National Intelligent Transportation Systems Program Plan: A Ten-Year Vision

Prepared by the Intelligent Transportation Society of America in cooperation with the United States Department of Transportation

January 2002

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Beyond Shock and Sorrow

DEVELOPING A PROACTIVE SURFACE TRANSPORTATION RESPONSE TO SEPTEMBER 11, 2001

>>From an early stage, the design of this Ten-Year Plan included attention to technologies to detect, report and respond to incidents, ranging from traffic crashes to large-scale natural disasters. Many of the themes included in the Plan touch on the issue. One such theme is "Automatic Crash and Incident Detection, Notification and Response" including tending to the injured, evacuating anyone at risk and returning the system to normal as rapidly as possible.

However, the events of September 11, 2001 have raised the consciousness of the transportation community, along with countless others, on the even greater need for prevention and detection, particularly in the instance of deliberate terrorist attacks.

While all terrorist attacks cannot be prevented, the technologies of Intelligent Transportation Systems can offer great promise for preventing attacks. Terrorist attacks can be minimized by threat assessment that combines objective inputs and both algorithmic and human assessment. Technologies in use today in surface transportation can be employed to make the infra-structure and the traveler more secure. Some of these technologies include smart card, biometrics identifiers, automatic vehicle location, map databases, video surveillance, vehicle classification sensors, weigh-in-motion technology, spatial geolocation and routing technologies to track the movement of trucks and transit vehicles. Technologies exist to detect the contents of vehicles, particularly hazardous substances, explosives and drugs, without opening the vehicle. Technology is available to match a specific vehicle with a specific operator and a specific cargo and to prevent travel in the absence of a match. In addition, technologies are available today to remotely control the starting and stopping of vehicles and engines.

Furthermore, should an attack occur, many of the technologies and the communication networks being used today to better manage transportation systems can be utilized to assess the extent of damage and facilitate the movement of traffic for recovery, evacuation or quarantine. Some of the current technologies include automated signal systems, signal priority systems, moveable lane barriers, variable message signs, incident detection systems, mayday systems and public safety response systems. To some degree, traffic management centers and fleet dispatch centers perform portions of this function today. Simply doing better surveillance of activities on commercial and passenger vehicles has deterrence and possibly prevention value.

The publication schedule for this first edition of the Ten-Year Plan did not permit the development of a thorough treatment of this area, although its importance is fully recognized. ITS America and U.S. DOT are now assembling the resources to address the role of ITS in maintaining and ensuring surface transportation aspects of homeland security. An update to this plan, incorporating these results will be published during the spring of 2002.

"ITS means powerful benefits in managing congestion, reducing crashes and improving the efficiency of the trucking and transit industries. Intelligent Transportation Systems have already demonstrated their value in improving mobility and safety, not only in North America but in Europe and Asia as well."

Secretary of Transportation
Norman Mineta
April, 2001

Executive Summary

THE ULTIMATE VISION FOR THE FUTURE OF ITS IS THE TRANSFORMATION OF SURFACE TRANSPORTATION INTO AN EFFECTIVELY MANAGED, WELL-INTEGRATED, UNIVERSALLY AVAILABLE AND AFFORDABLE SYSTEM. THAT SYSTEM PROVIDES FOR THE SAFE, SECURE, EFFICIENT AND ECONOMICAL MOVEMENT OF PEOPLE AND GOODS, A SYSTEM THAT ENHANCES CUSTOMER SATISFACTION AND IS COMPATIBLE WITH ENVIRONMENTAL CONCERNS.

>>Intelligent Transportation Systems (ITS) is the application of computers, communications and sensor technology to surface transportation. Used effectively, ITS opens the door to new ways of understanding, operating, expanding, refining, reconfiguring and using the transportation system. Over the past ten years, the public and private sectors have invested billions of dollars in ITS research and development and in initial deployment of the resulting products and services.

The objective of this Plan is to advance the safety, efficiency and security of the surface transportation system, provide increased access to transportation services and reduce fuel consumption and environmental impact. To accomplish these objectives, the Plan prescribes a broad set of policy, program and research activities, including necessary institutional reforms, enabled by ITS technologies.

ITS and the communications networks it provides also serves as the means by which to better detect possible problems and manage the transportation system during times of crisis, including natural disasters and security breaches. This is exemplified by the terrorist attacks of September 11, 2001, which resulted in the most significant travel restrictions ever implemented in the United States. The ability to provide timely information to travelers, as well as the ability to respond to regional crises through management of highway and public transportation systems under all conditions, is fundamental to the national role of ITS.

This Plan is built upon the ITS program foundation, in both the public and private sectors, of the past 10 years. This foundation includes ITS research, planning, deployment and operation. Major public initiatives such as the National ITS Architecture, the Standards Development program, Commercial Vehicle Information Systems and Networks (CVISN), the Metropolitan Model Deployment Initiative (MMDI), ITS deployment support, transit programs, Rural ITS, public safety activities and the Evaluation program, to name a few, have provided the groundwork upon which this National Program Plan is being built. Many of these initiatives are ongoing

efforts that support the ideas presented in this Plan and they must keep pace with the changes the next 10 years will bring. They provide vital links and guidance to integration and interoperability to realize this Plan's objectives.

Despite the progress of the last decade and the knowledge that has been accrued, we are only beginning to scratch the surface of the benefits that ITS can bring and the impact that ITS can have on the entire world of surface transportation and the interface with air and marine modes. If properly harnessed, ITS will help save lives, time and money at the same time that it improves homeland security and mobility for both people and goods.

Over the next ten years, ITS research, development and deployment will be a powerful and beneficial enabler in reshaping the ways we build, manage and use the transportation system and keep it secure. ITS will also become a major economic force in the United States and around the world, reshaping the ways in which we live and work and the ways in which we receive, use and share information.

Realizing this potential – and realizing it swiftly – depends crucially on a continued large-scale investment in ITS by both the public and private sectors and on the continued wide-spread deployment of ITS. Using ITS as a tool will help reinvent ways to look at, think about and undertake the development, management and use of vehicles and the infrastructure to meet the needs of the marketplace, our society and homeland security.

Near-term public and private sector decision-making and resource allocation will direct the ways in which ITS technologies will be developed and used. They will also direct the ways in which ITS approaches will help public and private institutions to evolve and transform to meet the transportation challenges of the years to come.

This Program Plan provides an overall vision that is both bold and reasonable; ready to undertake significant challenges, but maintaining a solid grasp on practical reality, particularly constraints on time, human resources and money. Most of the challenges which transportation faces relate less to creating new basic technology than to the need to change and update existing institutions. The industry needs to find better ways of gathering, organizing, analyzing and distributing information about the transportation system and to develop a far better understanding of the human factors of travel for drivers and other travelers in all modes.

Vision and Goals

>>The programmatic and enabling themes described below reflect a vision for the transformation of surface transportation into an effectively managed, well-integrated, universally available and affordable system that provides for the safe, secure, efficient and economical movement of people and goods, a system which enhances customer satisfaction and which is compatible with environmental concerns.

