Transportation Planning and ITS:

Putting the Pieces Together

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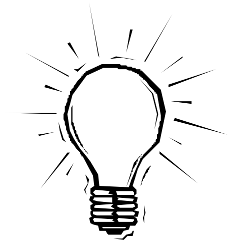

Rapid changes in technology and the emergence of the information age are having profound impacts on society. Choices related to when, where and why we travel are affected by technology and are, in some respects, greater than ever before. Yet, we rely heavily on the surface transportation system and take for granted that it will enable us to travel wherever we need to go, whenever we choose to go, and in a timely and predictable manner.

Use of the surface transportation system is greater than ever, and growth in travel and changes in travel patterns point to the need to improve management and operations of the existing system. The application of technologies in the transportation sector offers the potential to substantially improve operations and management, which is the foremost challenge to transportation planners and systems operators today.

Intelligent Transportation Systems (ITS) include the application of computer, electronics, and communications technologies and management strategies -- in an integrated manner -- providing traveler information to increase the safety and efficiency of the surface transportation system. ITS also provides useful, real-time information to system operators.

This publication presents information on how ITS can help us operate and manage the transportation system to its potential. In order to achieve this, we need to carefully plan and coordinate our investments, in both ITS and traditional transportation improvements.

Background

Between 1980 and 1995, the number of vehicle miles traveled annually in the United States increased by 58%, from 1.53 trillion to 2.42 trillion miles.[1] During the same period the capacity of the public road system only increased by about 1%, from 3.86 million to 3.91 million miles.[2] In 50 of the Nation's urban areas, congestion nearly doubled from 7.3 million daily person-hours in 1982 to 14.2 million daily person-hours in 1993.[3] Travel patterns have also changed, with enormous growth in travel outside of the central cities and between the suburbs of our metropolitan areas.

All of this adds up to increased traffic on highways, arterials and local roads. People spend more time driving than ever, with an *average driving time per day for all drivers of one hour and 13 minutes*.[4] Increases in traffic also impacts commercial vehicles which are experiencing increased

delays in transporting goods and services, thus adding to their costs. In addition, congestion and stop-and-go traffic can cause frustration among drivers and compromise safety. Growth in travel and changes in travel patterns also present new challenges to transit agencies.
The bottom-line result is a transportation system increasingly stretched in terms of its ability to provide the mobility, accessibility and safety that American consumers and businesses want and demand. Fortunately, opportunities exist to improve system operations and management through ITS in combination with traditional investments. For reasons noted below, a *combination* of investment approaches (including capital, operating, and management strategies) is needed, and can result in improved efficiency and safety of existing highway and transit systems.

Financial, environmental, safety, and other policy and political considerations make expanding the size of the transportation system difficult. Particularly in the Nation's metropolitan areas with the worst air quality, there are a host of barriers to adding new transportation capacity through construction or expansion of highways or roads. Even if adding new capacity weren't a problem, there is growing consensus that we can't build our way out of congestion. Time and time again new highway capacity is added only to be filled at some point in the future, sometimes within months. Policy makers confronted with this inevitability are seeking ways to address mobility needs with a combination of approaches that recognize resource constraints balanced against social, economic and environmental factors.

Given the economic and population growth the country has experienced throughout the 1990's, it is unlikely that people and business owners and operators will travel less. The demand for mobility and accessibility is driven by the need and desire for people to work, conduct personal business and enjoy recreational opportunities, and for businesses to deliver goods and services economically and quickly within local areas, regions, or throughout the country. The widespread adoption of just-in-time delivery philosophies in American businesses has also increased the demand on the transportation system. While such policies save on inventory and overhead costs for businesses, achieving such savings is heavily dependent upon the predictability of the transportation system. Businesses must gauge travel time accurately; profitability depends on it.

ISTEA's Planning Framework Emphasizes System Management and Operations

Operating the existing system better and smarter is a priority and is a principal tenet of contemporary Federal transportation policy. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 adopted policies that reflect the realities and conditions noted above.

ISTEA emphasized systems management and encouraged investments in a combination of capital <u>and</u> operating and management strategies..

ISTEA challenged transportation planners and systems managers to develop economically efficient and environmentally sound solutions to transportation needs. ISTEA emphasized a planning framework that required decision makers to develop a vision of the transportation system in a systematic fashion and without bias toward one mode over another. In addition, ISTEA promoted consideration of a host of environmental, economic and social factors designed to ensure that the transportation system fits harmoniously into the human and natural environments. And, for the first time ever, the Federal government required that transportation plans prepared in metropolitan areas be fiscally constrained. Finally, ISTEA reinforced transportation plan, program, and project compliance with the Federal Clean Air Act requirements.

ISTEA Promoted Investments in Intelligent Transportation Systems (ITS)

In concert with its planning paradigm, ISTEA recognized the opportunities presented by investments in ITS. ISTEA promoted the implementation of ITS applications as part of the investment mix for States and metropolitan areas and provided special research funding in order to "jump-start" the implementation of ITS technologies and strategies. Due to the availability of Federal funding and research, the development of the National ITS Architecture (a framework for deploying ITS across State, regional, and jurisdictional boundaries) and standards have progressed substantially since 1991. Dozens of ITS field operational tests have been initiated in which specific technology applications have been deployed and results evaluated. In combination, these initiatives have provided a great deal of useful information and know how for transportation professionals, consultants and vendors that develop, design and market ITS technologies.

Due to the special funding status (research and development) that ITS enjoyed in ISTEA, planning for ITS typically occurred outside of ISTEA's planning framework. So, while ITS applications have been developed for many years (e.g. traffic signal coordination on streets, automatic vehicle locator systems (AVL) on transit buses), consideration of the full complement of ITS approaches has not been an integral part of transportation planning and investment decision making. The benefits of ITS investments are becoming evident and ITS can no longer be considered a peripheral or incidental investment. And, ITS is certainly emerging into a real world, rather than research and development context.

...integrating ITS into planning is central to successful and wise deployment of ITS technologies.

Purpose of this Publication

It is time to *mainstream* ITS into the intermodal and multi-modal transportation plans of States and metropolitan regions. This publication shows how transportation planning can address ITS more fully and how ITS can be utilized to make the most of the existing transportation system. Mainstreaming ITS will be needed to maintain the mobility and accessibility the public demands and to leverage transportation investments with ITS operations and management approaches. Further, incorporating ITS in the planning process can help ensure that investments work together toward the operation of an efficient, customer-friendly, economically-sound and environmentally-sensitive transportation system.

This publication is not intended to show planners or decision makers how to design an ITS program. It shows why addressing ITS in planning is central to successful and wise deployment of ITS technologies. For readers with a need for more in-depth information on specific ITS technologies, a resource section is provided.

How this Guide is Organized

1 ***Part One*** defines major categories of ITS applications and provides examples of each. It also includes information on the estimated nationwide benefits of ITS implementation over the next twenty years. Part One also discusses the measured benefits of ITS applications to-date and how ITS helps local government agencies in areas other than transportation.

2 ***Part Two*** shows the relationship between transportation problems, traditional solutions and ITS approaches to improved systems management and operations. It also describes the major elements of the transportation planning process to familiarize the reader with how planning works under ISTEA. The National ITS Architecture is described and how it can be used in the planning process to facilitate development of ITS programs. The case for mainstreaming ITS is presented and we show how ITS fits into statewide or regional visions for the future transportation system. Steps in the planning process and the role of ITS are discussed. We also describe opportunities to incorporate ITS into corridor and sub-area analysis. In addition, we show how thinking "ITS Smart" from the immediate future on can lead to an integrated system of transportation investments that achieve local, regional, and State goals. Examples of ITS projects in place today are provided that show how ITS is being deployed and the resulting benefits in various locations throughout the country.

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Part Three discusses issues and challenges in implementing ITS. These challenges include: institutional cooperation and coordination in order to realize the maximum benefits of integrated technologies; technical coordination on issues relating to National ITS Architecture and standards, systems compatibility, data needs and interoperability; human resource and training needs related to deploying and managing ITS investments; financial constraints; and ways to involve the private sector. As a result of this publication, practitioners and decision makers will have a better appreciation of the benefits of ITS strategies and applications during all phases of planning, project development, and system operations and management. Mainstreaming ITS into transportation decision making will lead to development of strategic investments in ITS and traditional improvements that will, over time, enable States, regions, and localities to realize the full potential of their transportation systems.

PART ONE: ITS Applications and Benefits

Our goal in this Part of the guide is to describe the major features of ITS applications and the potential benefits of ITS investments from national, regional, and local perspectives.

In this Part of the guide, we provide definitions and examples of eleven types of ITS applications in three major areas:

- Multi-modal Regional Traveler Information,
- Commercial Vehicle Operations Systems, *and*
- Advanced Vehicle Control and Safety Systems.

