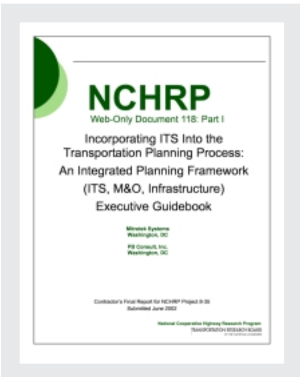
NCHRP
Web-Only Document 118: Part I
Incorporating ITS Into the Transportation Planning Process: An Integrated Planning Framework (ITS, M&O, Infrastructure) Executive Guidebook

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DETAILS

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Web-Only Document 118: Part I

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

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Contractor's Final Report for NCHRP Project 8-35
Submitted June 2002

National Cooperative Highway Research Program
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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I INTRODUCTION

The world and consequently, the issues that transportation decision making and planning must address are 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 from Hampton Roads Virginia, to Chicago Illinois, to San Francisco California, have begun to incorporate ITS into parts of their planning processes (See: Mitretek, 1999b; Deblasio, et.al., 1998; Siwek, 1998, AMPO, 1998).

In spite of these pioneering efforts and the potential of ITS to address the new issues and concerns, 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 of today (e.g. traffic and transit operations, maintenance) and those that plan, design, and construct our transportation facilities and infrastructure (the focus of conventional planning) for the future. 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 to strengthen the ties between ITS, management and operations, and the transportation planning process.

This Guidebook provides an overview of the key concepts found in the companion Practitioner's Guidebook. Both are the products of the NCHRP Project 8.35 "Incorporating ITS into the Transportation Planning Process." This version is 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 was developed based around four major perspectives, which are:

- Incorporating ITS into transportation planning is virtually equivalent to incorporating management and operations:
- Transportation planning goes beyond the Federal process and includes all decision making for developing, implementing, and operating the future transportation system.
- There is no one solution.

- Both traditional operations and planning must evolve to incorporate ITS and the system management which it enables.

Broadly defined, transportation planning involves all the components of the system -- operational planning, public/private participation, locally funded decisions, communications system, day-to-day operations, maintenance, and system management decisions and their impacts. It no longer consists of capital and infrastructure projects only, but also addresses operating strategies and how they change the performance relationships of the transportation system itself. **Transportation Planning must now be concerned with the combined set of actions and policies (infrastructure, ITS, system management, operations, and maintenance) that best meet a region's goals and objectives in a cost-effective manner.**

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. In addition, they 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. A new emphasis is required on determining the best development/operation paths for the future system.

Consequently, one goal of this project was to define and develop an integrated decision process that embraces ITS and addresses the above. An integrated process is one where ITS, system management, and operations strategies are considered on an equal basis with traditional elements of the transportation system. 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:

- 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.

The Integrated Framework developed around the above desired characteristics builds upon trends found in the pioneering practices across the country. It merges operations and planning decision-making causing both to evolve. . It is defined by three key features:

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- **New "performance" orientation** of planning and decision-making towards the management of the existing system first, followed by longer-term issues and concerns. This results in a shift in the cycles of planning and the creation of a "path of development" for each alternative that allows tradeoffs between today's actions and decisions with those implemented in the future.
- **New elements needed to define integrated alternatives**. These include the communications system, ITS equipment and services, a regional ITS architecture, operating rules and principals that determine system performance, and a concept of operations, or who does what.
- **Evolution of the institutional/organizational and technical relationships and processes of transportation planning and decision-making**. Institutional changes include: new stakeholders, institutional relationships that must implement and operate systems, explicit decisions on public/private roles, and creating a "concept of planning". Technical changes include introducing new goals, goals, objectives, and measures to capture the "World II issues and concerns, expanding the system inventory, and developing new analysis and decision processes that account for system variation, tradeoffs across time, and the interdependent 'system" characteristics of ITS and system management. ITS data also provides for continual performance feedback.

The remainder of this Guidebook first describes the factors that are pushing regions and states around the country towards integration. This is followed by a summary of the new Integrated Framework for carrying this out and an overview of institutional/organizational, and technical processes that are included within it. Last, remaining challenges, transition strategies for moving from where your region is today to the Integrated Framework, and sources for current information are provided at the end of the Guidebook.

II FORCES LEADING TO INTEGRATED PLANNING

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 have emerged (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. Legislation such as TEA-21's National ITS Architecture Conformity requirement, and Management and Operations (M&O) planning factor also is also pushing towards integration. Last, the fact that ITS incorporates characteristics of both traditional operations and planning solutions causes a need to "bridge the gap" between both worlds.

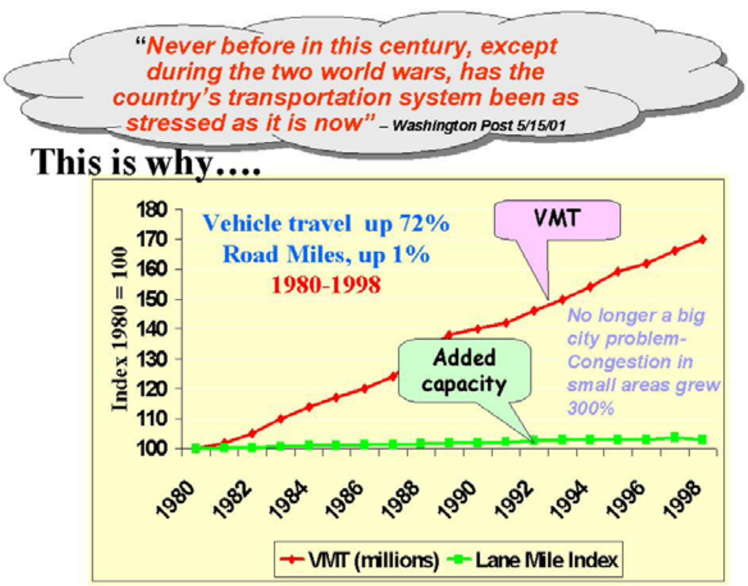
II.A RE-ORIENTATION TO MEET NEW ISSUES AND CONCERNS

A principal reason that planning and ITS, systems management, operations, and infrastructure 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

Figure II-1 Forces Towards Integrated Planning



Source: C. Johnson, 2001

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.

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 that in 1999 incident delay made up 54% of all delay (52% in large urban regions and 60% in small areas) (Schrank & Lomax, 2001). 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.