The ITS vision is to ensure that:

- Future transportation systems will be managed and operated to provide seamless, end-to-end intermodal passenger travel regardless of age, disability, or location and efficient, seamless, end-to-end intermodal freight movement.
- Public policy and private sector decision-makers will seize the opportunity to make ITS a vital driver in achieving the vision of the transportation system for the 21st century.
- Future transportation systems will be secure, customer oriented, performance driven and institutionally innovative, enabled by information from a fully integrated spectrum of computing, communications and sensor technologies.

The introduction of ITS technologies into the institutional and funding framework of surface transportation, the current and proposed transportation infrastructure and future vehicle development offers the opportunity to achieve:

- An electronic information infrastructure that works in concert with the physical infrastructure to maximize the efficiency and utility of the system and encourage modal integration and consumer choice.
- A secure system that can both detect and respond to regional crises.
- Far fewer and less severe crashes for all types of vehicles and far faster response and recovery when crashes do occur.
- Information for operators and users of the transportation system to help contain congestion and increase the effective capacity of the system while reducing the need for new construction.
- Facilities, technology and information that help reduce energy consumption and negative environmental impact.
- A vital domestic ITS industry that is able to compete effectively at home and in the international marketplace.

The National Intelligent Transportation Systems Program Plan identifies benefit areas and associated goals against which change and progress can be measured. These goals provide the guideposts for fully realizing the opportunities that ITS

technology can provide in enhancing the operation of the nation's transportation systems, in improving the quality of life for all citizens and in increasing user satisfaction, whether for business or personal travel.

Safety The goal is to reduce annual transportation-related fatalities by 15% overall by 2011, saving 5,000-7,000 lives per year.

Security The goal is a transportation system which is well-protected against attacks and responds effectively to natural and manmade threats and disasters, enabling the continued movement of people and goods even in times of crisis.

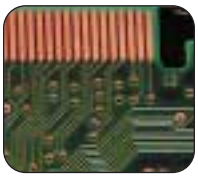
Efficiency/Economy The goal is to save at least $20 billion per year by enhancing through-put and capacity through better information, better system management and the containment of congestion by providing for the efficient end-to-end movement of people and goods, including quick, seamless intermodal transitions.

Mobility/Access The goal is universally available information that supports seamless, end-to-end travel choices for all users of the transportation system.

Energy/Environment The goal is to save a minimum of one billion gallons of gasoline each year and to reduce emissions at least in proportion to this fuel saving.

Themes

>>This Plan develops a series of programmatic and enabling themes to describe the opportunities, benefits and challenges of the transportation system of the future and activities required to realize this system.



Programmatic Themes

Programmatic themes reflect opportunities to apply technology to the problems and priorities of surface transportation. This is the traditional pursuit of ITS, but with novel approaches to addressing the high profile problems that industry stakeholders have identified. These themes include:

An Integrated Network of Transportation Information The new vision for surface transportation is based on information management and availability, connectivity and system control and optimization – in short, the creation of an integrated national network of transportation information. The information to be gathered and managed includes real-time information on the physical state of the infrastructure, how it is being built, used, maintained and kept secure, as well as its environment, including relevant weather conditions and expectations. It also

includes information about the operators and users of systems, prospectively and during travel. Realizing this vision depends on forging new partnerships within and between the public sector at all levels and the private sector in its broadest sense, including manufacturers, carriers, service providers and travelers in all modes.

Advanced Crash Avoidance Technologies ITS can help to significantly reduce the number and severity of crashes. Unprecedented levels of safety, mobility and efficiency will be made possible through the development, integration and deployment of a new generation of in-vehicle electronics, vehicle and highway automation and selective automated enforcement, including the determination of fitness to drive. This represents a major shift in emphasis from mitigating the consequences of crashes to eliminating many of them altogether and reducing the severity of many others.

Automatic Crash and Incident Detection, Notification and Response Getting emergency response teams as quickly as possible to the scene of a crash or other injury-producing incident is critical to saving lives and reducing other adverse consequences of crashes. To achieve this timely medical care, public safety providers must receive timely notice of the incident, be efficiently routed to the scene and to the hospital and be aware of and able to convey the nature and degree of the injuries. Information is also needed to minimize system disruption and to return traffic conditions to normal.

Advanced Transportation Management Advanced transportation management intelligently and adaptively manages the flow of vehicles (automobiles, commercial vehicles, public transit vehicles and trains) through the physical infrastructure, often across multiple jurisdictions and modes. Advanced transportation management relies on systems that enable area-wide surveillance and detection, rapid acquisition of traffic flow data, real-time evaluation of traffic flows, predictive capabilities regarding near-term, real-time operational responses to traffic flow changes and evaluation of the operational responses to traffic flow changes. Opportunities range from better detection and operational tools to full automation.

Enabling Themes

Enabling themes set the stage and lay the groundwork for the application of technology to surface transportation. It has often been observed that the truly difficult issues in ITS are not technical, but social, institutional and political. These themes include:

A Culture of Transportation Systems Management and Operations In the past ten years, the ITS program has been focused on technology and systems deployment. The next ten years will focus on customer service and systems performance. The demands of both the external and internal environments are

generating changes in the culture of both service providers and users. These changes imply a profound change in culture from an engineering-dominated environment to multidisciplinary staffing; from fragmented jurisdictions to high levels of cooperation; from focus on speed and capacity to a focus on reliability and information; from independent vehicles and infrastructure to a new level of coupling; from a modal focus to a multimodal approach; from arms-length public and private sectors to new forms of cooperation; and from reactive to proactive support of public safety operators.

Public Sector Roles, Relationships and Funding While public funding for ITS projects continues to grow and ITS continues to be adopted throughout the United States, the widespread deployment of ITS depends on mainstreaming ITS into the basic funding/planning process and seeking creative alternative funding mechanisms. Over the next decade, increased funding for ITS programs needs to be available to plan and deploy new systems, to support operations of those systems and to hire and train the skilled personnel to manage the systems. Federal, state and local governments will provide much of this funding through traditional resources such as the Highway Trust Fund. However, innovative finance techniques including direct funding and user incentives, as well as private sector initiatives will play an important role.

Federal Policies and Initiatives to Achieve Extensive Private Sector Product Deployment The private sector plays a major role in developing and delivering advanced transportation services and in providing access to the social and economic benefits of these systems to all users, including state and local governments, public and private transportation system operators, other businesses and consumers.

Private sector organizations recognize both the economic opportunity provided by a robust market and the social opportunity to enhance the well-being of citizens. However, for these opportunities to be realized, improvements in public-private cooperation are needed. Traditional business-government relationships need to be redefined to enhance private sector opportunities in the commercial marketplace.

Governments need to help accelerate deployment by encouraging and endorsing the sale of appropriate products and services, providing access to data and services, providing market incentives to users and removing barriers that impede private sector participation.