In addition, we discuss the estimated aggregate and nationwide benefits of ITS implementation over the next twenty years. We also provide specific information on measured benefits to date of selected ITS applications. Finally, we discuss the benefits of ITS to local governments, including non-transportation related benefits. Our goal in this Part of the guide is to describe the major features of ITS applications and the potential benefits of ITS investments from national, regional, and local perspectives.

Major Areas of ITS Investments

The U.S. DOT has classified ITS investments into three major areas: Multi-modal Travel Management and Traveler Information; Commercial Vehicle Operations Systems; and Advanced Vehicle Control and Safety Systems. Within the three categories there are eleven types of ITS applications as shown in Exhibit 1. The exhibit defines each type of application and provides generic examples of these ITS investments.

Realization of the full potential of ITS technologies can only occur with integration of the technologies and the information made available through their implementation. For example, information from a freeway management system is valuable to emergency management services in detecting, locating and evaluating emergency situations. Likewise, response and clearance information from an emergency management system helps freeway operators and others redirect traffic. So, while these examples are shown as discrete systems or technologies, their full benefits will only be realized if they are implemented in an integrated manner.

EXHIBIT 1: Intelligent Transportation Systems Applications

Multi-modal Regional Traveler Information	
Systems that provide real time travel information to the public, allowing them to predict trip times accurately and make route and mode choices.	C En-route traveler information such as kiosks at transit stops with real time information on bus schedules and arrival times. C Pre-trip traveler information such as a home page on the Internet with up to date information on the current status of traffic on the highways.
Incident Management	
Technologies that allow transportation managers to identify and respond quickly to incidents on the highway system.	C Video systems and loop detectors that identify slowdowns and then allow traffic managers to view the cause of slowdown in traffic and divert traffic from congestion caused by an incident. C Call-in systems where travelers or transit operators report incidents on the highway to a central dispatching center.
Emergency Response Management	
Systems that enable the rapid dispatch of emergency vehicles and personnel to the scene of an accident.	C Locations of 911 calls appear on digital map displays allowing emergency personnel to know the exact location of a call. C Global Positioning Systems onboard vehicles (buses, truck, cars) with MAYDAY systems that alert emergency personnel of an accident and help them quickly locate the vehicle.
Electronic Toll Collection	
Technology that allows vehicles to go through toll plazas without stopping, and pay toll fee electronically.	C A computer in the toll plaza identifies a transponder in the vehicle and bills or deducts credits from the owner electronically.
Freeway Management	
A system that collects information on current traffic conditions and responds to problems by managing traffic flow.	C Ramp metering that can be adjusted to accommodate increases and decreases in traffic flow. C Signal systems on arterials that can be adjusted to divert or slow traffic coming onto freeways. C Variable message signs that warn of upcoming traffic problems and suggest alternative routes.
Transit Management	
Technologies that help manage transit fleets more efficiently and effectively.	C Automatic vehicle location devices placed onboard buses that allow transit managers to monitor on-time performance and route efficiency of buses. C Computer aided dispatching that allows riders to make reservations and operators to choose the most efficient routes to meet demand.
Traffic Signal Control	
Traffic light technologies that allow the signal system to respond to real time traffic conditions and give emergency and transit vehicles priority.	C Emergency vehicles equipped with devices to hold through-street lights green. C Signal coordination systems that respond to events at special event centers (i.e., a sports arena), allowing the smooth flow of traffic entering and exiting the event location. C Signal systems that can be adjusted from a traffic control center to respond to incidents or congestion.
Highway-Railroad Crossing Safety	
Technologies that respond to incoming trains with enhanced warning and barrier systems at rail/highway intersections.	C Photo enforcement of grade-crossing and red-light violations. C Traffic signal systems that adapt to incoming trains to stop traffic early. C Systems that detect vehicles which have illegally crossed barriers onto the rail tracks.
Electronic Fare Payment	
Technology that allows electronic debit or credit processing of transit fares.	C Smart cards that encode credits or credit cards used to pay subway, bus and park-and-ride lot fares. C Smart fareboxes that record riders and bill employers for employee transit use.
Commercial Vehicle Operations Systems	
Comprehensive technology systems designed to keep freight traffic flowing through States and across interstate and international borders.	C Weigh-in-motion devices embedded in roads linked to computer systems to clear trucks in advance of weigh stations so that they can pass the weigh station without stopping. C Pre-clearance systems that allow trucks to communicate electronically with State computers to verify that registration, safety and other credentials are in order.
Advanced Vehicle Control and Safety Systems	
Collision Avoidance Programs through sensors that detect the location of vehicles to avoid collisions.	C Sensors that measure the relative distance and speed of vehicles ahead and warn the driver, if needed, to prevent rear-end collisions. C Intelligent cruise control that automatically adjusts vehicle speed when vehicle ahead slows or stops.

Estimated Aggregate Nationwide Benefits of ITS Investment

The *ITS National Investment and Market Analysis*[5] was conducted for ITS America and the U.S. Department of Transportation (DOT) in order to estimate the benefits of ITS investments on a nationwide basis over the next twenty years. This report concluded that ITS infrastructure investments produce substantial efficiency, safety and economic benefits. The study found that:

> *"ITS infrastructure investment will generate an overall benefit-cost ratio of 5.7 to 1 for the group of nearly 300 metropolitan areas examined, with even stronger returns to the top 75 most congested metropolitan areas (8.8 to 1)."*

> *"Safety benefits of ITS investments are equally as important as those derived from congestion reduction."*

A model evaluating the breakdown of savings from the nationwide deployment of the basic Metropolitan ITS Infrastructure from 1996-2015 showed savings in the following areas as depicted in Figure 1 below.

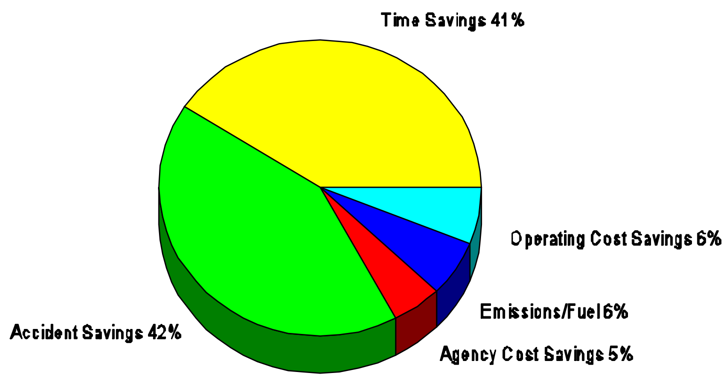

Figure 1

... the outcomes of ITS investment will include between $300 and $350 billion in direct economic impacts and the creation of nearly 600,000 jobs.

In addition, the study estimated economic consequences of direct investment of ITS in seventy-five metropolitan areas over the twenty year period (1996-2015). According to this estimate, the outcomes of ITS investment will include between $300 and $350 billion in direct economic impacts and the creation of nearly 600,000 jobs. *Readers are encouraged to review this study for a full understanding of assumptions and* *methodologies used.*

Measured Benefits of Selected ITS Applications to Date

One of the key questions that elected officials ask when considering ITS investments is:

"What are the Benefits?"

The U.S. DOT has been collecting information on benefits of ITS investments including: Field Operational Tests, Model Deployment Initiatives, and Commercial Vehicle Information Systems and Networks (CVISN). A report titled *ITS Benefits: Continuing Successes and Operational Test Results*[6] has documented the most recent benefits of these initiatives. Future reports will periodically update the benefits information.

The report provides benefits in three categories: measured, anecdotal, and predicted. The categories of benefits used are listed below along with measured results for selected ITS applications. *Readers are urged to review the specific details in the above mentioned report to understand the specific projects for which benefits were measured, the total number of projects used in the benefits ranges reported, assumptions and constraints in the interpretation of results and additional anecdotal and/or predicted benefits information. The report also contains references for source documents which will be useful to readers looking for full details on these projects.* The purpose of this summary information is to show that substantial benefits are being quantified as these projects are implemented.

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Below is a brief discussion of each of the categories of benefits and the ranges of impacts reported. It should be noted that ranges of benefits are provided because each setting is unique, the conditions under which ITS is implemented are different, and complementary technologies are in place in some settings while not in others. These ranges can serve as an indicator of the possible range of benefits of the noted application and not a precise estimate of the benefit of any single, specific application. The report also discusses reductions in fatalities (due to fewer crashes) and increases in customer satisfaction which is measured through before-and-after surveys of travelers.

Crashes

C *measured by percent of accidents reduced*

The percent of accidents reduced as a result of ramp metering, speed enforcement cameras, collision warning systems, and the Motor Carrier Safety Assistance Program (MCSAP) are presented in the report. Ramp metering results show a range of 24%-50% reduction in accidents based on seven locations measured. The percent of accident reduction due to speed enforcement cameras ranged from a low of 20% to a high of 80%. Collision warning systems yielded results ranging from 33% to 40% reduction in accidents.