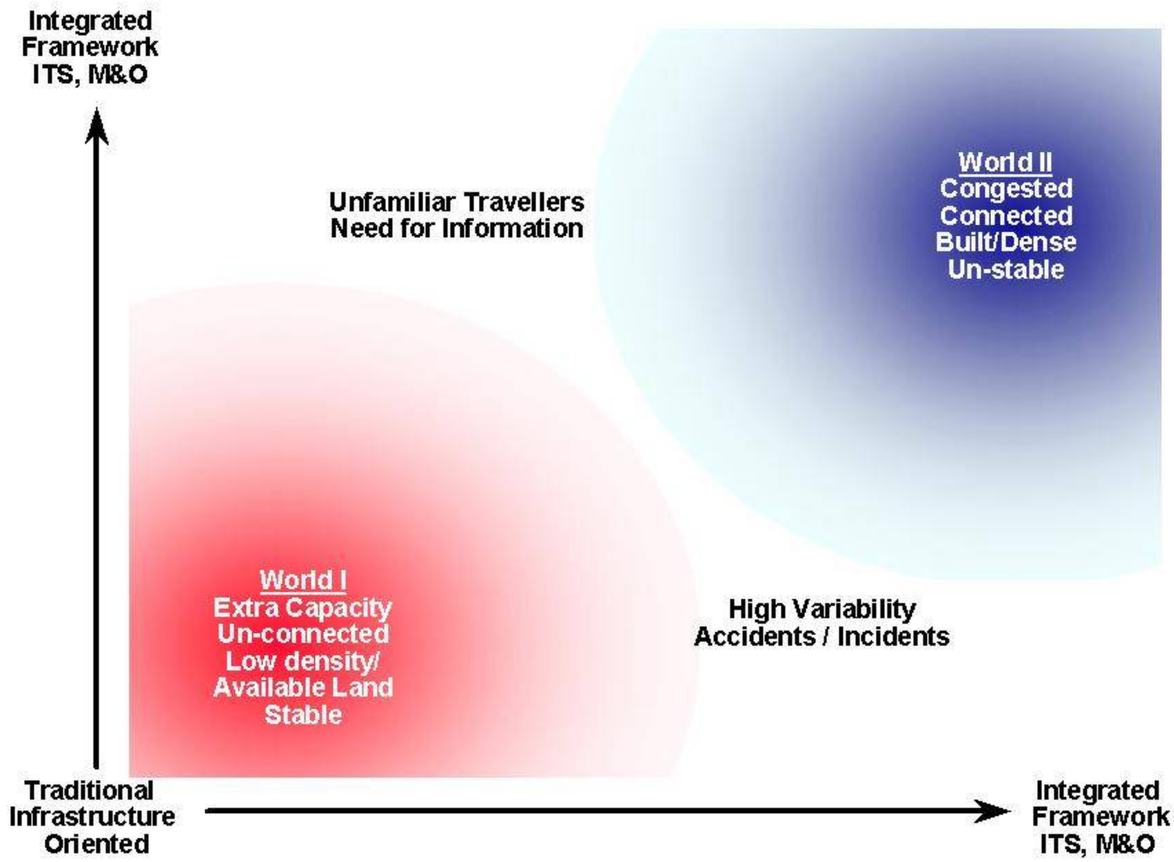
New Service Attributes Required. The service orientation of the U.S. economy is raising customer expectations – both passenger and freight – for a broader range of performance and service options. As society moves further into the information age, instant knowledge of the system and its conditions is 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. However, they 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 (see Figure II-2). 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, systems management and operations to solve its problems. Consequently, the approach a region or state may take depends on where it lies between the two.

Figure II-2: World 1 and World II Contexts



II.B INCREASED 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 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.

II.B.1 THE TEA – 21 MANAGEMENT & OPERATIONS (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, "**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 focus 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.
- 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 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.B.2 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.

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. They also require the use of a systems engineering analysis for ITS projects.

The Rule/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.

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

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.C ITS IS BRIDGING 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 **procedure oriented**, 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. It has been **project oriented**. Regional system performance is assessed against the overall goals of the region and fiscal/environmental requirements.

Figure II-3 shows the separation of traditional planning and operations found in the current state-of-the-practice for transportation decision-making. Traditional "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) using different goals and performance criteria. These factors create gaps or hurdles - in terms of communications, perspective, and cooperation – that make the integration of traditional facility planning, ITS, and operations difficult. Consequently, no comparisons or tradeoffs are made of ITS, systems management, and operations with other types of improvements, or explicit evaluations conducted on 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.

Traditional operations are 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.

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.

ITS bridges the gap between operations and planning (see Figure II-4). 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 operations and maintenance 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).

However, ITS 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 peak congestion 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 that 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.

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.

Figure II-3 Planning and Operations as Separate Processes

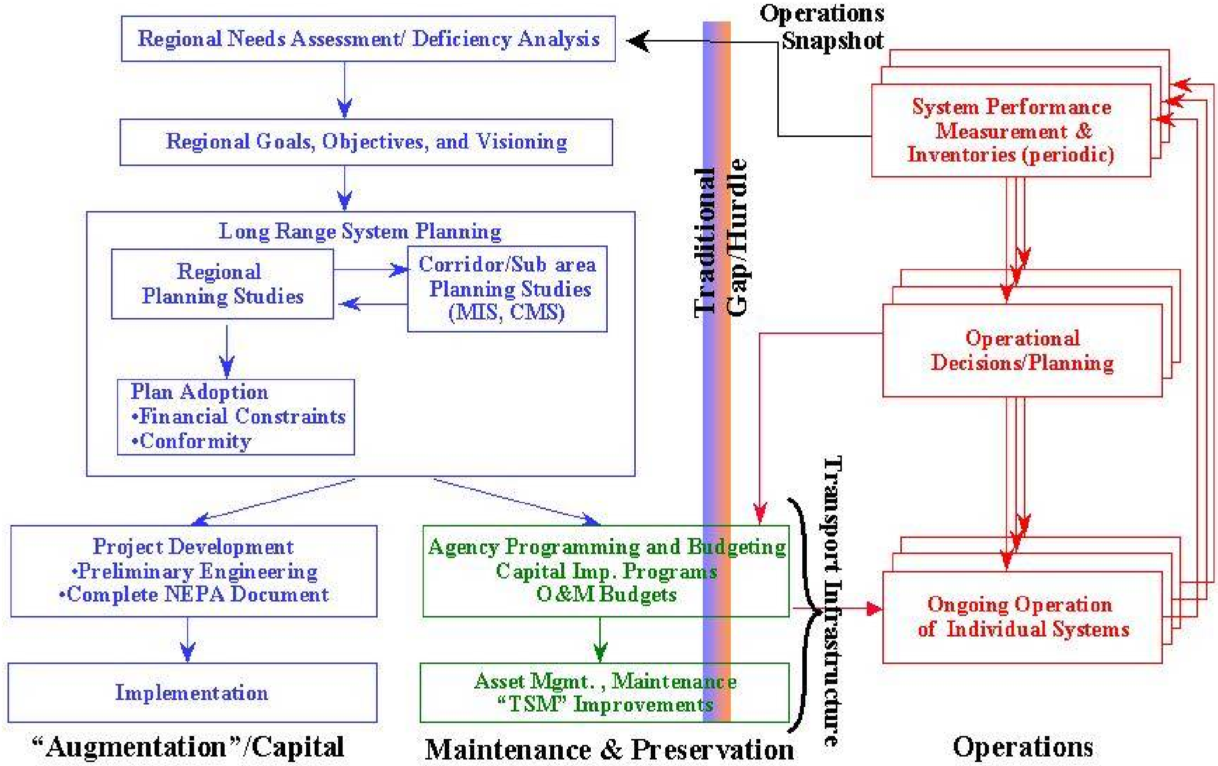
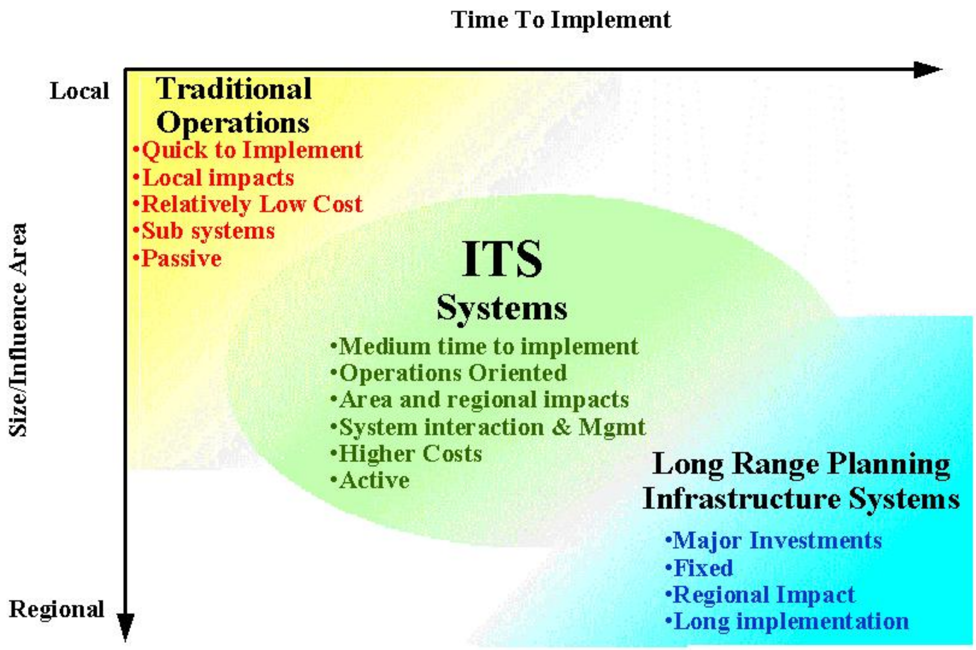