Human Factors While the new information opportunities that ITS creates are clearly valuable – in many cases essential – the sheer volume of information can create potential problems: overload, distraction and confusion. This applies to both users of the transportation system – commercial and private drivers, pedestrians, cyclists, public transit and rail passengers – and to the people who operate the system, including personnel at transportation management and control centers and

incident response centers. Human factors does not only mean avoiding overload; it means delivering information in the most effective, most timely way and constructing controls – both in vehicles and at centers – which are intuitive, consistent and easy to use correctly. Understanding human factors is a fundamental key to the effective delivery of the benefits of ITS.

Major Stakeholders

>>Over a dozen major stakeholders are identified and called on to contribute to the realization of this Plan. Most of these stakeholders fall into one of three macro-level stakeholder groups:

The Public Sector

The Public Sector includes government agencies at all levels that have responsibility for planning, building, maintaining, regulating, operating, overseeing and in many cases funding the transportation system, particularly the roadway infrastructure and public transportation. This includes those governmental agencies that must use the infrastructure to accomplish their responsibilities (e.g., public safety for traffic control and the U.S. Department of Defense in Washington, D.C.). The overriding responsibility of the public sector is to look out for the public good, namely, to ensure that the transportation system serves the widest possible constituency effectively and safely, impacts the environment as little as possible and fosters a robust and productive transportation industry. Government's regulatory role and the magnitude of the funds it controls gives the public sector enormous power for setting directions and for making programs happen (or not happen).

At the same time, the public sector is not monolithic. It is composed of thousands of agencies at multiple levels, each with its own constituencies and immediate problems to address. This Plan encourages both coordination and flexibility, working with one another and with the private sector to pursue common goals and realize the vision. For the most part, this Plan encourages the public sector to let the private sector develop and deploy as much of ITS as it reasonably can and to focus public sector resources on updating and transforming public institutions, managing and updating the infrastructure, spearheading high-risk/high-reward research and safeguarding the public infrastructure.

It also encourages the public sector to be early adopters of ITS technologies where these technologies have clear promise for saving lives, time and money.

The Private Sector

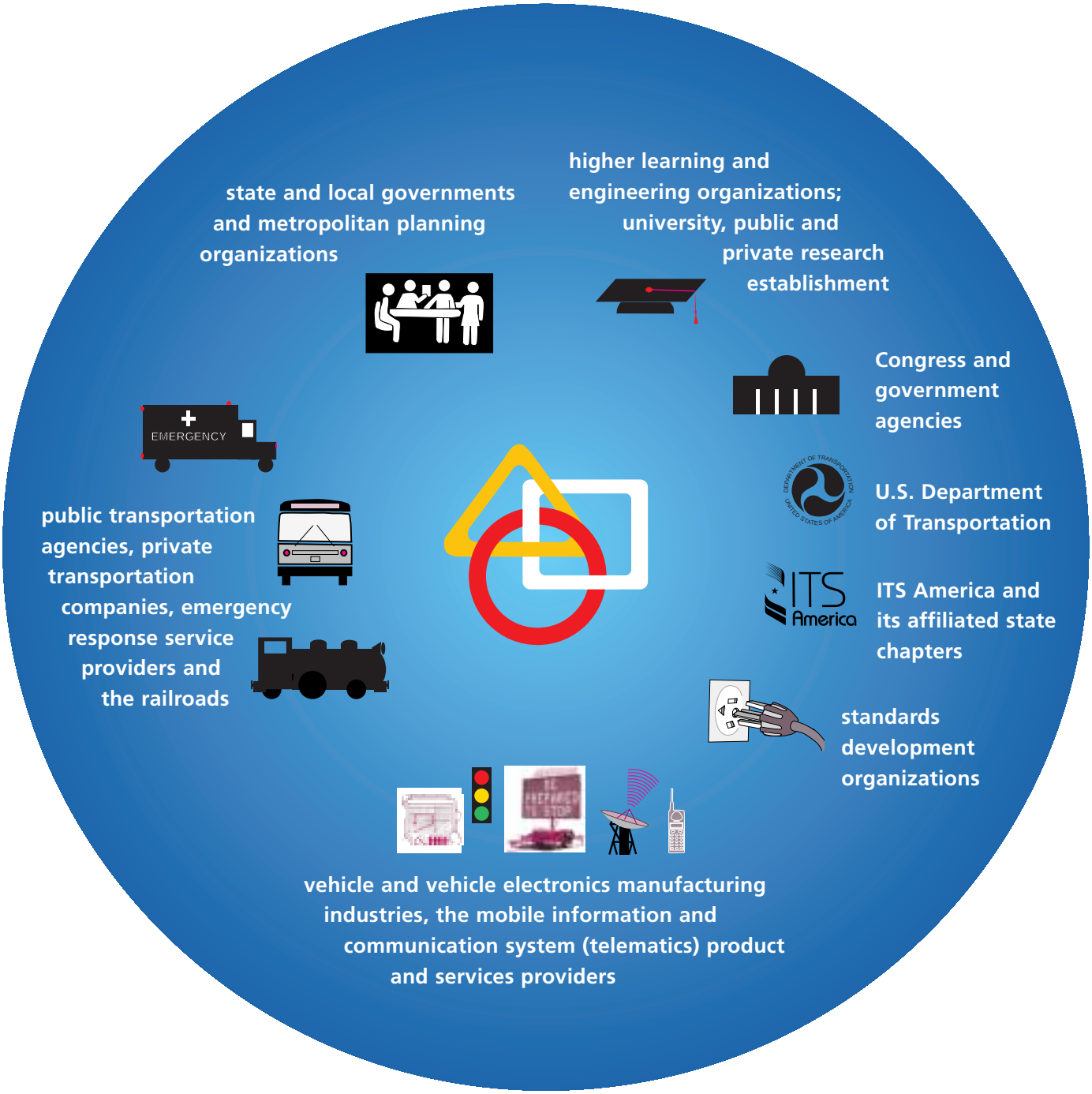
The private sector's primary responsibility is to create and deliver systems, products and services to business, government and consumers. In each case the business model is different. However, if the markets are robust, there is sufficient motivation for the private sector to produce the stream of valuable goods and services that have made the United States the world leader in ITS development.

In addition, there are a number of ITS areas (most notably emergency notification and traveler information) where the private sector is filling niches that had previously been assumed to require a public sector presence.

This Plan encourages a high level of cooperation and a deeper and more interactive relationship between the private and public sectors. It encourages initiatives and incentives that will enhance the acceleration of ITS use by consumers and operators of transportation systems. It encourages the public sector to help remove obstacles.

The Universities

The universities are responsible for carrying out a significant portion of ITS research. However, this Plan identifies a far more important and far-reaching responsibility. That responsibility is to reinvent the transportation profession for the 21st century to meet the challenges that a new focus on customer-oriented, performance-driven operations will present. A new curriculum is needed that not only pays attention to traditional arts and practices, which will clearly continue to be needed, but which adds new focuses on operations management; systems, software and communications; and the new relationships that are being forged by fluid jurisdictional boundaries, wireless communications and new demands for mobility, security and access.