Travel Time Savings

C *measured by reduction in travel time and delay*

Travel time savings is increasingly important nationwide and is a major goal of the U.S. DOT's ITS program. Examples of operational systems that yield travel time savings for both private vehicles and public transit vehicles include ramp meters, traffic signal control systems, incident management systems, in-vehicle navigation systems, and signal priority systems. The measured percent travel-time savings ranges from 10%-45% for incident management systems; 13%-48% for ramp metering programs; 8%-25% for traffic signal systems; 5%-8% for signal priority systems; and 4%-20% for in-vehicle navigation systems.

Throughput Improvements

C *measured by reported percentage increases in maximum throughput achieved*

Increases in throughput in number of people, number of vehicles, or amount of goods moved per unit of time while maintaining or improving level of service have been measured for selected ITS applications. Results show that for electronic toll collection and collision avoidance systems, the range of benefits amounts to a 200%-300% and 30%-60% increase in throughput respectively.

Reduced Operating Costs and Increased Productivity

C *measured by reduced operating costs and productivity improvements*

Operating cost reductions were measured for electronic toll collection, automatic vehicle locator systems and fleet management systems. These cost reductions have been realized for public transit operations and private vehicles. The range of benefits is 34%-91% reduction in operating costs for electronic toll collection, 4%-9% operating cost reduction for automotive vehicle locator and computer-aided dispatching systems, and 5%-25% reduction in operating costs for fleet management systems.

ITS Benefits to Local Government Agencies

ITS benefits do not only accrue on a nationwide or regional level or only to transportation agencies, providers, and users. Implementation of ITS provides substantial benefits to other public agencies, including public safety officials, medical emergency officials, and the managers of individual jurisdictions' streets and roads. In *How ITS Helps Local*

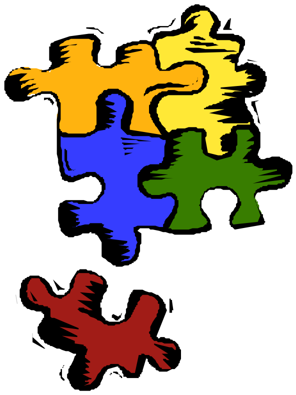
Governments Do Their Jobs Better[7], the author makes a persuasive case that shows how local government agencies and functions benefit from ITS applications. Exhibit 2 shows the potential beneficiaries of ITS applications across public agencies. As can be seen from the exhibit, the benefits of technologies reach beyond the transportation sector to social service agencies, educational institutions, and public utilities, to name a few. As examples, ITS benefits accrue to fleet managers by improving efficiency; educational institutions by improving school bus safety; and parks and recreation departments by facilitating fee collection and automatic vehicle location. This exhibit provides us with a better appreciation of the secondary benefits of information age technologies as well as the benefit of close coordination with local agencies when implementing ITS programs and projects.

EXHIBIT 2: ITS Applications Benefit Local Agencies

Applications	Police	Fire & Rescue	Public Works	Education	Social Services	Health Services	Parks & Recreation	Revenue Collection	Utilities	Transit
Multi-Modal Traveler Information	X	X	X	X	X	X	X			X
Incident Management	X	X	X	X	X	X	X	X		X
Emergency Management	X	X	X	X	X	X	X		X	X
Electronic Toll Collection	X	X	X					X	X	
Freeway Management	X	X	X	X		X			X	X
Transit Management	X	X			X	X	X			X
Traffic Signal Control	X	X	X	X	X	X	X		X	X
Highway Rail Intersection	X	X	X	X						X
Electronic Fare Payment					X	X	X	X	X	X

Source: <u>How ITS Helps Local Government Do Their Jobs Better</u>, John Mason, Science Applications International Corporation, October, 1997.

PART TWO: Integrating ITS into Transportation Plans and Programs



This Part of the guide discusses the major elements of the transportation planning process, the National ITS Architecture, and the consideration of ITS in transportation plans and programs. If we think about ITS investments as part of a strategic approach to identifying projects and ITS components *within* projects today, then the incorporation of ITS technologies into the future transportation system will naturally flow from investments made over a period of time. This requires a systematic and thoughtful planning strategy and the routine consideration of ITS in all aspects of planning. Planning is the underpinning for investment decisions and ITS needs to be part of the process. This entails a recognition that *electronics, technology and communications systems are part of the transportation system*-- and that they need to be addressed along with the physical infrastructure.

ITS enables the gathering and communication of information to users of the system and facilitates their selection of travel choices based upon individual needs. Examples of ITS strategies are provided in Exhibit 5 at the end of this Part of the Guide. These examples illustrate how ITS can yield measurable results and improved system performance.

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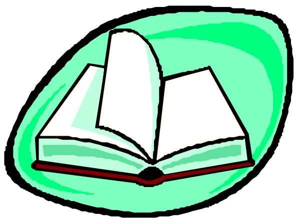
Major Elements of the Transportation Planning Process

The transportation planning process provides a forum for coordination, communication, and decision making by planners, system operators and managers, State and local governments and elected officials. Through the planning process, capital, operating and management strategies are identified to improve the performance of the transportation system. Planning is a continuing process that responds to changing conditions and new opportunities as they arise. Planning involves a broad array of stakeholders including the public and provides opportunities for inclusive participation in transportation decision making.

ISTEA fundamentally enhanced the role of transportation planning in States and metropolitan areas. Below is a brief overview of the major elements of the planning process. For a complete understanding of the statewide and metropolitan planning requirements, readers should refer to *Statewide Transportation Planning Under ISTEA: A New Framework for Decision Making* and *Metropolitan Planning Under ISTEA: How the Pieces Fit Together*.[8]

Transportation Plan- The transportation plan covers a 20-year period and identifies facilities (including, but not limited to, major roadways, transit, and intermodal facilities) that should function as an integrated system. The plan should reflect environmental and intermodal considerations and provide a financially-constrained vision of future transportation investments.



Transportation Improvement Program (TIP)- The TIP serves as a management tool that accomplishes the objectives of the plan. The TIP is a short-term document covering 3 years, and it must be updated at least every 2 years. The TIP includes the list of priority projects to be carried out each year. Projects in the TIP must be consistent with the transportation plan.

The planning process has four major elements as described below.

1. **Public Involvement-** Public involvement and input is essential to adequately consider the impacts of transportation on land use, as well as the overall social, economic, energy, and environmental effects of transportation decisions. Effective public involvement should facilitate participation in the planning process and inform transportation decisions.

2. **Planning Factors-** The planning process must explicitly consider and analyze, as appropriate, major factors based on sound planning principles. These factors reflect major themes of ISTEA including: Mobility and Access for People and Goods, System Performance and Preservation, and Environment and Quality of Life. While the manner in which agencies consider and analyze the planning factors will vary, it is important that the factors be explicitly considered.

3. **Financial Planning-** The transportation plan must include a financial element which identifies resources that are reasonably expected to be available to carry out the plan. This financial element should recommend any innovative financing techniques needed to fund projects and programs, including such mechanisms as public-private sector partnerships, value capture, tolls, and congestion pricing. In metropolitan areas, TIPs must also be financially constrained and, in air quality nonattainment areas, they must rely on available and committed funds in the first two years.

4. **Transportation Conformity-** Transportation conformity ensures that in air quality nonattainment and maintenance areas, transportation plans and programs that are paid for with Federal-aid are in conformance with the transportation provisions of the State

Implementation Plan (SIP) for attainment of the Federal air quality standards.

Congestion Management System (CMS) - A CMS is required as part of the planning process in urbanized areas over 200,00 population. The CMS is oriented toward ensuring efficient performance of the transportation network and should provide information that will enhance investment decisions and improve system efficiency. The actions, strategies, and needs identified through the implementation of the CMS, including those which enhance system performance, should be considered and reflected in the development of, and revisions to, the transportation plan and TIP.

National ITS Architecture is a Tool for Integration

The National ITS Architecture is a framework for the application of key elements of ITS functions and data that must be exchanged between ITS subsystems. The National ITS Architecture is a resource for planners, builders, designers and operators of highway and transit systems to use in extending and integrating their ITS operations. It supports a wide range of functions and services and can be tailored to address local and regional transportation goals. Employing the National ITS Architecture is an effective way to: lower ITS development costs, enable future system expansion, foster synergies between subsystems and across the entire transportation system; and improve the payoff of technology investments.

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. Exhibit 3 provides an example of incremental investments that will advance ITS in a strategic manner and lead to an integrated system of improvements.

EXHIBIT 3: Strategic Incremental ITS Investments Lead to an Integrated System

In all cases, agencies and localities will need to address the consistency of ITS applications with **National ITS Architecture** and standards.