Figure II-4 Traditional Operations and Planning versus ITS



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**.
- **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.
- **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 more up-to-date information significant improvements to an individual's choice can occur, especially under unusual circumstances.
- **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 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." Thus, ITS creates a need for integrated planning and at the same time cannot simply be incorporated into traditional approaches. Decision making for ITS, systems management, operations, and traditional planning all need to **evolve** to achieve an integrated approach.

III AN INTEGRATED DECISION-MAKING 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 Section 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. Many pioneering areas across the country are on their way towards developing integrated processes (see the callout box for examples). The new Integrated Framework is a natural extension of their efforts. 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 operations each rely upon different funding different sources; or because they require planning for different time horizons.

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 system management of day-to-day 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).

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 & Smoliak, 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. 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.

The Integrated Framework is defined by three key changes to planning and decision-making as it currently exists:

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.

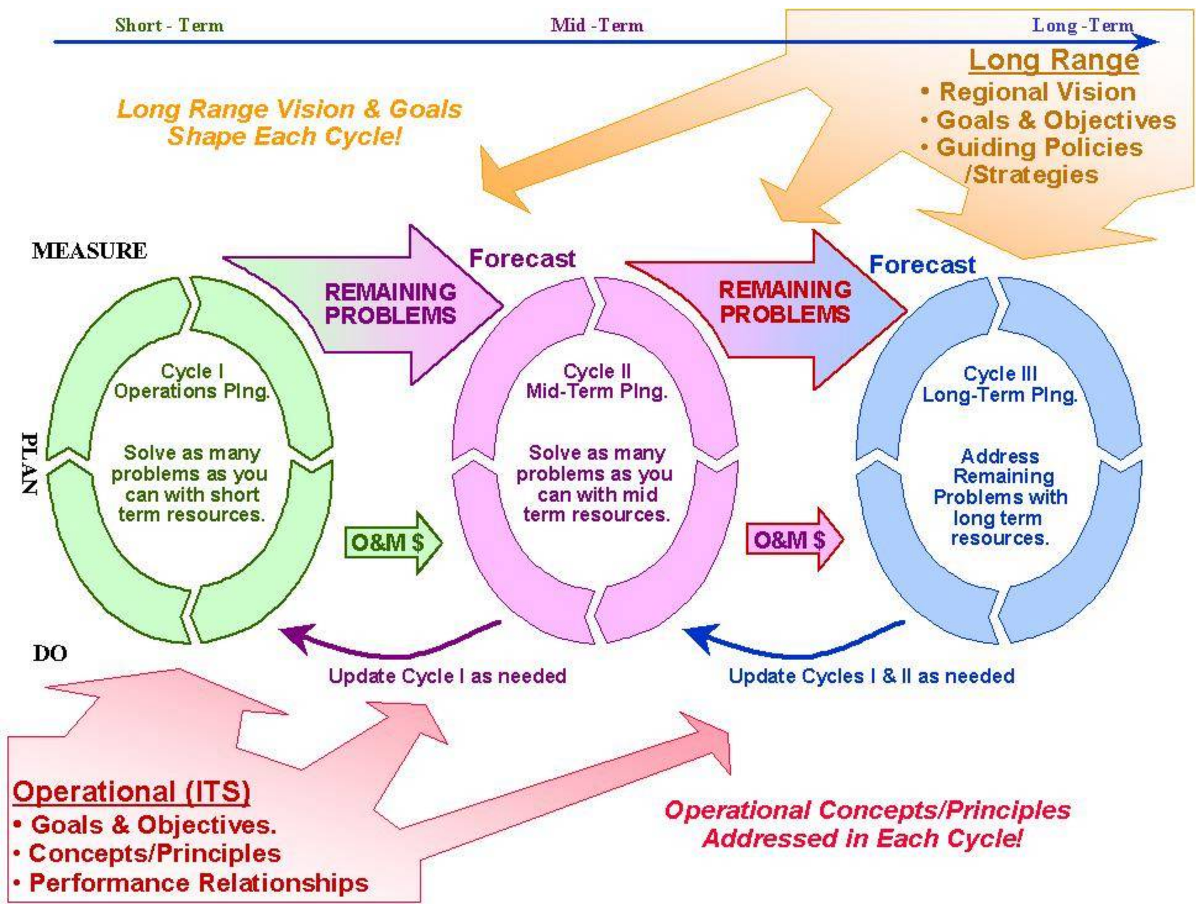
3. Merging of planning and operations decision-making, relationships, activities, and functions into a single process.

III.A 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 Section II continue to shift the focus of decision-making to balance near-term system management and ongoing operations with longer-term needs.

Figure III-1 provides a more detailed view of the cycles and feedback captured within the Integrated Framework that results. Three "cycles" of planning are shown:

Figure III-1 Orientation to the Near-Term, Cycles, and Feedback in the Integrated Framework



- **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.
- **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.

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 created 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.

III.B NEW ELEMENTS 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.