Major Stakeholders

Stakeholder Roles

This Plan calls on all government agencies to:

- Lead by example and help jump start the market by specifying the inclusion in the government fleets of ITS products that enhance safety, security, efficiency and economy and by creating incentives for state and local public agencies and for companies operating van pools to do the same.

This Plan calls on state and local governments and metropolitan planning organizations to:

- Shift the emphasis of infrastructure management from construction projects to customer-responsive systems performance.
- Work together to create new cross-jurisdictional cooperation (virtual organizations) to manage the transportation infrastructure.
- Initiate ITS programs that will provide the tools to monitor, assess and respond to regional crises and disasters.

This Plan calls on the U.S. Department of Transportation to:

- Fund and oversee a comprehensive, integrated basic and applied research program.
- Support the development of ITS-related security requirements.
- Fund and oversee an Integrated Network of Transportation Information.
- Develop programs to provide incentives to encourage deployment of ITS products and services.

This Plan calls on Congress to:

- Provide the funding necessary for successful ITS research and deployment.
- Initiate a funding program to provide incentives to support ITS deployment and performance-based, customer-oriented infrastructure.
- Initiate revisions to current federal law and regulations that inhibit private sector opportunity.

This Plan calls on public transportation agencies, private transportation companies, emergency response service providers and the railroads to:

- Seek opportunities to deploy ITS technologies where they can save lives, time and money and provide homeland security.
- Participate in the definition and development of the Integrated Network of Transportation Information.
- Support development of technologies that foster seamless, end-to-end travel among the transit modes and between transit and auto users.

This Plan calls on the vehicle and vehicle electronics manufacturing industries, the mobile information and communication system (telematics) products and services providers and the motor carrier industry to:

- Strengthen and coordinate fundamental research on driver behavior and the safe, effective integration of mobile information and communications systems (telematics) as well as advanced safety systems in the vehicle.
- Work with the U.S. Departments of Transportation, Energy, Commerce, Defense and Justice and with the National Science Foundation to find new modes of creative cooperation for funding and conducting pre-competitive ITS research.
- Participate in the definition and development of the Integrated Network of Transportation Information and put it to effective use.

This Plan calls on institutions of higher learning and accrediting bodies, working in conjunction with the engineering organizations to:

- Reconfigure the curriculum for transportation-related engineers, managers and other professionals to incorporate and exploit new approaches and technologies for building and operating the transportation infrastructure.

This Plan calls on university, public and private research establishments to:

- Participate in the development of new models for funding and conducting transportation research related to technology development and deployment, human factors, institutional renewal and transformation and public policy.

This Plan calls on ITS America and its affiliated state chapters to provide the leadership and structure to:

- Be the advocate for advanced technology in current and future transportation.
- Provide a private-public forum under which all ITS public and private sector interests can come together to advance mutual interests and resolve conflicts.
- Continue to advise U.S. DOT on critical policy and program issues.
- Facilitate the development of the Integrated Network of Transportation Information.

This Plan calls on standards development organizations to:

- Continue their focus on the definition of standard interfaces, data formats and communications protocols to promote the national integration and interoperability of ITS technology.

"Railroads cannot any longer just think railroads, they must think highways and airways. Trucks cannot just think about highways, but must also think about creating and maintaining deepwater ports. We have the technology to bring our separate transportation infrastructures together to create true intermodalism. This is where ITS is so important."

Secretary of Transportation
Norman Mineta
April, 2001

Introduction

"THE INFORMATION REVOLUTION WILL ULTIMATELY BE AS IMPORTANT TO TRANSPORTATION AS THE INVENTION OF THE AUTOMOBILE AND JET ENGINE. AND THOUGH THE COURSE OF THIS REVOLUTION IS NOT CLEAR, IT IS PROVIDING UNPRECEDENTED OPPORTUNITIES TO DEVELOP AN INTEGRATED NATIONAL TRANSPORTATION SYSTEM THAT WILL IMPROVE SAFETY AND MOBILITY OF PEOPLE AND GOODS WHILE REDUCING ITS IMPACT ON THE ENVIRONMENT AND ENERGY CONSUMPTION."

Vision 2050—An Integrated National Transportation System,
Federal Transportation Advisory Group, February 2001

Technology and Society

>>There are few aspects of modern American society which have not been profoundly affected over the past ten years by the proliferation of low-cost computing power, widely available wireless communications and the advent of the Internet. We have rapidly gotten used to shopping for books, music and clothing online and to doing our banking, our stock trades, our bill paying, our correspondence, our budgets, our home photograph albums and our schoolwork on the computers which are now present in the majority of American homes and almost every business.

We have become a connected society, with vast arrays of information at our fingertips and the ability to instantly reach our friends and family wherever they are by cell phone, e-mail and instant messages. Information technologies have become well imbedded in nearly all of our everyday activities, serving as a tool to enable the efficient delivery of improved services.

Technology and Transportation

>>Many similar opportunities exist within the transportation sector. Intelligent Transportation Systems (ITS) encompasses the technologies that can lead to:

- Enhanced management and operations of the existing highway, public transportation and railroad infrastructure, to ease congestion and respond to crises.

- Safer and more comfortable travel.
- Safer and more efficient goods movement.

ITS is the application of computers, communications and sensors to surface transportation. Used effectively, ITS produces a greater understanding of surface transportation and how it can be transformed to meet the challenges of the future. ITS opens the door to whole new ways of understanding, operating, expanding, refining, reconfiguring and using surface transportation.

Over the past ten years, the public and private sectors have invested billions of dollars in ITS research and development and in initial deployments of the resulting products and services. Many of these initial deployments, in the infrastructure and in vehicles of all kinds, have already demonstrated their value, by allowing improvements such as the following:

- Allowing better, more efficient use of the infrastructure.
- Providing travelers with information to better plan and schedule their trips using a variety of travel modes.
- Reducing the number and severity of crashes for all kinds of vehicles.
- Enhancing the ability to respond swiftly to incidents when they occur, to provide better, faster care for the injured and to clear disruptions more rapidly off the roadways.
- Helping to keep traffic flowing by mitigating congestion, reducing crashes and by automating toll collection and elements of commercial vehicle safety and border checks.
- Reducing administrative costs for vehicle registration, fuel tax collections and permitting for both motor carriers and state regulatory agencies.

ITS also serves as a means to better manage transportation during times of crisis, including natural disasters and security breaches. This is exemplified by the terrorist attacks of September 11, 2001, which resulted in the most significant travel restrictions ever implemented in the United States. Restrictions on ground travel in New York, the mass evacuations of central business districts and several days of airport closures nationwide forced citizens in general to consider the importance of managing and operating the nation's surface transportation system. The ability to detect impending crises and to provide timely information to travelers, as well as to monitor and manage traffic and public transportation services under all conditions, is fundamental to the national role of ITS in the new, less certain environment.