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

Opportunities to Integrate ITS in Transportation Projects Today

The ultimate goal is to ensure that ITS strategies and technologies are an integral component of transportation plans and programs. However, as with all transportation investments, ITS technologies must work with existing systems and will be put in place incrementally. This does not imply uncoordinated or incompatible investment. As shown above, ITS requires thoughtful consideration of what projects can be implemented in the short-term, how they will complement the existing transportation infrastructure, and how they will work with other investments, both traditional and technology-based, in the medium-and-longer terms. This strategic view of ITS requires both incremental investment and long-term vision, both of which are supported by the planning process and by the National ITS Architecture and standards. This "smart-planning" approach to ITS is vital to realizing the full potential of ITS.

Exhibit 4 shows in summary fashion the relationship between transportation problems, conventional approaches to addressing them, and an operational and management approach using ITS. This exhibit shows a wide range of ITS applications from basic communications technologies to much more sophisticated applications which will take years to become fully operational. ITS is *not* a substitute for conventional approaches that have been proven. But, as the exhibit shows, ITS can enhance the effectiveness of these approaches.

EXHIBIT 4: Summary of Transportation Problems, Conventional Approaches, and Operational Approaches with ITS

Problem	Solutions	Conventional Approach	Operational Approach with ITS	Supporting ITS Components	Considerations
Traffic Congestion	C Increase roadway throughput	C New roads C New lanes	C Advanced traffic control C Incident management C Corridor management C Advanced vehicle systems	C Surface street control C Traveler information C Real-time toll/parking fee management C Regional traffic control C Railroad operations coordination	*Conventional and Advanced-* C Environmental considerations C Land use & community needs *Advanced-* C Near-term services yield modest benefits C Interjurisdictional issues
	C Increase passenger throughput	C HOV lanes C Carpooling C Fixed route transit	C Real-time ridematching C Integrate transit & feeder services C Flexible route transit C New personalized public transit	C Real-time ridesharing C Multi-modal coordination C Demand response transit operations	C Privacy & personal security
	C Reduce demand	C Flex time programs	C Telecommuting C Transportation pricing	C Real-time toll/parking fee management	C Amount of non-discretionary travel
Lack of Mobility & Accessibility	C Provide user friendly access to quality transportation services	C Expand fixed route transit & paratransit services C Radio & TV traffic reports	C Multi-modal pre-trip & en route traveler information services C Real-time response to changing demand C Personalized public transportation services C Enhanced fare card	C Interactive traveler information C Demand-response transit operations C Transit passenger & fare management	*Conventional-* C Declining ridership *Advanced-* C Interjurisdictional cooperation C Equitable access to information
Disconnected Transportation Modes	C Improve intermodality	C Construct inter-modal connections	C Regional transportation management systems C Regional transportation information clearinghouse C Disseminate multi-modal information pre-trip & en route	C Regional traffic control & information sharing C Multi-modal coordination C Interactive traveler information	*Conventional-* C Often slow to adopt change *Advanced-* C Existing system incompatibilities C Standards
Budgetary Constraints	C Use existing funding efficiently	C Existing funding authorizations & selection processes	C Public-private partnerships C Barter right-of-way C Advanced maintenance strategies	C Transit maintenance	C Market uncertainties make private sector cautious C Telecommunications deregulation makes right-of-way barter a near-term opportunity
	C Leverage new funding sources		C Increased emphasis on fee-for-use services		C Equity
Transportation Following Emergencies	C Improve disaster response plan	C Review & improve existing emergency plans	C Establish emergency response center C Internet with law enforcement, emergency units, traffic management & transit	C Emergency response C Incident management C Emergency routing	C Conventional interagency coordination challenges C Advanced interagency coordination issues C Standards
Crashes, Injuries, & Fatalities	C Improve safety	C Improve roadway geometry & sight distances C Grade-separate crossings C Driver training C Sobriety check points C Install street lights C Reduce speed limits C Post warnings in problem areas	C Partially & fully automated vehicle control systems C Vehicle conditions monitoring C Driver condition monitoring C Driver vision enhancement C Advanced grade-crossing systems C Automated detection of adverse weather & road conditions, vehicle warning, & road view notification C Automated emergency notification	C Intersection collision avoidance C Vehicle safety monitoring C Driver safety monitoring C Driver visibility improvement C Advanced railroad grade crossing C Network surveillance C Traffic information dissemination C Mayday support	*Conventional and Advanced-* C High costs C Human error is primary cause of accidents *Advanced-* C Mixed results for initial collisions warning devices C Tort liabilities issues hinder innovative deployments

(Source: "National ITS Architecture Implementation Strategy")

Mainstreaming ITS into the Transportation Vision for the Future

To ensure continued support for key ITS projects or programs, "mainstreaming" into the planning and decision-making process is essential. Institutionalizing ITS in the planning process can mean that ITS receives sustained attention at the technical level, with the *possible* (but not guaranteed) result that a State or region's overall approach to ITS will be more strategic and have a longer-lasting impact. ITS impacts are *systemic* in nature and have broad economic and mobility impacts. It therefore makes sense that ITS considerations should be fully integrated into statewide and metropolitan planning. In effect, ITS becomes part and parcel of programs and projects at the State, regional, corridor and local level. This avoids putting ITS in what may be perceived as an adversarial position vis-a-vis conventional highway and transit investments.

Areas that have chosen this approach generally develop a strategy for institutionalizing ITS into the planning organization's activities and addressing utilization as part of routine transportation decision making. Typical steps in this process include:

- Establishing **on-going research and analysis** activities relating to ITS, becoming more knowledgeable about the private sector's views and issues, and gaining a better understanding of ITS applications and their benefits as well as of the ITS *business* from the private sector perspective.

- Establishing an **ITS task force or committee**, including membership by other planning agencies, transit service providers, highway patrol, emergency medical service providers, freight railroads, ports, trucking firms, and other interested public and private sector members. This Committee should always be asking the question: "Are our transportation systems operating as efficiently as possible?"

- Developing an **ITS strategic plan** as part of the ITS element of the transportation plan, providing an overview of the ITS architecture for a State or region, identification of near-term and long-term issues, and a public-private action plan for ITS deployment.

Summary of Steps in Plan

What is the *problem*?

In developing a transportation plan, a State or MPO will need to identify the current setting and future trends including factors such as: growth in population and employment; congestion levels on highways and arterials;

transit ridership; maintenance needs and condition of existing systems;

truck and rail goods movement issues; revenue forecasts; and air-quality nonattainment status. This analysis provides the underpinning for the plan and allows the State or region to develop goals, objectives and policies which will guide the vision for how the transportation system will function in the future. Included in this analysis should be an assessment of existing system strengths and weaknesses including approaches to systems operations and management.

The transportation needs can then be articulated and either a top-down, bottom-up, or combination of the two approaches initiated during plan development. A top-down process would examine options to address problems in the context of the goals, trends, and performance measures. A bottom-up process would have agencies submit projects to be evaluated against criteria embodied in performance measures.

What are the *Goals*, *Objectives* and *Performance Measures?*
As part of plan development, State or regional goals, objectives and performance measures can be identified to take into account how transportation facilities and services address, now and in the future, the social, environmental and economic goals of the State or region.

Goals Might Include: [9]

- Meet the Mobility and Access Needs of the Growing Population
- Ensure that Transportation Investments are Cost Effective
- Protect the Environment and Neighborhoods
- Promote Energy Efficiency and Enhance the Quality of Life
- Serve Transportation Needs in a Safe, Reliable and Economical Way
- Develop Regional Transportation Solutions that Complement the Needs of Cities and Communities
- Promote Innovative and Market-Based Transportation Strategies
- Encourage New Technologies and Support the Economy

Policies Which Might be Developed From these Goals:

- Transportation Investments Shall be Based on Performance Measures
- Transportation Investments will Mitigate Environmental Impacts to an Acceptable Level
- Implement Advanced Transportation Technology and Traveler Information Services.

These goals can be translated into objectives and performance measures upon which the transportation plan and its components are evaluated. *Examples include*:

- Average Work Trip Travel Time shall not exceed 22 minutes
- PM Peak Highway Speed shall not be less than 33 miles per hour
- Percent of PM Peak Travel in Delay shall not be greater that 33%

- Work Opportunities shall be accessible in 25 minutes for 88% of the population
- Meet Federal Air Quality Standards and Emissions Budgets
- Fatalities per Million Passenger Miles shall not be greater that 0.008
- Injury Due to Accidents shall not be greater than 0.929 per million passenger miles
- Reduce Vehicle Trips by 1.5%
- Reduce VMT by 10%
- Enhance Residential Communities and Commercial areas

Once the current setting, goals, policies, objectives, and performance measures are established, the State or region can assess the transportation problems it faces and their underlying causes.

Next, packages of projects can be developed targeted at each of the ***goals*** and should include ITS as a component of each package. Another option is to develop a set of investments which utilize ITS applications as its cornerstone. Projects may be drawn from the existing transportation plan, the TIP, and/or an ITS Strategic Plan for the region or subarea.