Table III-1 Summary of New Elements for Integrated Alternatives

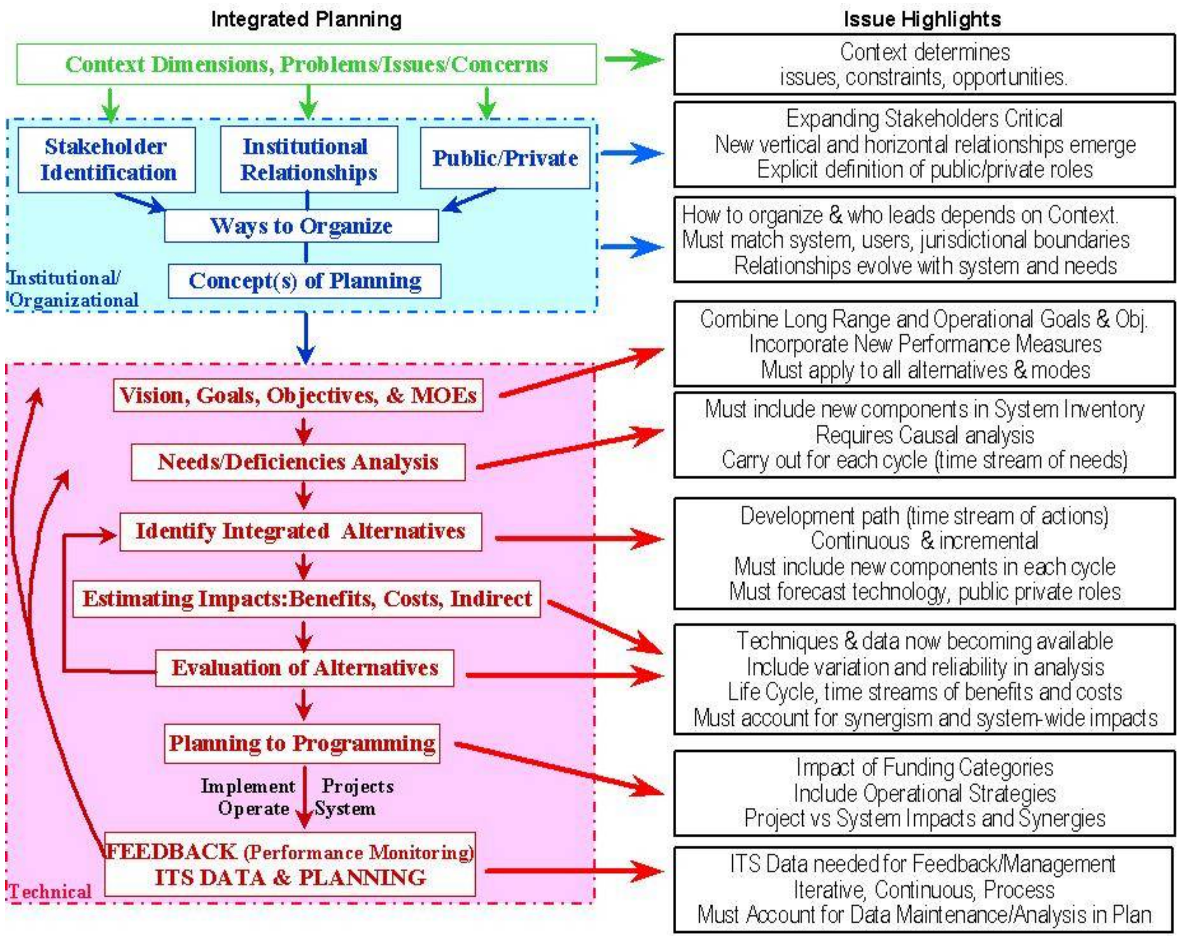
New Element	Description
ITS and communications infrastructure	ITS and communications facilities, equipment, hardware, and software used to implement the desired User Services. Examples include: transportation management centers, ramp meters, surveillance, variable message signs, toll and fare facilities, 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 path of development.

III.C PLANNING AND OPERATIONS DECISION-MAKING RELATIONSHIPS, ACTIVITIES, AND FUNCTIONS WITHIN A SINGLE PROCESS

Last, the institutional and organizational relationships, and the activities that are carried out within each of the planning cycles must be merged within a single process. Figure III-2 offers a more detailed look at the integrated activities, functions, and shifts in relationships for the Integrated Framework. 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 two 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 provide the information and support to decision-makers to help them make their choices. They 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-2 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.** 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 evolve 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. They are more fully discussed in Section IV (institutional/organizational) and Section V (technical) of this Guidebook.

III.D MEETING FEDERAL AND OTHER GOVERNMENTAL PLANNING REQUIREMENTS

While the Integrated Framework reorients the planning process and expands its focus to include ITS, systems management and operations, 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. Once the three cycles (short, mid, long-range) have been carried out, reconciled, and a full path of development chosen the inputs exist to create each of the documents and products needed to meet the regulations.

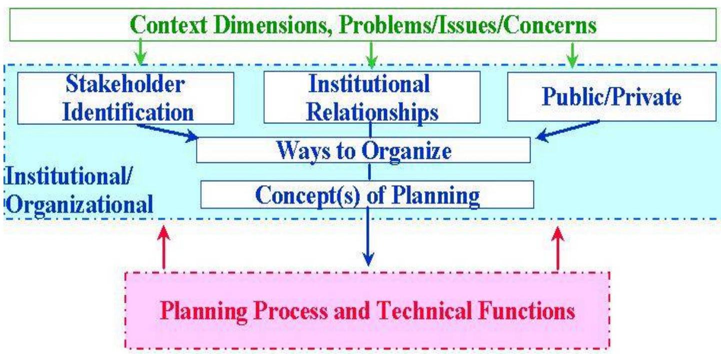
Table III-2 summarizes where in the Integrated Framework the information is found for each of the major Federal planning requirements. The Congestion Management System, Transportation Improvement Programs (TIP, STIP), and Regional ITS Architecture are based primarily on results from the short-term and mid-term cycles. The Transportation Plans (LRPs), major investment alternatives and environmental analyses, and air quality conformity use the full path of development that results after the long-term cycle is completed.

Table III-2 Meeting Federal Requirements In The Integrated Framework

Federal Product/Analysis	Integrated Framework
Congestion Management Systems	Taken from short & mid-term cycles Reflected in new performance MOEs, ITS Data and feedback, and Concept of Operations
Regional ITS Architecture	Taken from short & mid-term cycles Reflected in new stakeholders, Selection of alternative components, Operations orientation
Transportation Improvement Programs	Taken from short & mid-term cycles Reflected in Planning & Programmng, Incremental development
Transportation Plan (LRP)	Taken from full development path, financial feasibilty implicit in process
Corridor/Subarea Alt. Dev. & Environmental Analyses	Similar process, except at sub-area. Requires additional Systems Eng. Anal. for Arch. Conformity
Air Quality Conformity	Carried out for points along the path of development. May require adjustments to prior time frames

IV INSTITUTIONAL RELATIONSHIPS, ACTIVITIES, AND FUNCTIONS

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

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 Section 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.

IV.A 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).

A key precondition to institutionalizing ITS and system management 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-1 provides an initial screening of stakeholders by category of ITS User Service (See Ertico, 1998, Transcore, 1998 for additional stakeholder lists).