Despite the progress of the last decade and the knowledge that has been accrued, we are only beginning to scratch the surface of the benefits that ITS can bring and the impact that ITS can have on the entire world of surface transportation and its interfaces with air and marine modes. ITS can help to reinforce and accelerate the transformation toward performance-oriented operations that is already under way.

Based on the experience of the past ten years and the advances in technology that have occurred during that time, ITS is positioned to be a major force in this transformation of surface transportation. At unprecedented levels, ITS will help save lives, time and money at the same time that it improves mobility and security for both people and goods.

Over the next ten years ITS research, development and deployment will be a powerful and beneficial enabler in reshaping the ways we build, manage and use the transportation system and keep it secure. ITS will also become a major economic force in the United States and around the world, reshaping as well the ways in which we live and work and the ways in which we receive, use and share information. However, the United States must move expeditiously to stay at the forefront of ITS, or risk losing much of the market to off-shore competitors.

Realizing this potential – and in particular, realizing it swiftly – depends crucially on a continued large-scale investment in ITS by both the public and private sectors and on the continued wide-spread deployment of ITS. "Deployment" does not merely mean instrumenting more roads, vehicles and transit stops, but using ITS as a tool to help reinvent the ways we look at, think about and undertake the development, management and use of vehicles and the infrastructure to meet the needs of the marketplace, our society and homeland security.

Furthermore, meeting the needs of the next generation of transportation system users and customers requires a comprehensive transformation of the fundamental institutions that plan, own, operate and fund transportation. The institutional focus must change from infrastructure construction and maintenance to user-driven, performance-based operations and systems management. The way these institutions operate, organize and interact, both with one another and with the traveling public, needs to be reexamined. It is important to refocus:

- The manner in which infrastructure management is funded.
- The incentive structure which sets transportation priorities.
- The ways in which transportation professionals are educated, oriented and employed.
- The mechanisms through which planning is done.
- The ways in which planning, operating and enforcement jurisdictions are organized.

Moving to a more secure, operations-based and performance-oriented approach to transportation service delivery poses a variety of opportunities and challenges – technological, institutional, political, cultural and financial. ITS becomes the enabler for meeting these opportunities and addressing these challenges.

Near-term public and private sector decision making and resource allocation will direct the ways in which ITS technologies will be developed and used. They will

also direct the ways in which ITS approaches will help public and private institutions to evolve and transform to meet the transportation challenges of the years to come.

This Program Plan states the urgency of and points the way for creating:

- New and transformed transportation institutions.
- New approaches for pursuing transportation goals including increased security and mobility.
- New mechanisms for conducting transportation-related research and exploiting its results.

The Plan provides an overall vision that is both bold and reasonable: ready to undertake significant challenges, but maintaining a grasp on practical constraints on time, human resources and money.

From the current vantage point, realizing the benefits of ITS does not require any fundamental breakthroughs of science or technology. We confidently expect that computers will continue to get faster, cheaper and more capable without any special intervention by transportation interests. We similarly expect that voice and data communications, through wires and fiber, through the air and via the Internet will continue to become more flexible, operate through broader bands, move at higher speed and become less expensive through non-transportation mechanisms in the economy, which are already largely in place. However, ensuring that all these elements come together in support of the ITS opportunity will require a definite and focused set of actions. It will be a challenge to provide for both protection and response in times of national crises as well as improved day-to-day operations.

Most of the challenges which transportation faces relate less to creating new basic technology than to the need to change and update existing institutions and the need to change deep-seated habits and attitudes. The industry needs to find better ways of gathering, organizing, analyzing and distributing information about the transportation system and to develop a far better understanding of the human factors of travel for drivers and other travelers. It needs to eliminate communications barriers between people, between companies and agencies and between interrelated systems in order to provide secure, seamless, end-to-end movement of people and freight. In addition, the ability to act upon and disseminate information rapidly in times of crisis or when supporting infrastructure is impacted will be crucial. Even so, there is much research and development to be done to devise sensible, appropriate and innovative ways of applying and combining technologies to achieve our particular goals. ITS will be a key to making this happen.

The Two Stages of Automation

>>The application of computers and communications to complex systems like transportation generally moves through two major stages.

The first stage mainly applies technology to specific tasks, but without changing their character or basic sequence. We essentially substitute computers for labor and ledgers: automate manual activities, using computers and communications to speed up the execution of traditional tasks, increase their reliability and lower their cost. This first stage generally provides enough savings of time and money to be worthwhile, but its real value is in laying the groundwork for making fundamental changes to the way we conduct business. Once the message has been separated from the medium and the essence of the tasks has been separated from the physical mechanisms traditionally used to pursue them, the fundamental underlying logical characteristics of the work begin to emerge and it becomes amenable to in-depth restructuring.

In the second stage, entirely new approaches to solving problems and conducting business begin to appear because they are no longer tied to or hidden behind inherited physical workstations and paper flows. We gain the ability to see through tasks to find completely new ways of thinking about our problems and achieving our goals.

EXAMPLES FROM OTHER INDUSTRIES

In the banking world, stage one replaced manual ledgers and mechanical accounting machines with computer transactions and magnetic tape. Stage two introduced electronic funds transfer, national and international networks of ATM machines and online, paperless banking.

■ ■ ■

In the design of computer chips, stage one automation helped to keep track of designs and to automate masking and testing, but without major changes to work flow. In stage two, chip development moved to world wide networks, with various tasks being handled by facilities and laboratories scattered around the world, with workflow moving electronically rather than physically and many formerly sequential activities now able to be done in parallel.

Applicability to ITS — What Has Been Accomplished in Stage One

Most of ITS' first ten years falls into Stage One of automation. Technology has been used to improve the ways we traditionally did things.

- Traffic Management Centers have been created in two-thirds of the 75 largest metropolitan areas, monitoring freeway traffic and providing early notification of incidents.
- Traffic signals and ramp meters have been tuned to improve traffic flow and safety.
- Travel information is more readily available to the public to assist in their travel planning and decision-making.
- Electronic toll collection has been installed on 70% of existing toll road mileage and over ten million toll tags have been issued in North America. Non-toll electronic payment applications have begun to appear.
- Thirty states have begun using transponders and roadside computers to screen safe and compliant commercial vehicles past weigh stations and other roadside facilities at up to mainline speeds and nearly 7,000 motor carrier fleets participate in these programs.

ITS EXAMPLE: ELECTRONIC TOLL COLLECTION

The first generation of electronic toll collection, now essentially complete, basically substituted wireless electronic toll collectors for the human toll collectors and mechanical coin baskets of the past forty years, but still collected fixed tariffs at fixed points on the roadway.

Now that this first stage is complete, additional degrees of freedom begin to appear. We are able to see that wireless toll collection offers the promise of flexible tariffs that can vary by time, level of congestion and/or a variety of other policy-driven variables to help maximize traffic flow, level loads and maximize revenues.