...decision makers should evaluate how ITS can work in concert with other investments to provide cost-effective, incremental and strategic improvements that lead to long-term system efficiencies.

What is the *Role* of ITS?

One way to look at ITS is as a communications and technology overlay on the transportation network that serves two purposes. ITS facilitates the collection of real-time information which, when passed on to customers, helps them use the system more efficiently. In addition, when information collected through ITS is provided to system operators, it helps them improve system management.

It is important that criteria used to evaluate candidate improvements be flexible enough to accommodate ITS, for which commonly used evaluative tools are not particularly helpful. Therefore, it may be necessary to use a combination of quantitative and qualitative approaches for evaluation. For example, in evaluating ITS proposals, it may be necessary to consider benefits such as improvements in operating efficiencies or management of the system. In evaluating the air quality benefits of ITS proposals, it is important to address regional air quality impacts, not only project-level impacts.

What *Kind* of ITS?

Given the many types of ITS applications, the decision maker should evaluate which ITS application makes sense for a particular local situation. An improvement may integrate an ITS component into a traditional investment or operating strategy or work in combination with other conventional approaches. Exhibit 5 at the end of this Part shows examples of how ITS addresses specific transportation issues.

Steps to Implementing the Transportation Plan

If Federal Highway Administration (FHWA) or Federal Transit Administration (FTA) funds are to be used for implementation, then such projects must be included in the plan, which is approved by the MPO or State. From the plan, the TIP will be developed and will include the first three years of projects to be implemented. The TIP must include more project detail and specificity than the plan, and projects should be ready for implementation once placed in the TIP. An agency or sponsor of a project must be identified to take responsibility for implementation and funds should be identified. Stakeholder input, including the public, is important throughout this process so that the final State or MPO-adopted plan has the political and public support needed for successful implementation.

Opportunities to Incorporate ITS Strategies into Corridor-Wide Investments

ITS alone cannot solve the transportation problems of our States and metropolitan areas, yet ITS applications can and should be an integral part of transportation projects and programs. While ITS applications may not reduce the *demand* for mobility and accessibility, ITS can provide transportation agencies and the public better information and thereby increase awareness of travel made and route options.

Systems level planning and enhanced systems management and operations are key to the changes brought about in ISTEA. Congestion Management Systems (CMS) are required in Transportation Management Areas (TMAs) and identify intermodal and multi-modal solutions to transportation problems. CMS strategies should be focused on systems-level operations and management improvements. Due to the system management attributes of ITS, all corrdier-level planning should include ITS as an integral part of the alternate investments under consideration.

EXHIBIT 5: ITS Technologies Improving Systems Operations and Management Today

The following are examples of ITS technologies that have been deployed and proven helpful in areas around the country. The examples are organized in the eleven ITS areas defined in Exhibit 1. These examples do not represent a comprehensive list, and many other organizations and jurisdictions have implemented similar programs. Readers are encouraged to review the source material for this Exhibit in order to fully understand each project, the local context in which it was implemented, and the evaluation methodology used to assess the benefits.

Multimodal Regional Traveler Information Systems

Real Time Information - Atlanta, Georgia

During the 1996 Olympics, Atlanta, Georgia braced for a massive influx of visitors. To deal with the traffic increases, the City installed "smart" cameras on the ground to monitor traffic volume and flow. Additionally, the bus systems were installed with Global Positioning Systems that allowed traffic managers to know where points of congestion were.

Travelers could get information on the status of the transportation system from k iosks, cellular phones, computers and local television. Through the Internet, commuters could view a map of major highways in the region and get real-time information on traffic conditions along those roads. This information allowed motorists to alter their routes or take alternative modes of transportation depending on highway conditions.[10]

Incident Management

Comprehensive Transportation Management Systems - San Antonio, Texas

The City of San Antonio, Texas installed a comprehensive traffic management system along 26 miles of freeway to speed up the detection and response to traffic incidents. The system uses detectors along the highways that calculate changes in speed of traffic. Video cameras placed along the highway allow traffic managers to detect problems from the traffic management center and quickly dispatch the appropriate emergency vehicle. Additionally, the data is sent to the area's traffic signal computer which draws on over 34,000 pre-programmed responses to adjust signal timing on arterials, lane control signals and message signs for commuters along the roadway.

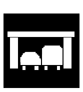
This system regulates traffic flow on arterials to keep traffic from reaching congested levels on the freeway. Changeable message signs alert motorists of a problem ahead and provide information on optional routes. According to a study by the Texas Transportation Institute, this system helped San Antonio reduce accidents by 15% and decrease police and other emergency personnel response time by 20%. These reductions are estimated to save the city $67 million over the next 20 years.[11]

Emergency Response Management

Electronic 911 Systems - Chicago, Illinois

Chicago's 911 system has been upgraded to include an electronic map of the City with a high level of detailed information including 20,000 street segments, over 20,000 alleys, the location of hydrants, and footprints of the buildings. Emergency vehicles are outfitted with automatic vehicle locators which allow a central computer system to locate the nearest emergency vehicle to the scene of an emergency and dispatch the vehicle with instructions and routing. This system has the potential to link up to databases which can provide information on the medical conditions of people who request assistance.[12]

Electronic Toll Collection



PIKEPASS - State of Oklahoma

Traffic backups at toll facilities are a congestion problem and a substantial source of air pollution. To prevent congestion around toll booths, the State of Oklahoma decided to use electronic toll collection on the State's turnpike system. Motorists can purchase a "PIKEPASS" that attaches with velcro to their dashboard and communicates via radio frequencies with a toll booth. An electronic reader at the toll booth reads the signal and automatically deducts the toll from the PIKEPASS, allowing cars to maintain freeway speeds through the toll collection area.

The State also uses technology to catch those motorists who use coin-basket lanes but do not pay the toll. A video camera records their license plate and gathers information for a letter to be sent to the offender. By using the electronic toll system, the State has reduced pollution in these areas between 27% to 70%, and has almost completely eliminated accidents around toll plazas. Additionally, the State saves $160,000 per lane annually through using automatic collection instead of a manual toll booth.[13]

Freeway Management

Freeway Management System - Houston, Texas

The TranStar system uses loop detectors embedded in the roads with closed circuit television to detect and then monitor delays on the freeways. Once a problem is detected, whether it be congestion, an incident, or more serious emergency, the transportation system can respond accordingly. A traffic center can alter signal timing on arterials to regulate traffic entering the highway, and change variable message signs to encourage motorists to divert to alternate routes. Additionally, information on the conditions of the freeways are available to commuters over the Internet, allowing them to choose alternative modes or routes if there is a high congestion level on their usual freeway route. The system is estimated to save the City $8.4 million annually through reduced delay.[14]

Transit Management

Automatic Vehicle Locator System (AVL) - Kansas City, Missouri

To improve the efficiency of their transit system, the Kansas City, Missouri transportation authority installed 160 transponder-equipped sign posts along 38 bus routes. These sign posts communicate with a transit management center and detect when a bus passes. A display appears on the bus as well, giving bus drivers an "E" if they are running early and a "L" if they are running late. If a bus continues to run early, a dispatcher may call up the bus and ask it to stop until it is back on schedule. Additionally, buses are equipped with communications equipment that allow them to respond quickly to emergencies by immediately notifying the transit management center of an incident.

This system allowed the City to increase on-time performance of buses from 78% to 95%. Part of the on-time performance improvement simply comes from letting bus drivers and dispatchers know very accurately where a bus is in its schedule. Because schedulers can monitor the actual time it takes buses to cover their routes, they are able to refine their scheduling of buses and run the buses faster. This has allowed the City to eliminate seven buses from its system without adversely affecting customers -- at a savings of $400,000 annually in operating expenses. An additional benefit has been a 10% decrease in emergency response time in crisis situations. [15]

Traffic Signal Control

Traffic Management System - Portland, Oregon

Transportation planners knew that Portland, Oregon's new 20,000 seat Rose Garden Arena would put a heavy strain on local roads and an adjacent freeway when there was an event at the facility. To respond to anticipated traffic problems around the arena, the City entered into a public-private partnership with arena owners to install ITS applications that would help manage the traffic around the arena. Video cameras were installed around the arena to monitor traffic conditions. These images are relayed to a traffic operations center, which adjusts the signal timing in the area to smooth traffic flow. This system also provides freeway monitoring capability for the State and shares information with the City of Portland.[16]

Highway Railroad Crossing Safety

Highway Railroad Crossing Safety - Los Angeles, California

Los Angeles County is improving the rail-highway and pedestrian rail-crossing systems for the Blue Line segment of the Light Rail System. This ITS system includes a number of technologies including video surveillance of crossings and intrusion detection devices. Additionally, the system uses photo enforcement for red-light or grade-crossing violations. To further prevent cars from crossing the tracks when a train is coming, the system uses traffic signal strategies to stop cars at traffic lights "upstream" from the tracks. Another part of the system equips vehicles such as buses and hazardous materials trucks with alert devices that can warn upcoming trains of these vehicles on the tracks.[17]

Electronic Fare Payment

Single Fare Card for Multiple Modes - Washington, D.C.