Several categories of stakeholders are shown in Table IV-1. 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. Examples include traffic operations, incident response units, public safety and security, and traveler information providers. Most of these have had little or nothing to do in the past with the planning and programming process and its focus on physical improvements. It is also important to identify new constituencies who benefit directly from ITS and operations. These supporters may include health providers, employers, real estate business interests with a stake in the smooth operation of the overall transportation network. Last, 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. Their interest in ITS as stakeholders is thus increasing.

Table IV-1 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

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 requires 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.

IV.B REDEFINE INSTITUTIONAL RELATIONSHIPS BOTH WITHIN AND BETWEEN ORGANIZATIONS.

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.

The institutions involved in planning and operations act as loosely coordinated “stovepipes” that develop policies, physical and operating plans, and programs of priority projects. 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. 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.

This institutional and organizational 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.

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. Key changes that must take place to overcome the gaps and hurdles 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

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 that include:

- Creating a Wider Understanding the Basic Concepts of ITS and system management.
- Clarifying the benefits of the ITS and integration.
- Finding champions.
- Redefining agency missions towards system performance from the users perspective.

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.

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. This requires both cooperative regional decision-making and coordination of transportation agencies operating within the same area, and interjurisdictional coordination. However, 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. 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

IV.C 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.

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.

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.

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. 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.** 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.** General guidelines must be developed on the public / private sector ownership of work and information. Preserving the privacy rights of individuals and firms must also be addressed (see Buffkin & Remer, 1997 for further discussion).
- **Statutory authority and liability.** Liability, 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.

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. 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.

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. This is critical sense with ITS, who provides the service often changes the customers that use it and the impacts that it has on how the overall system operates.

IV.D 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.D.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.D.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.

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.D.3 STATE CENTRIC

Likewise, States have played a central role in planning and organizing for ITS and operations decisions. 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.D.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.D.5 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.

Important factors to consider in determining who should lead the ITS, systems management, and operations components within an Integrated Framework are:

- 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.E 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.

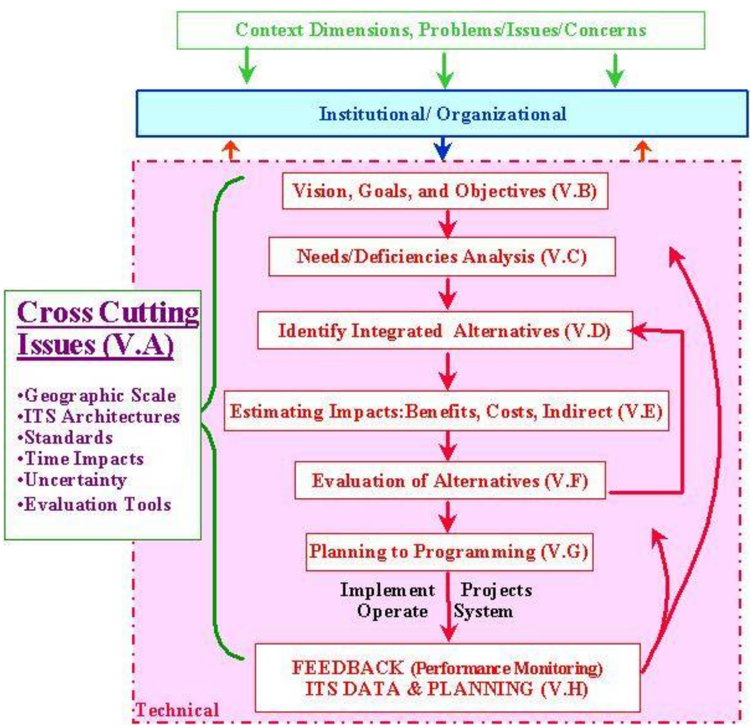
Regions would have to assess their own needs, context and setting to determine what would work best.

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.

V TECHNICAL ACTIVITIES AND FUNCTIONS

This Section describes the technical activities and functions that are associated with the Integrated Framework described in Section III. 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.

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



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. Sections on the crosscutting issues and other technical activities shown in the figure follow. These are:

- Section V.A: Crosscutting Technical Issues.
- Section IV.B: Identification of Vision, Goals, Objectives, and Measures.
- Section IV.C: Needs/Deficiency Analysis. Section IV.D: Integrated Alternative Definition.
- Section IV.E. Estimating Impacts (Benefits & Costs).
- Section IV.F: Evaluation of Alternatives.
- Section IV.G Planning to Programming.
- Section IV.H: ITS Data and Planning Decision-Making

V.A CROSSCUTTING TECHNICAL ISSUES

There are several crosscutting technical issues that impact the integrated planning process at all levels. First, ITS depends upon communication and the interplay between a number of electronic devices and protocols if it is to function at all. Therefore, there are a number of different components such as the communications backbone that are necessary to provide ITS, but provide no direct service to the transportation system or traveler. More important, a systems architecture is needed to insure that the system will function once it is implemented. The use of standards also provide important benefits and help ensure that systems perform as planned and are inter-operable. Next systems can overlap at a number of different geographic scales – from the project and site level, to a corridor, metropolitan, or inter-urban level. Making sure that the overlapping systems are coordinated and work together is critical for successful ITS implementations. Third, decision-making is also carried out for different time periods – short, medium, and long , which in the past have often been independent. This is no longer true in the Integrated Framework. Uncertainty in technological development and other issues must also be addressed. Last, is the perception of many practitioners that there is a lack of evaluation tools and data on ITS benefits and costs. These are explored further below.

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.