In stage two, toll collection expands from simply being an alternative mechanism for paying for road construction to an instrument of public travel policy and transportation management. In addition, toll collection technology becomes the basis for a wide variety of modest-sized electronic payments, including parking and fast-food drive-throughs.

- Public transit systems have installed satellite-based, computer-aided dispatch systems that provide more effective and safer service to the public and provide desired information to make informed choices and provide greater customer satisfaction.
- Ride-matching services have been automated and connected to the Internet.
- In-vehicle electronics improve vehicle handling, summon help in emergencies and provide good driving directions.
- The number of driving-related fatalities and injuries have decreased relative to vehicle miles traveled.
- The private sector is providing traveler information services that were previously thought to be exclusively a public sector responsibility.

While significant progress has been made, it has been made incrementally.

The Challenges for ITS in Stage Two

Stage One will continue for many years, as additional areas of transportation begin to engage the new technologies. However, while Stage One continues to unfold, a Stage Two revolution is beginning, whose foundations were laid over the past ten years and many of whose initial aspects are already underway. The industry has begun the work of understanding the fundamental nature of driving and of driver/operator behavior in all transportation modes. The process has started to move the focus of the public sector from construction projects to customer-driven operations. Public transportation systems are adopting new technologies to provide a more attractive travel alternative to a large portion of the traveling population. These include bus, commuter rail and light and heavy rail systems. Freight systems are beginning to coordinate services across modes and provide integrated, flexible, door-to-door service from shipper to receiver. The need has been recognized to develop the data and the tools to genuinely understand and effectively control the transportation infrastructure. The long-sought ability to prevent crashes in large numbers as well as mitigate their consequences is being realized. Vehicles are being connected into telematics networks; this capability is ready to be deployed in volume.

But moving from start-up to ongoing operations requires a plan and requires a commitment. It requires consolidating and understanding the accomplishments of the past ten years. It requires priorities, funding and human resources. It requires establishing incentives to encourage the acceptance of new ways of thinking and doing business. This Plan provides the roadmap to accomplish these goals and it seeks the commitment, from Congress, from the federal, state and local transportation agencies, from all sectors of private industry, from the transportation profession and from the research community to move the Plan forward.

Just as the proliferation of computers and communications has transformed and enhanced everyday business and personal life, ITS has the potential to be a transforming force for transportation. If properly guided, ITS will help meet the need for safe, secure, efficient and accessible transportation by facilitating constructive change. It will greatly improve the ways that the transportation infrastructure is managed and the ways in which vehicles interact with the infrastructure, with their operators and with the environment.

Purpose of This Plan

>>The purpose of this Plan is to advance the safety, security and efficiency of the surface transportation system, provide better detection and response in times of national crisis, provide increased access to transportation services and reduce fuel consumption and environmental impact. To accomplish these objectives, the Plan prescribes a broad set of policy, program and research activities, including necessary institutional reforms, enabled by ITS technologies. The execution of these activities will result in a robust and competitive domestic ITS industry and in the multimodal integration of systems and system elements:

- Transportation *facilities and infrastructures* that are effectively managed under all conditions, integrated, performance-oriented and driven by customer needs.
- Safe, well-integrated *vehicle* technology in passenger cars, transit vehicles, public safety vehicles, commercial vehicles, small trucks and vans and roadway construction and maintenance vehicles.
- High-quality, high-relevance *information* that facilitates integration of vehicle and infrastructure for all customers of the transportation system and allows quick response during crisis situations.

It will also result in a traveling public that is more informed and better qualified and better able to cope in times of emergency. Drivers and commercial vehicle operators will be better equipped and better qualified to drive safely. Travelers will be better informed to make better travel choices.

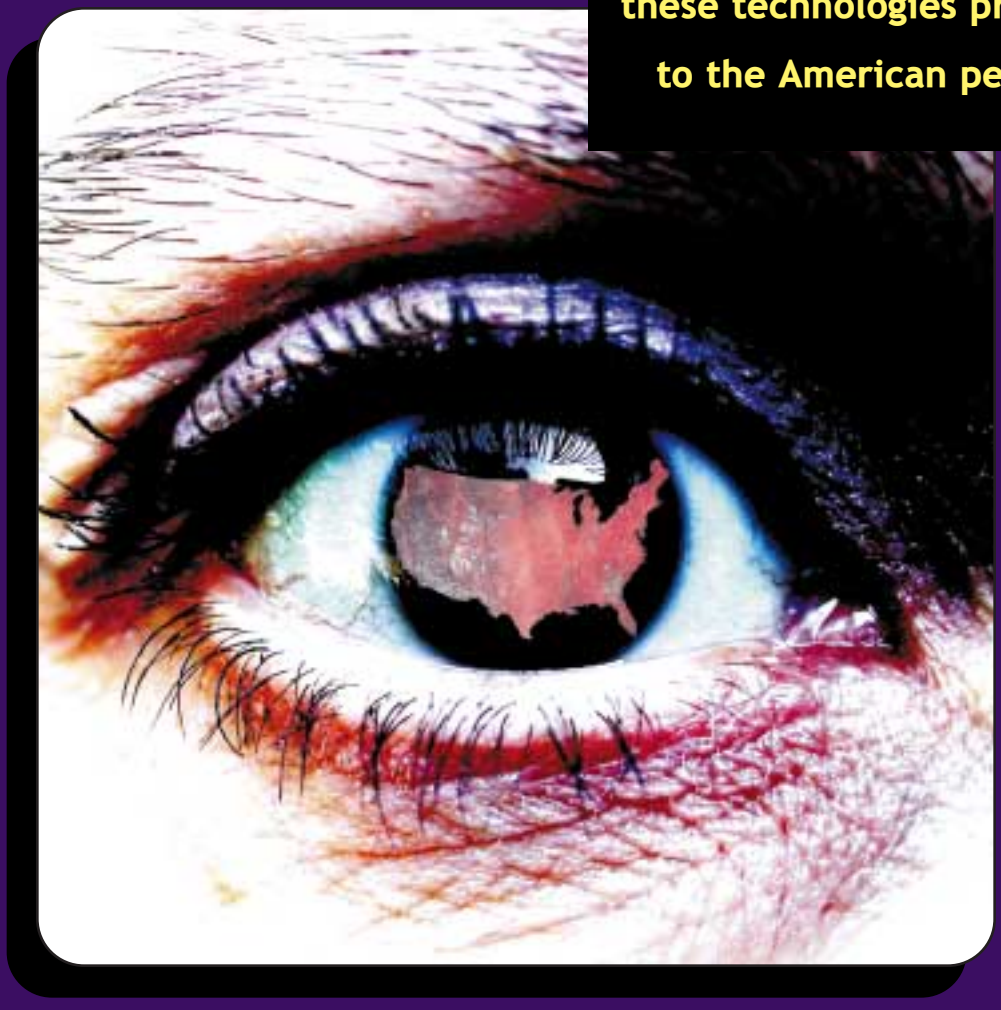
This Plan is built upon the ITS program foundation, in both the public and private sectors, of the past 10 years. This foundation includes ITS research, planning, deployment and operation. Major public initiatives such as the National ITS Architecture, the Standards Development program, Commercial Vehicle Information Systems and Networks (CVISN), the Metropolitan Model Deployment Initiative (MMDI), ITS deployment support, transit programs, Rural ITS, public safety activities and the Evaluation program, to name a few, have provided the groundwork upon which this Program Plan is being built. Many of these initiatives are ongoing efforts that support the ideas presented in this Plan and they must keep pace with the changes the next ten years bring. They provide vital links and guidance to integration and interoperability to realize this Plan's objectives.