The Washington Metropolitan Area Transit Authority (WMATA) has been testing the "Go Card," a single farecard that a commuter can use to pay for bus rides, trips on the subway, and parking fees. The system uses a "radio-frequency proximity fare card," that a traveler places near a reader. The correct fare is then deducted from the card. This system provides simplicity and convenience for travelers, and also saves the transit agency money by reducing maintenance costs. The proximity fare card reader is less likely to have mechanical problems than contact readers where a card has to be physically run through the machine. Based on the success of the "Go Card" pilot project, WMATA plans to expand the program to the entire subway and parking system by the end of 1998.[18]

Smart Fareboxes and Employer Transit Subsidy - Phoenix, Arizona

Installing technology-equipped bus fareboxes can contribute to making the bus system operate more efficiently, making payment more convenient for passengers and reducing delays caused by passengers fumbling for change at the farebox. In Phoenix, Arizona, employers can participate in the Bus Card Plus system. The transit agency retrofitted fareboxes with reader and recording systems that allow the transit system to keep a record of commuters and bill their employers accordingly. The employers, in turn, either deduct the cost of the bus rides from the employee's paycheck, or cover part or all of the cost themselves. As an added convenience, the fareboxes accept credit cards. This system provides a simple and convenient way to pay for transit, allows employers to subsidize transit encouraging its use, and allows transit agencies to keep an accurate count of ridership. It is also easy to adjust for fare changes.[19]

Commercial Vehicle Operations Systems

Commercial Vehicle Operations (CVO) - Southwestern States

ITS applications are being used to improve freight management, improve safety and reduce traffic congestion caused by trucks. A seven-State coalition has been formed to coordinate development, management and installation of ITS/CVO technologies. These include a wide range of ITS technologies that help coordinate truck movements to and from ports and other loading facilities, to Weigh-in-Motion (WIM) technologies that prevent backups at highway inspection points.

The West Coast and Southwestern States are currently implementing a program called PREPASS. This system connects Arizona, New Mexico, Texas, Arkansas, Colorado, California, Oregon and other States, allowing trucks "pre-clearance" in each State. A truck participating in the program has a transponder on its dashboard that provides information electronically to weigh station facilities. As a truck goes down the highway at a normal speed, a reader embedded in or above the roadway identifies the truck and a computer in the weigh station verifies the truck's credentials. Additionally, a Weigh-in-Motion device embedded in the road checks the vehicle weight as it travels down the highway. If the truck passes inspection, it is given a green light to continue. If not, a light flashes indicating that the truck needs to pull over at the upcoming weigh station. This system allows a truck to clear a weigh station without slowing its speed, saving truckers valuable time, keeping highway traffic moving smoothly, and reducing emissions.[20]

Studies of such systems estimate that State agencies responsible for administering credentials and permits of trucks could save 33 to 40% in administrative costs through the electronic credentialing systems.[21]

Automated Vehicle Control and Safety Systems

MAYDAY Systems - Washington State

In cooperation with the Washington State Department of Transportation, several companies tested their Mayday systems in the Puget Sound area. Vehicles were equipped with a device with three buttons, a Global Positioning System receiver, and a cellular phone. The buttons represented either "emergency," "traveler information," or "mechanical problems." When one of these buttons was pressed, the car would be hooked up with an information center that would give directions to the traveler over the cell phone, dispatch a tow-truck or other road-side assistance vehicle, or dial 911 and connect the person with the emergency response system.

Because the "Mayday" service provider could locate exactly where the vehicle was on the roadway, it made emergency vehicle dispatching much easier. Ford, General Motors and other automobile companies are now offering these "Mayday" systems on their new vehicles. In the future these systems may send automatic 911 signals to an emergency response center if a sensor in the car detects an accident.[22]

In-Vehicle Navigation Systems - Orlando, Florida

In 1993, Orlando tested in-vehicle navigation systems that gave drivers access to information on directions to where they were going as well as the current conditions of the roadways. Users, all of whom were unfamiliar with the area, reduced their travel time by 20%, and reduced travel planning time by 80%.[23]

PART THREE - ISSUES AND CHALLENGES

While ITS technologies should be an integral component of transportation plans and programs, success in implementing ITS depends on people and institutions working to achieve common objectives. As planners and decision makers work to mainstream ITS, a number of issues and challenges must be addressed. In many of the regions that have been leading the way on ITS implementation, experience has shown that the following issues pose the greatest risk to success:

Institutional Coordination and Cooperation- This includes the need for new institutional relationships that will enable ITS to be mainstreamed into transportation systems planning, operations, funding, maintenance and management;

Technical Compatibility Between and Among ITS Projects- This includes use of the National ITS Architecture as the framework for system interoperability and agreement on standards to ensure compatibility of ITS technologies.

Human Resource Needs and Training- This includes building needed technical capacity to implement, maintain and operate ITS technologies; and,

Financial Constraints and Opportunities to Involve the Private Sector- This includes the value of marshalling private sector participation and support for ITS and ways to leverage private sector resources.

Institutional Coordination and Cooperation

Institutional coordination has emerged as a key challenge to implementation of ITS projects. Two dimensions of needed coordination are: ì the integration of operations and management strategies into transportation plans and programs, and, í multi-jurisdictional coordination and cooperation in executing these strategies and implementing projects which cross jurisdictional boundaries.

Traditionally, the development of plans and programs has focused on identifying capital improvements that, once implemented, increase the capacity of the transit or highway system. Operations and management of these improvements are straightforward. Today's emphasis on improving system operations and management requires that new stakeholders be included in developing transportation plans, and that multi-jurisdictional cooperation be enhanced.

Cooperation between agencies is critical to implementing, operating, and managing ITS technologies to their full potential. Private sector entities such as communications companies and information providers, and public agencies such as the U.S. DOT, State Departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), cities, transit agencies, and transportation management associations all have roles in working together to make ITS deployments successful.

In tailoring the framework provided in the National ITS Architecture to local needs, agencies must work together to decide what information is needed, how it will be collected and maintained, and when different agencies have access- to or control-over information.

One example of institutional coordination is where facilities can be shared among agencies to reduce costs and enhance the sharing of information and resources. Traffic Management Centers are being implemented in many regions and offer opportunities for agencies to co-locate personnel and share resources. Agreement on the funding, design, staffing, and operating protocols for such centers can be complicated and is most effective if institutional commitments are made to resolve issues early on in the planning process.

Institutional coordination is also needed on *technical* issues including agreement among agencies on their roles in the collection, sharing, maintenance and exchange of data. Examples include: sharing or distributing CCTV or video images between agencies; sharing information about accident locations; providing accurate data and schedule and route information on transit services; and providing real-time network access and status on incidents and accidents.

A good example can be found in the Houston TranStar System and how it collects and filters information that is shared among many agencies.

The Houston TranStar System uses loop detectors and closed circuit television which transmit information to the traffic management center. The centerpiece is an Automatic Vehicle Identification (AVI) System that monitors speed on the highways by noting how fast specially instrumented cars move between loop detectors. The agencies involved in TranStar have recently initiated a project to use the information gathered by this system to make planning decisions and prioritize projects based on this up-to-date and accurate information. The Houston TranStar system filters information including:

- peak travel times on segments of highway;
- traffic volumes;
- vehicle speed and occupancy;
- origin and destination of vehicles;
- entrance and exit data onto the highway system; and,

, sites of repeated accidents.

This information will be valuable in prioritizing future transportation investments by helping decision makers determine which investments will provide the most benefits given a specific transportation problem. For example, depending on vehicle loads or origin and destination information, a transit agency may want to revise the schedule or run more buses between two heavily traveled locations. Heavy traffic on specific entrances to the freeway system may warrant the implementation of traffic signal adjustments or widening of an on-ramp.

As can be seen from this example, the State DOT, transit operators, local governments and emergency services entities all have a role in data sharing and coordination and all benefit from use of some or all of this information.

In tailoring the framework provided in the National ITS Architecture to State, regional or local needs, agencies must work together to decide what information is needed, how it will be collected and maintained, and when different agencies have access- to or control- over information. This has necessitated that agencies develop solid, working relationships. Some regions have developed formal agreements to address institutional coordination issues. Because information flow and the maintenance of data and systems are central to the effectiveness of ITS, each agency -- and ultimately one or more individuals -- must take responsibility for ensuring the accuracy of information and data that is passed along to other agencies.

Regardless of the nature of agreements reached, the technical coordination and institutional cooperation needed to work through these issues involves a commitment by leadership within, those agencies involved in ITS implementation.

Technical Compatibility Between and Among ITS Projects

As States and MPOs have been implementing Field Operational Tests, the U.S. DOT has been working to ensure that national ITS issues are addressed. As discussed above, agreement on architecture helps reduce development costs. It also allows implementing agencies to work from a common foundation to design systems that are compatible and will work together.