> 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

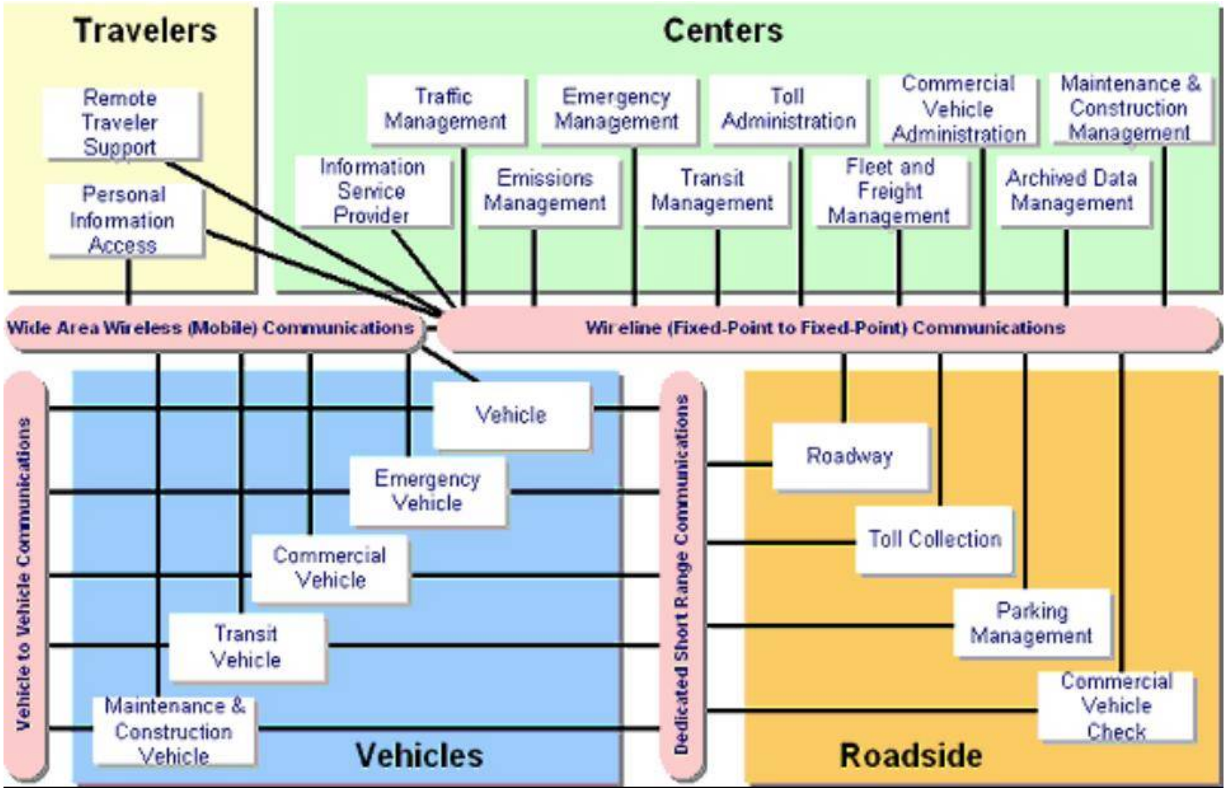
The National ITS Architecture was created to reduce the burden and assist in managing the development and implementation of ITS across the U.S. It provides the logical and physical architectures for the implementation of the **32 ITS User Services** which capture from a "users" perspective what we would like the ITS in the United States to do. The building blocks that it 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 now defined describes the subsystems, interfaces and conceptual equipment packages needed 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 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. Figure V-2 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

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,

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 an inter-city corridor or even National level.

Figure V-2 Physical Architecture (Transportation and Communications Layers)



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

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

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.

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. Systems and architectures planned at one geographic scale need to fit with systems planned at another scale. Corridor planning, for example, 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. Local projects must be consistent with the regional architecture, which in turn nests within statewide, or multi-state systems.

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)

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. As previously discussed 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. Bridging the gap between the two is one of the main challenges that must be overcome for integrated planning. Tradeoffs between short and long term decisions along the path of development must be evaluated as part of the decision-making process. This calls for determining the time-stream of benefits and costs and discounting future impacts to their present worth. Discounting must account for the time-value of money and the uncertainty of future benefits as well. Incremental improvements along the path, and their impacts upon travel behavior and system performance must also be "fed back" into the analysis of the future system. This requires incremental forecasting and evaluation, which increases the burden of already overloaded staffs. Last, uncertainty is inherent in any forecast, and the uncertainty becomes greater the further in the future one looks. This is particularly true when rapidly changing technology is involved.

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.

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. 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.

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. 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 (e.g. The U.S. DOT ITS benefits and cost data base, and the ITS Deployment Analysis System (IDAS) sketch planning tool.). One only needs to know where to look. The rest of this Section not only discusses the technical methods that are suitable for analyzing ITS as a part of an integrated planning process, they also point to sources of benefit, cost, and other data that can be used in the analyses.

V.B VISION, GOALS AND OBJECTIVES AND THEIR MEASURES

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.

Identifying an appropriate vision and its goals, objectives, and performance measures is a critical part of developing a balanced integrated planning process that incorporates ITS, M&O, and traditional improvements. The goals and objectives should reflect the emerging trends and concerns discussed earlier, which focus attention on more efficient management and operation of the system (increased system variability and non-recurrent events/conditions, new attention on customer satisfaction, increased lack of information). They should also still include the concerns addressed in traditional transportation planning (Typically these include: Accessibility, Mobility, Economic Development, Quality of Life, Environment, Safety and Security, Operational Efficiency, System Condition and Performance - see Cambridge Systematics, 1999). It is important that they reflect the values and concerns of the region in question. Also, goals which predetermine or promotes specific modes or alternatives such as "increase ITS deployment" are not recommended.

Adding new goals addressing the increased concern for efficiency and management of the system to the regional planning process is important to shift the emphasis from infrastructure oriented planning to a more balanced approach. Several pioneering regions around the country have already begun this process. The Washington D.C. area has also recently updated its Vision for its area to include system management and performance oriented goals, objectives and strategies (MWCOG, 1998):

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.

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. If the planning process is to be balanced, considering ITS, system management, and traditional solutions equally, then 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 the calculation of both the traditional and new performance measures chosen be 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.

V.C Initial Conditions and Needs/Deficiencies Analysis

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.

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.

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

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 Evaluation**
  - 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 its 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.D IDENTIFYING ALTERNATIVES

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 Meyers, 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.

With the incorporation of ITS, system management, and operations into the decision process new elements become part of any alternative development and definition. 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-2.

Table V-2 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.**

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 it will change the path of development. 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.

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 below.

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.

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.

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, make a rough high level screening of potential ITS User Services: matching the problems and causes with User Services that may contribute to a solution. Second, determine the level of each and how it should be combined with traditional improvements and policies.

It is presumed that transportation professionals have established processes for identifying non-ITS components. Table V-3 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. 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 Section II such as improved reliability, customer satisfaction, and safety. Incident management and HERO services, and real-time multimodal 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.

Table V-3 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)

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.

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.

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 and the level that it will be deployed in the future. 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. 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.*

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.

V.E ESTIMATING IMPACTS, BENEFITS AND COSTS

In the past the meaning of, "evaluation" and "estimating impacts" varied depending on the world one came from: either operations, or planning. Operations 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 decision when they must be made.

The integrated planning process 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 development path 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.

Estimating the impacts of integrated alternatives combining ITS, systems management, operations, 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. Over-arching evaluation issues that should be incorporated are:

New Relationships. Incorporating ITS introduces new changes between alternatives in operating conditions and travel behavior that previously remained constant. If the impacts of these strategies are to be properly captured then the analysis techniques must be updated to reflect these new dimensions. For example, traditionally travel networks used in analyses are validated to reflect both travel times and volumes under current operating conditions. The volume-to-speed functions are then held constant for future analyses. This presumes that the operations of the system remains the same and if it changes with for example the introduction of coordinated signals will no longer be valid.

Time Streams of Impacts. Since the alternative consists of the complete development path the time stream of both benefits and costs must now be incorporated. This requires the use of life-cycle costing as well as estimating when benefits occur. Discounting of future impacts and costs to allow comparisons between changes that occur today versus those that take place in 10 or 15 years from now must also be incorporated.

Uncertainty. As discussed under alternative development the uncertainty of technological advancements, and the costs and impacts of new services create new issues when considering ITS. 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: carrying out sensitivity and risk analysis on key assumptions to assist in developing "robust" alternatives; using conservative assumptions; or applying additional discounting to future impacts as a reflection of their uncertainty.