"I found the in-vehicle navigation system in my rental car very easy to use. The turn-by-turn voice instructions were nice and it quickly guided me to each of my destinations. The dash mounted display and the emergency road-side assistance 'Locate Button' were also nice to have on-board while traveling through unfamil-iar areas."

An 18-wheeler traveling west on Interstate 84 toward the Oregon Farewell Bend Port of Entry, located near the Idaho border, passes over a weigh-in-motion scale, past roadside over-height detectors and under an automatic vehicle identification reader. Over 70,000 trucks each month are successfully pre-clearing Oregon Green Light equipped weigh stations.

Emergency response time is reduced and location of accident can be pinpointed with global positioning, even if driver is unable to report.

An effective program of precompetitive research by the private sector and deployment leadership by the public sector will help to put American industry at the forefront of these life saving technologies... and bring the benefits of these technologies promptly to the American people.



Vision and Goals

CHANGE AND PROGRESS CAN BE MEASURED. ITS TECHNOLOGY CAN ENHANCE THE OPERATION OF THE NATION'S TRANSPORTATION SYSTEMS, IMPROVE THE QUALITY OF LIFE FOR ALL CITIZENS AND INCREASE USER SATISFACTION, WHETHER FOR BUSINESS OR PERSONAL TRAVEL. BENEFITS INCLUDE SAFETY, SECURITY, EFFICIENCY, ECONOMY, MOBILITY AND IMPROVED ENVIRONMENT.

Vision

The ITS vision is to ensure that:

- Future transportation systems will be managed and operated to provide seamless, end-to-end intermodal passenger travel regardless of traveler age, disability, or location and efficient, seamless, end-to-end intermodal freight movement.
- Public policy and private sector decision makers will seize the opportunity to make ITS a vital driver in achieving the vision of the transportation system for the 21st century.
- Future transportation systems will be secure, customer-oriented, performance-driven, responsive in times of crisis and institutionally innovative, enabled by information from a fully integrated spectrum of computing, communications and sensor technologies.

The introduction of ITS technologies into the institutional and funding framework of surface transportation, the current and proposed transportation infrastructure and future vehicle development offers the opportunity to achieve:

- An electronic information infrastructure that works in concert with the physical infrastructure to maximize the efficiency and utility of the system and encourage modal integration and consumer choice.
- A secure system that can both detect and respond to regional crises.
- Far fewer and less severe crashes for all types of vehicles and far faster response when crashes do occur.
- Information for operators and users of the transportation system to help contain congestion and increase the effective capacity of the system while reducing the need for new construction.

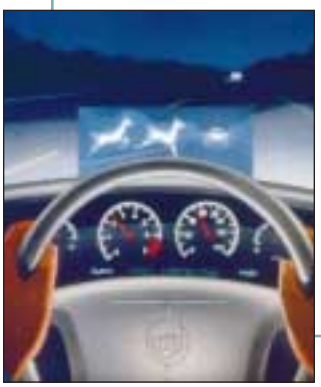
- Facilities, technology and information that help reduce energy consumption and negative environmental impact.
- A vital domestic ITS industry that is able to compete effectively at home and in the international marketplace.

Goals

>>This Plan identifies five benefit areas and associated goals against which change and progress can be measured. These goals provide the guideposts for fully realizing the opportunities that ITS technology can provide in enhancing the operation of the nation's transportation systems, in improving the quality of life for all citizens and in increasing user satisfaction, whether for business or personal travel.

Safety

A nighttime scene from the driver's point of view, with Cadillac's Night Vision technology.



ITS presents the opportunity to save thousands of lives and billions of dollars in property and prevent millions of injuries and untold productivity losses through improvements such as:

- Preventing crashes in large numbers through technology that improves the performance of drivers, vehicles and the infrastructure.
- Reducing the severity of crashes that do occur and mitigating their consequences through improved, sensor-based injury-reducing technology in vehicles and by enabling surer and swifter responses by emergency services.
- Identifying and influencing the behavior of high-risk commercial drivers; identifying high-risk carriers and working with them to improve their safety management processes.
- Encouraging safe and responsible behavior through automated enforcement.
- Enabling communication and cooperation between vehicles and the infrastructure, to allow vehicle performance to adapt to changing traffic patterns, weather conditions and topographic features.
- Connecting vehicles, vehicle operators, travelers, public safety agencies and the infrastructure through an integrated network of transportation and environmental information and applying information to enhance safety management by both the public and private sectors.
- Helping to keep transportation safe from terrorist attacks.

An effective safety program of pre-competitive cooperative research and deployment leadership will help to put American industry at the forefront of these lifesaving technologies, assuring that domestic requirements are thoroughly met and bringing the benefits of these technologies promptly to the American people.

The goal is to reduce annual transportation-related fatalities by 15% overall by 2011, saving 5,000-7,000 lives per year.

Security

ITS provides tools and enhanced opportunities to help safeguard the transportation system against a variety of threats, both natural and manmade and to react swiftly and responsively in case of disruptions, by:

- Providing commercial vehicle operations surveillance, matching cargo against bills of lading, matching routing against intended destination and providing commercial operator verification.
- Providing surveillance and analysis technology for public transit, including passengers, operators and route/schedule adherence.
- Providing surveillance and detection at major transportation centers.
- Providing tools for infrastructure surveillance and the intelligent computer-assisted analysis of raw surveillance data to detect and prevent potential threats.
- Providing software safeguards against inadvertent or deliberate incursions into transportation systems and their information networks.
- Helping infrastructure managers track the performance of the system, including identifying and assessing breakdowns from whatever cause.
- Providing the logistical and communications tools to enhance existing systems to enable swift and appropriate responses to system disruptions, rescue the injured, clear guideways, smoothly reroute travel to available alternatives and restore services as promptly as possible.
- Helping to coordinate transportation agency support of law enforcement, defense, emergency response and security organizations.
- Helping to assure that vehicle and drivers licenses, particularly commercial licenses, are issued appropriately.
- Providing the public with prompt and accurate information on transportation alternatives in case of disruptions to portions of the system or when quarantine or evacuation is necessary.

