, system performance, and system preservation used?	NO - - - - - - - - YES
Are the system characteristics and need to bundle inter-related projects included in the programming process?	NO - - - - - - - - YES
Are continued operations and system maintenance/preservation included in the programming process?	NO - - - - - - - - YES
Are opportunities to combine ITS and other operational improvements with traditional construction and service expansion projects part of the programming process?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.

Table C-12 ITS Data, Performance Monitoring, and Feedback Self-Assessment

Question	NO YES
Is ITS data currently being collected and archived for highway, arterial, or transit system performance? Is it being analyzed to assist in operational or other planning activities?	NO - - - - - - - - YES
Is system performance being continually monitored and used in the transportation decision process? Is ITS data being used in this process?	NO - - - - - - - - YES
Is there a data quality control and management program for ITS data?	NO - - - - - - - - YES
Are the costs for ITS data collection, maintenance of surveillance equipment, and maintenance and cleaning being accounted for in system plans?	NO - - - - - - - - YES

Mark the relative position of your area's advancement.