Wide Range of Criteria. As stated, ITS has different characteristics and creates different system responses than are the result of traditional transportation improvements. These include measures such as increased reliability, customer satisfaction, and improved information. These may be difficult to value and put in a monetary benefit cost analysis. It may also be important to show the tradeoffs and improvements in these new dimensions to decision makers so they can see how the performance between options varies.

New Stakeholder Groups and Distribution of Impacts. ITS and operations have very different constituencies and stakeholders than those traditionally involved in transportation planning. The distribution of both the costs and impacts may also be very different from traditional facility oriented options. Consequently, the analysis may need to show how the integrated alternatives impact these new constituencies as well as the public in general.

V.E.1 TRANSPORTATION AND TRAVEL DEMAND ANALYSIS

How capture the impacts of integrated ITS and traditional alternatives depends upon the level of detail needed, resources (time, staff skills, and cost), and the point in the decision cycle being addressed. Approaches vary by: coverage and level of detail; complexity and ease of use; and their internal causal relationships and ability to capture integrated solutions.

A thorough discussion of all possible analytical approaches is not covered here. However, it is important to keep in mind the general types of techniques that apply. Analytical techniques and tools used in planning studies generally fall into these major categories (presented in general order of increasing complexity and data requirements):

Performance Measurement and Extrapolation. Today's operating agencies often rely on the "test it and see" approach. As system evaluation and feedback into the management and operation of the transportation system is one of the main goals of the evolving process. Thus, as more ITS and operational strategies and surveillance and performance analysis are incorporated into standard practice. Knowledge of the system's response to conditions will grow. Incremental change, based upon current conditions can then rely less on models and other external methods, and more on actual observations of the system. Ongoing evaluation and performance measurement is described in depth elsewhere in this textbook.

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 Cost/Benefit/Benefits Data Bases
  - Intelligent Transportation Systems Benefits: 1999 Update (Proper, A.,1999) http://www.its.dot.gov/eval/Analyses/Analyses_BenefitsAndCosts.html
- ITS-Transit Impacts Matrix (Mitretek Systems, 2000) http://www.mitretek.org/its/aptsmatrix.html
- 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 (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 is 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 baseline 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.

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).

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.2 ENVIRONMENTAL AND OTHER IMPACT ANALYSES.

Environmental and other impacts include changes in:

- 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 and system management change 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).

V.E.3 COST ANALYSIS

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 costs. Because the operations and maintenance requirements for ITS are typically higher 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. 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/M&O and traditional. While a growing data base of ITS implementation and management and operations costs is developing and is available at the Federal ITS website (http://www.its.dot.gov/eval/Analyses/Analyses_BenefitsAndCosts.html) life cycle costs for traditional elements may still be difficult to come by.

Economic Life of ITS and Communication Elements. The economic life impacts how the project is discounted and the replacement need when estimating life cycle costs. Due to rapid advancements and early obsolescence technology elements have 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. Communications systems may also quickly be replaced. When comparing costs the economic life assumptions should always be examined. Also, the need to upgrade should be incorporated into the alternative design.

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. If the National ITS Cost database is to be used, then it is important to understand where and how it allocates costs. 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).

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 shard center costs among services.

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 dis-benefit 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.

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.

V.E.4 FINANCIAL ANALYSIS

The requirement that plans and TIPS be financially constrained and address the maintenance and preservation of the overall transportation system was introduced as part of ISTEA, and continued in TEA-21. As ITS and operations become more significant this requirement takes on additional importance, since the systems must both be implemented and operated.

The financial analysis can provide a feasibility check on the ITS assumption and other operations assumptions in the development path. . Yet, it also presents challenges. The fact that a market analysis might need to be done as part of the study is clearly one of the challenges. Many of the issues related to public-private partnering have implications for the financial analysis and decision-making framework since many other stakeholders and decision makers (including the private sector equipment manufacturers and/or information service providers) dictate the overall viability of the defined alternative. For example, if dynamic route guidance is planned, and the assumption is that it is delivered using the private sector, the viability of the alternative requires decisions on the part of the individual consumers to purchase the equipment and service, the private sector to offer the service, and likely the public sector to share traffic conditions information with the private sector. Some financial analyses might assume that the public and private sector trade data on traffic conditions, to mutual benefit, while others might assume that the information flow is more one-sided, with a potential need to include the expected value of the information into the analysis.

Other issues concern the leasing versus purchase of communications and other infrastructure/services, and the obsolescence of equipment and technology. Of course, as operating becomes a more significant budget element for stakeholders that traditionally did not have significant operating expenses, the funds must be identified and programmed as part of the financial analysis and programming/budgeting process.

V.F EVALUATION OF ALTERNATIVES

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.

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.

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.

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

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.

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. 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.

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.

V.G PLANNING TO PROGRAMMING

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.

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.

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-4 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-4 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 carrying it out. 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. It identifies 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. 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.

V.H ITS DATA AND PLANNING DECISION-MAKING

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.

The importance of ITS data and its feedback to planning and other "secondary" uses has recently been recognized by the addition of the Archived Data User Service (ADUS) in the National ITS Architecture (USDOT, 1999). Unless the data exists to support the performance based measures and the continual monitoring and feedback, capturing the management and operations focus brought by ITS to 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. 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).

The pioneering efforts in the use of ITS data have begun to provide some insights on the use of ITS data and its comparison with traditional data sources (See Table V-5). 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-5 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

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 are (Mergel, 1998; Flannery, 2000; TRB 2000 ADUS presentations):

- *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.
- *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 .

- *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).

There are several issues associated with the use of ITS data (see Mergel, 1998, Margiotta, 1998, Turner et.al, 1997,1999).

Data Content and Coverage Must be Useful to Planners. In San Antonio, the automatic vehicle identification system provides travel times for the regional CMS. However, portions of the CMS network are not covered because the MPO was not consulted on where the field locators would be located (Mergel, 1998). Likewise, in Minneapolis, the traffic management center will be able to collect data every 30 seconds across the region, yet could not provide ramp meter delay information to the MPO in a timely fashion because the loop detector placement required was not part of the original design (Mergel, 1998). Planners must be aware of the existence and potential uses of the ITS data, and provide input into its collection or it may not meet their needs. This requires an ongoing dialog.

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.