The importance of technical compatibility and interoperability between ITS applications cannot be overstated. It is expected that, when Federal funds are used for ITS investments in the future, such investments will be required to be consistent with the National ITS Architecture and use approved standards.

Human Resource Needs and Training

Decision makers need to understand that the technical skills needed to design, construct, operate, and maintain ITS operations and management systems are, to some degree, different from those found in many State DOTs or local public works departments. In addition, since most agencies have limited operations staffs, and likewise limited ability to expand those staffs, it is important that ITS deployment provide for the improvement of the tools and skills of existing staffs.

Special training is required and programs are becoming readily available at local colleges, technical schools, in courses offered by the private sector, and through the FHWA and FTA. The U.S. DOT has made professional capacity building for ITS a high priority. FHWA, through the National Highway Institute, and FTA, through the National Transit Institute, have developed extensive training programs and are offering them throughout the country. For information, call your local FHWA Division office or FTA Regional Office or contact them through the Internet as shown in the Resource Section of this document.

Financial Constraints and Opportunities to Involve the Private Sector

In an era when funding for transportation is extremely limited compared to needs, States and regions face difficult trade-offs when contemplating ITS investments. The need to both maintain and expand the existing system puts tremendous pressure on State DOTs, MPOs and cities. In this atmosphere, decision makers need to identify the funds necessary to support a comprehensive ITS strategy. One way to achieve this is to involve the private sector.

Private sector involvement in the ITS arena is more extensive than is usually found in traditional highway and transit investments. This involvement takes a number of forms:

- Private sector as *users*: ITS applications in the area of commercial vehicle operations (CVO) and goods movement provide a direct and tangible linkage to the "bottom lines" of companies which are directly involved in, or depend on, the efficient and timely movement of freight.

- Private sector as *suppliers*: Some companies provide technical services and equipment to public agencies who are implementing ITS strategies. Other companies act as suppliers to manufacturers of consumer items (e.g., automobiles, personal computers) who are offering ITS-related features for their products in order to gain a competitive advantage in the market place.

- Private sector as *franchisees*: In some instances, private companies are awarded franchises to operate certain ITS-related applications, such as automatic toll collection or traveler information systems.

- Private sector as *information service providers*: Some companies are in the business of taking data generated by public sector ITS systems (e.g., traffic operations centers) and repackaging that information in a form that is useful to consumers or businesses. Real time traffic information is a good example of this.

By bringing in private sector partners who have a "bottom line" interest in the issue, recommended ITS policies, programs and projects have a built-in constituency to advocate for them at the policy level and in other political arenas. In addition, private sector interests with a profit motive can bring financial resources to the table as part of joint, public-private funding strategies.

In certain circumstances, such as strong interest in ITS from elected or business leaders, a strong ITS constituency may already exist. In these circumstances, it may be appropriate to give ITS special programmatic status to ensure that ITS receives continued political and funding support. Such status also helps leverage ITS investments for funding from Federal and State sources, since it is easier to make the case that the program or project in question is critical to an area's transportation future.

Another strategy is to establish the basis for cost-sharing arrangements with the private sector by developing analytic tools for estimating the public and private shares, respectively, of costs and benefits associated with a given project. By providing tools that implementing agencies can use in project planning and development, the planning agency helps to ensure that ITS considerations get some level of attention by implementing agencies. This is not a strategic approach, and system-wide functionality and connectivity may suffer in the long run. In other words, individual projects may be "ITS smart" but the system in its entirety may not be, so the whole may be less than the sum of the parts.

CONCLUSION

The implementation of ITS technologies offers tremendous opportunities to improve the operation and management of the transportation system. Yet, harnessing technology presents a whole set of new challenges to transportation decision makers. Moreover, realizing the potential of ITS requires a new way of *thinking* about the transportation system and how agencies can work together to address transportation problems.

This Guide promotes mainstreaming ITS into the planning, program, and project development processes in order to build and sustain support for ITS investments. Examples of benefits of ITS investments are provided from several different perspectives and are used to illustrate that ITS is working today in many regions that are pioneering ITS deployment.

A discussion of the planning process and an example of the typical steps in plan development are provided to show that ITS does in fact fit in with traditional investments, both in long-term plans and the development of corridor-specific approaches to transportation problems. The importance of the National ITS Architecture is discussed, and its role as the framework for statewide or regional agreement on the long-term vision for ITS. It is hoped that readers will appreciate the need to think strategically about ITS in order to ensure that systems are compatible and work together in the long term. At the same time, readers should recognize that short-term investments can and should be implemented in order to realize the benefits of ITS technologies today.

Just as advances in technology are changing the way we live and work, ITS technologies will change the way we address transportation problems. The investment of human capital to reorient our thinking about technology's role in transportation is well worth the effort. It is hoped that, as a result of this Guide, readers will have a fuller appreciation of why we should invest our energies to advance the integration of ITS into transportation plans and improve service to our customers, the American public.

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GLOSSARY

A

Arterial - A class of street serving major traffic movement that is not designated as a highway.

Advanced Traffic Management Systems (ATMS) - An array of institutional, human, hardware and software components designed to monitor, control and manage traffic on streets and highways.

Advanced Traveler Information Systems (ATIS) - Vehicle features which assist the driver with commute planning by giving accurate, real-time information on routes, road conditions, etc.

Advanced Vehicle Control Systems (AVCS) - Vehicle and/or roadway-based electromechanical and communications devices that enhance the control of vehicles by facilitating and augmenting driver performance. Of particular importance are collision avoidance or warning systems to prevent accidents.

Automated Vehicle Identification (AVI) - A system that transmits signals from an on-board tag or transponder to a roadside receiver for the automated identification of vehicles. AVI systems are used in automated toll collection, incident management, and Commercial Vehicle Operations systems, among others.

Automated Vehicle Location (AVL) - A computerized system that tracks the current location of trucks, buses, emergency vehicles etc., enabling fleet manager to coordinate activities more efficiently. AVL also is installed on vehicles to locate help located them accurately and quickly in emergencies.

B

Beacons - Short-range roadside transceivers for communicating between vehicles and the traffic management infrastructure. Common transmission technologies include microwave and infrared.

Bus Lane - A lane reserved for bus use only. Sometimes also known as a "diamond lane." See also "HOV".

C

Changeable Message Signs - Electronic signs that can change the message it displays. Often used on highways to warn and redirect traffic. Also referred to as variable or electronic message signs.

Commercial Vehicle Information Systems and Networks (CVISN) - The communications and information systems component of CVO. The national CVISN project is developing protocols to ensure the compatibility of systems that collect and exchange electronic information on commercial vehicles, including state registration, fuel-tax requirements, weight and safety inspection information, cargo-type etc. The intent is to streamline and simplify commercial vehicle application and clearance processes across the states.

Commercial Vehicle Operations (CVO) - Intelligent transportation technology applied to commercial vehicles in order to assist in the safe and efficient movement of trucks and buses. These systems use electronic screening and vehicle identification systems, advances in administrative functions automation, automated inspections and reporting, hazardous materials response and on-board monitoring.

Computer-Aided Dispatch (CAD) - Uses advanced communications to coordinate and relay information efficiently to vehicle fleets, such as transit buses, patrol cars, emergency-response vehicles and private carriers.

Conformity - Process to assess the compliance of any Federally funded or approved transportation plan, program, or project with air quality implementation plans. The conformity process is defined by the Clean Air Act.

Congestion Management System (CMS) - ISTEA requires that each Transportation Management Area (see definition of TMA) develop a CMS that provides for effective management of new and existing transportation facilities through the use of travel demand reduction and operational management strategies.

GLOSSARY

D

Demand Response - Segment of public transit designed to efficiently move persons not able to access regular, fixed transit routes. This form of transit is utilized especially for persons with disabilities and senior citizens.

E

Electronic Toll Collection (ETC) - Scanners at toll plazas read transponders on vehicles entering the facility and automatically deduct or charge toll fees. This system allows traffic to flow without stopping to pay toll fees.

Electronic Fare Payment- Systems that allow electronic debit or credit processing of transit fares.

Expressway - A controlled access, divided arterial highway for through traffic, the intersections of which are usually separated from other roadways by differing grades.

F

Federal Communications Commission (FCC) - The Federal agency which regulates telecommunications in the United States.

Federal Highway Administration (FHWA) - An agency of the U.S. Department of Transportation that funds highway planning and programs.

Federal Railroad Administration (FRA) - The agency of the U.S. Department of Transportation that funds rail planning and deployment programs.

Federal Transit Administration (FTA) - An agency of the U.S. Department of Transportation that funds transit planning and deployment programs.

Fiber (optical fiber)- A medium used to transmit information via light impulses rather than through the movement of elect rons. A single strand of optical fiber, the approximate size of a human hair, can carry thousands of digital voice conversations or data transmissions at the same time.