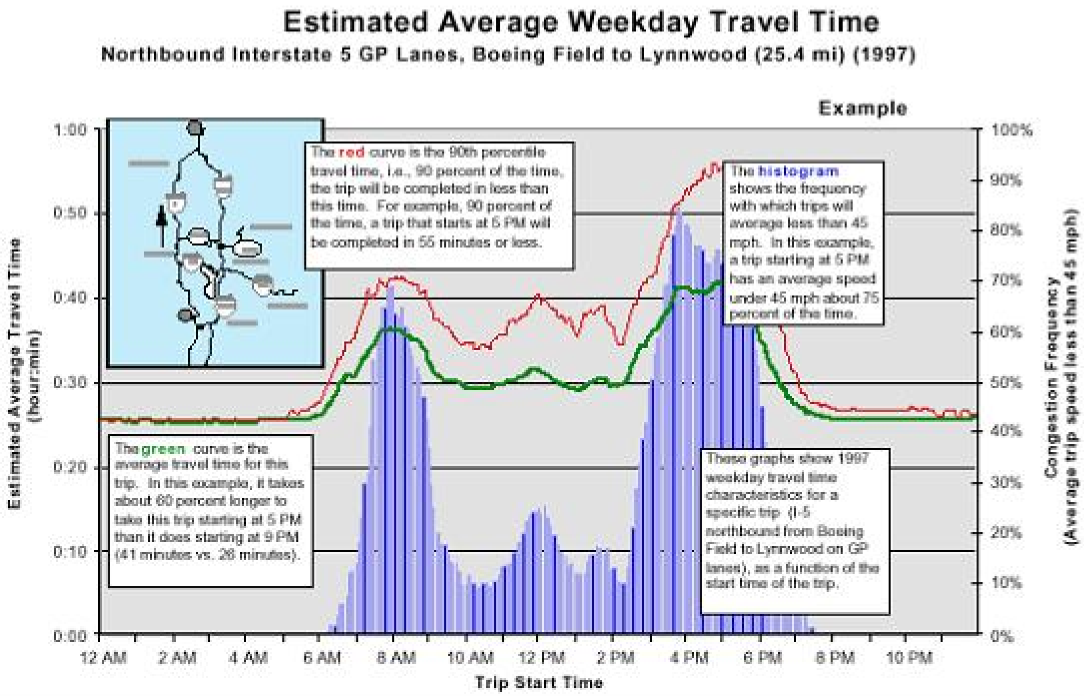
ITS data does provide more information than just average conditions and is a critical part of the causal analysis described in Section V.B. However, this must also be communicated and explained to be useful. Thought should therefore be given on how the ITS data will be summarized, and displayed to show 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-3 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 90^{th} percentile travel time also gives an indication of variation and reliability of travel time depending upon when the trip starts (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 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 (Margiotta, 1998, Brydia et. al. 1998, Turner et. al. 1999). 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.

Figure V-3 Example of Travel Time Variation along A Corridor



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 in 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 to and may require additional quality control analyses, error trapping, and imputation of missing values. For example, 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.

The Archived Data User Service.

The Archived Data User Service (ADUS) was added to the National ITS Architecture in 1999. ADUS' purpose is to provide the technical foundation for 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 should therefore be considered as part of the development of the Regional ITS Architecture.

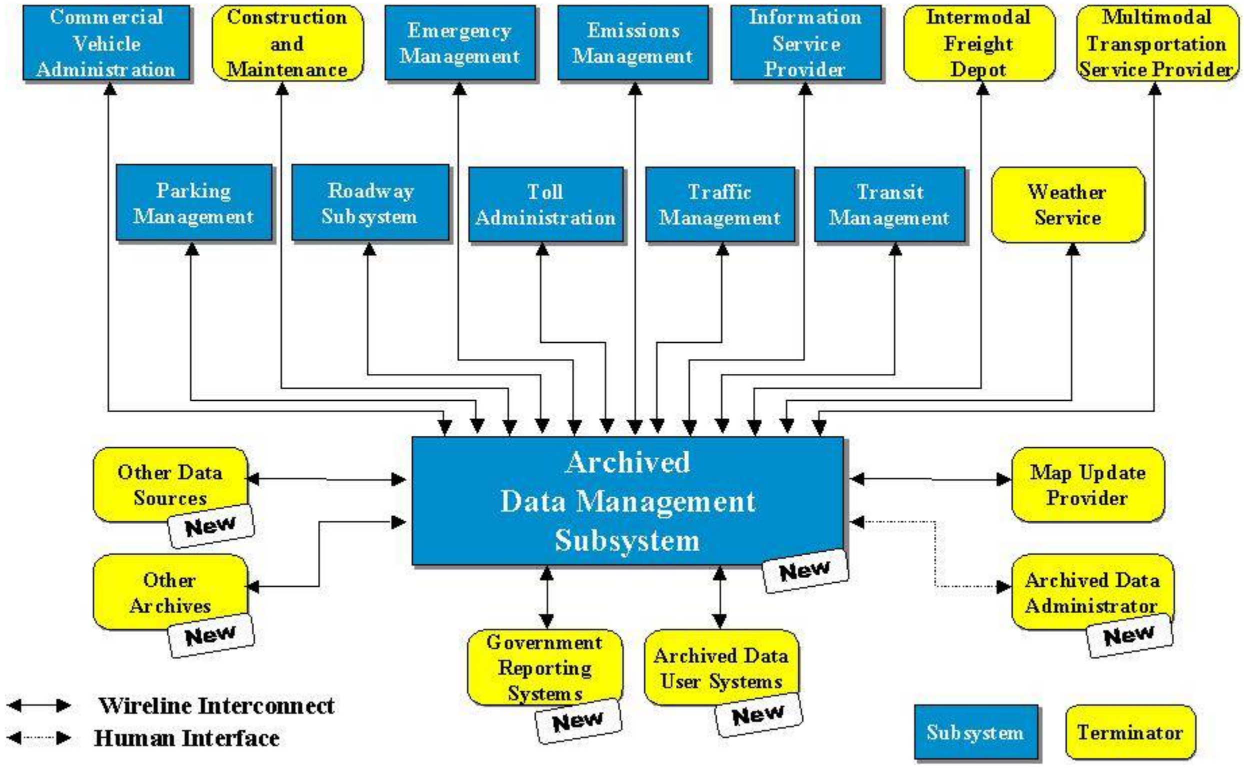
Within the National ITS Architecture ADUS defines the information flows and functions required when someone is considering saving and using ITS data. A new Center Subsystem, Archived Data Management System (ADMS), has been defined as part of ADUS. Figure V-4 shows the potential information flows and 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-4 ADUS Information Flows and Interfaces



VI CONTINUING CHALLENGES AND INITIAL ACTIONS FOR MOVING TO THE NEW FRAMEWORK

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 un-determined. 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 INITIAL ACTIONS FOR MAKING THE TRANSITION.

This section examines the transition from today's state of the practice to the Integrated Framework. Many regions are already part of "World 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. Consequently, transition assessments are provided in Appendix A to help determine which may apply to an area's specific situation.

VI.B.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. MPO's 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.

VI.B.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).

VII 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. They are:

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
ITE Regional Operating Organizations Site	http://www.ite.org/library/Reg_Trans_Ops.htm
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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APPENDIX A SELF-ASSESSMENTS ON REGIONAL PROGRESS TOWARDS INTEGRATED PLANNING

A.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.

A.2 THE CHANGING CONTEXT OF PLANNING AND DECISION MAKING: FORCES LEADING TO INTEGRATED PLANNING.

Table A-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 A-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.

A.3 AN INTEGRATED DECISION-MAKING FRAMEWORK

Table A-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.

A.4 INSTITUTIONAL RELATIONSHIPS, ACTIVITIES, AND FUNCTIONS

Table A-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 A-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 A-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.

A.5 TECHNICAL ACTIVITIES AND FUNCTIONS

Table A-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 A-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 A-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 A-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 A-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 A-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 A-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 A-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.