Financial Capacty - Refers to the ISTEA requirement that an adequate financial plan for funding and sustaining transportation improvements be part of the plan and TIP.

Freeway - A divided arterial highway designed for the unimpeded flow of large traffic volumes. Access to a freeway is rigorously controlled and intersection grade separations are required.

G

Geographic Information Systems (GIS) - Computerized data management system designed to capture store, retrieve, analyze, and report on geographic/demographic information.

Global Positioning Systems(GPS) - A system that determines the real-time position of vehicles using communications with a satellite. Also, refers more specifically to a government owned system of 24 Earth-orbiting satellites which transmit data to ground-based receivers and provides extremely accurate latitude/longitude ground positions.

H

High Occupancy Vehicles (HOVs) - Vehicles carrying two or more people. The number that constitutes an HOV for th e purposes of HOV highway lanes may be designated differently by different transportation agencies.

Highway - Term applies to roads, streets, and parkways, and also includes rights-of-way, bridges, railroad crossings, tunnels, drainage structures, signs, guard rails, and protective structures i n connection with highways.

I

Intelligent Transportation Infrastructure(ITI) - The computer, communications, and contro l sys tems required to support a variety of intelligent transportation system products and services i n urban and rural areas.

GLOSSARY

Intelligent Transportation Systems (ITS) - The application of technology to improve the efficiency and safety of transportation systems.

Intermodal -The ability to connect, and make connections between modes of transportation.

Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) - Legislative initiative by the U.S. Congress that restructured funding for transportation programs. ISTEA authorized increased levels of highway and transportation funding and an increased role for regional planning commissions/MPOs in funding decisions. The Act also requires comprehensive regional and Statewide long-term transportation plans and places an increased emphasis on public participation and transportation alternatives.

Internet - A collection of computer networks, all connected using a common set of protocols and rules on sharing and directing messages.

Interstate Highway System - The system of highways that connects the principal metropolitan areas, cities, and industrial centers of the United States. The Interstate System also connects the U.S. to internationally significant routes in Mexico and Canada.

J

Joint Program Office (JPO) - The office of the U.S. Department of Transportation established to oversee and guide the multi-modal National ITS program.

K

Kiosk - In the transportation context, an interactive computer center for traffic or travel-related information. Usually located in shopping malls, hotels, airports, businesses, and transit terminals, kiosks provide pre-recorded and real-time information using text, sound, graphics, and video clips.

L

Local Street - A street intended solely for access to adjacent properties.

Long Term - In transportation planning, refers to a time span of, generally, twenty years.

Loop Detectors - Sensors embedded below the surface of roads and highways that monitor the flow of vehicles and help authorities manage traffic and incidents.

M

Metropolitan Planning Organization (MPO) - The forum for cooperative decision making for the metropolitan planning area.

Mode - A form of transportation such as an automobile, bus or bicycle.

Multi-Modal - The availability of transportation options using different modes within a system or corridor.

N

National ITS Architecture - Establishment of a framework that defines the key elements required for ITS functions and data that must be exchanged between ITS subsystems.

National Highway System (NHS) - The transportation system designated by Congress that includes Interstate Highways and nationally significant roads for interstate travel, national defense, intermodal connections, and international commerce.

National Highway Traffic Safety Administration (NHTSA) - The agency in the U.S. Department of Transportation that is charged with overseeing transportation safety research and standards.

O

Open System - A vendor-independent computer system that is designed to interconnect with a variety of commonly available technology products.

GLOSSARY

P

Paratransit - A variety of smaller, often flexibly-scheduled and routed transportation services using low-capacity vehicles, such as vans, to operate within normal urban transit corridors or rural areas. These services usually serve the needs of persons that standard mass transit services would serve with difficulty, or not at all. Often, the patrons include the elderly and persons with disabilities.

Public Participation - The active and meaningful involvement of the public in the development of transportation plans and programs.

R

Radio-Frequency Identification (RFID) - An electronic identification method that uses radio-frequency signals to read on-vehicle tags for automated vehicle identification.

Ramp-Metering - Traffic-sensitive regulation of vehicle entry to a freeway, typically via sensor-controlled freeway-ramp stoplights.

S

Smart Card - Electronic information systems that use plastic cards (similar to credit or debit cards) to store and process information. Used in fare-payment and parking applications.

Statewide Transportation Improvement Program (STIP) - means a staged, multi year, statewide, intermodal program of transportation projects which is consistent with the statewide transportation plan and planning processes and metropolitan plans, TIPs and processes.

Statewide Transportation Plan -means the official statewide, intermodal transportation plan that is developed through the statewide transportation planning process.

T

Telecommuting - The substitution, either partially or completely, of transportation to a conventional office through the use of computer and telecommunications technologies (e.g., telephones, personal computers, modems, facsimile machines, electronic mail).

Transit - Generally refers to passenger service provided to the general public along established routes with fixed or variable schedules at published fares. Related terms include: public transit, mass transit, public transportation, urban transit and paratransit.

Transponder - Electronic device designed to store information. Electronic readers access the information stored on these devices for such functions as toll collection and trucking activities.

Transportation Control Measures (TCMs) - Actions to adjust traffic patterns or reduce vehicle use to reduce air pollutant emissions. These may include HOV lanes, provision of bicycle facilities, ridesharing, telecommuting, etc.

Transportation Demand Management (TDM) - Programs designed to reduce demand for transportation through various means such as the use of high occupancy vehicles, alternative work hours, transit and telecommuting.

Transportation Improvement Program (TIP) - This is a document prepared by metropolitan planning organizations listing projects to be funded with FHWA/FTA funds for the next one to three-year period.

Transportation Management Area (TMA) - All urbanized areas over 200,000 in population and other areas that request designation.

Transportation System Management (TSM) - The element of a TIP that proposes non-capital intensive steps toward the improvement of a transportation system, such as refinement of system and traffic management, the use of bus priority or reserved lanes, and parking strategies. It includes actions to reduce vehicle use, facilitate traffic flow, and improve internal transit management.

Transportation Research Board (TRB) - Part of the National Academy of Science, National Research Council. Serves to stimulate, correlate, and make known the findings of transportation research.

U

U.S. Department of Transportation (DOT) -The principal direct Federal funding agency for transportation facilities and programs. Includes the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), and others.

Urbanized Area - Area which contains 50,000 or more population plus incorporated surrounding areas.

V

Variable-Message Sign(VMS) - Electronic highway sign that can change the message it displays. Used with traffic-management systems. Also referred to as changeable or electronic message signs.

Vehicle Miles of Travel (VMT)- A standard area wide measure of travel activity. The most conventional VMT calculation is to multiply average length of trip by the total number of trips.

W

Weigh-in-Motion(WIM) - Technology that determines a vehicle' s weight without requiring it to stop on a scale.

Wide Area Network (WAN) - A method of connecting several computers together in a wid e geographic area using fiber optic cables.

Z

Zone - The smallest geographically designated area for analysis of transportation activity. A zone can be from one to 10 squ are miles in area. Average zone size depends on the total size of study area.

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RESOURCES

ITS on the Internet

http://www.itsa.org	The ITS America homepage offers a variety of ITS information as well as a publications database that helps the user locate useful studies, reports and other data on ITS.
http://www.odetics.com/itsarch	An Odetics website that deals with the National ITS Architecture.
http://www.jhuapl.edu/cvo/frames.html	John Hopkins Applied Physics Lab website that covers the latest ITS news and provides links to other ITS websites.
http://nahsc.volpe.dot.gov	Website of the National Automated Highway System Consortium (NAHSC), includes technology demonstrations and ITS workshops available across the country.
http://www.dot.gov/dotinfo/fhwa/its	U.S. Department of Transportation website covering ITS deployment issues.
http://www.its.dot.gov	U.S. Department of Transportation website listing links to other ITS resources on the web.
http://www.its.dot.gov/read	U.S. Department of Transportation website with a reading room on ITS technology developments.
http://www.its.dot.gov/links	U.S. Department of Transportation website covering the full range of ITS issues.
http://itsdeployment.ed.ornl.gov	U. S. DOT Federal Highways Administration (FHWA) website with a database on Intelligent Transportation Infrastructure deployment for 75 metropolitan areas.
http://www.itsonline.com	A consortia of industry groups' online magazine on ITS.
http://www.trafficworld.com	Traffic World Homepage with links to ITS-related sites, including research sites and model deployment initiatives.
http://rce.tamu.edu	U.S. Department of Transportation designated ITS Research Centers of Excellence page run by the Texas Transportation Institute with links to other Centers of Excellence and research on ITS.
http://www-path.eecs. berkeley.edu	Partners for Advanced Transit and Highways (PATH), a California-based consortium with information, research, and links on ITS.
http://www.nas.edu/trb/about/path1.html	PATH's bibliographic database on ITS, with over 13,000 records and abstracts.

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