The goal is a transportation system that is well-protected against attacks and responds effectively to natural and manmade threats and disasters, enabling the continued movement of people and goods even in times of crisis.

Efficiency/Economy

Electronic credentialing reduces up to 75% of the current costs for credentials administration for both states and motor carriers; potential cost savings of $20 per processed credential (preliminary estimates from systems deployed in Kentucky).

ITS provides the means to save large amounts of time and money by more effectively and economically moving people and goods throughout the transportation system. Beyond reducing the delays and the property and healthcare costs related to crashes, ITS will provide infrastructure management tools and information for both operators and users of the transportation system, that will enhance efficiency and economy by making improvements such as:

- Delivering faster, more accurate and comprehensive travel information via more media to more users to enable decision making on whether to make a trip, when to start and what modes of transportation to use.
- Providing information management tools to better manage the infrastructure, increasing its effective capacity and throughput.
- Providing information management tools to facilitate the effective use of new construction techniques and materials and to monitor the condition of guideways, bridges, stations, terminals, tunnels and pedestrian crosswalks to economically guide maintenance and repair of the infrastructure, prolong its life and moderate the need for its expansion and replacement.
- Tracking and providing more transparent interchange of information about shipments, containers, trucks, trains and freight cars through checkpoints and at and between terminals, shipping points and arrival points, thereby enabling more reliable and timely freight movement and management.
- Reducing administrative and regulatory costs for public agencies and commercial vehicle operators.
- Promoting automated infrastructure-vehicle cooperation to optimize both individual trips and overall system throughput.

The goal is to save at least $20 billion per year by enhancing throughput and capacity through better information, better system management and the containment of congestion by providing for the efficient end-to-end movement of people and goods, including quick, seamless intermodal transitions.

Mobility/Access

ITS provides travel opportunities and additional travel choices over more modes for more users – wherever they live, work and play – regardless of age or disability by:

- Providing better, faster information for both users and operators of the transportation system to open new employment and recreation opportunities and help make travel time more productive.
- Providing necessary information in times of regional crisis – natural or manmade – to maintain mobility.

- Providing information on available services to the public to help make public transportation more innovative and flexible, offering more and better travel services to the elderly, the disabled and non-drivers in both urban and rural settings.
- Helping to inform infrastructure managers of customer wants and needs.

The goal is universally available information that supports seamless, end-to-end travel choices for all users of the transportation system.

Energy/Environment

ITS helps to optimize trips, eliminate unnecessary travel miles and reduce time spent caught in traffic through improvements such as:

- Keeping traffic flowing – on urban freeways, on toll roads, at commercial vehicle checkpoints and elsewhere – thereby increasing effective capacity, reducing delays due to congestion and incidents and reducing the disproportionate pollution caused by stop-and-go driving.
- Using location-based road condition and weather information to help make vehicles more operationally efficient.
- Making trips more efficient through more optimal route planning and timing and more reliable route-following.
- Enabling flexible transportation pricing and demand management to respond to the current state of congestion and pollution.
- Increasing the attractiveness and use of public transportation and ride-sharing, our most energy-efficient and environmentally friendly travel modes.
- Strengthening compliance with vehicle emissions standards for all vehicles.

In addition, as part of an overall system approach to vehicle design, ITS contributes to improved fuel consumption by enabling more efficient vehicle performance and by allowing vehicle weight to be reduced without compromising the safety of occupants.

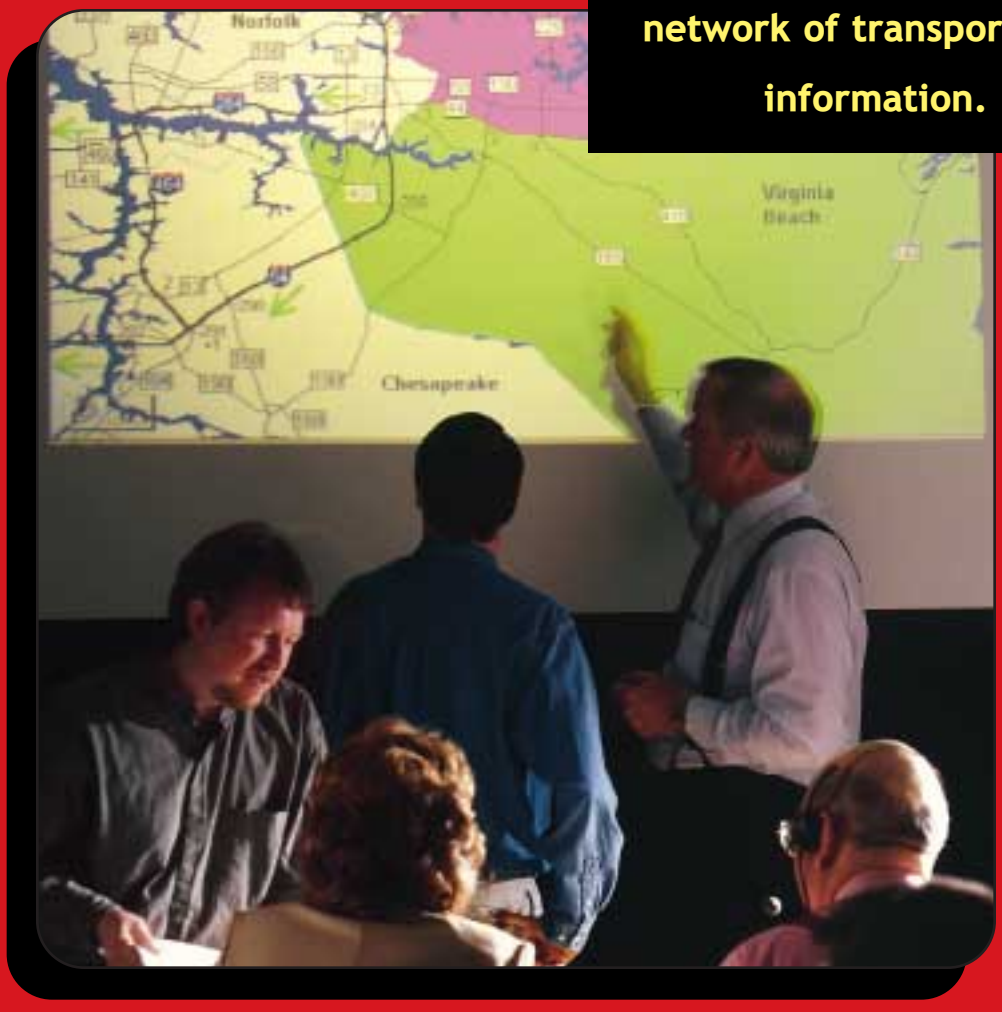
Altogether, ITS helps to contain fuel consumption and noxious emissions, reduce dependence on foreign energy supplies and safeguard the quality of the air.

The goal is to save a minimum of one billion gallons of gasoline each year and to reduce emissions at least in proportion to this fuel saving.[1]

"We process over 1,000 vehicles per hour per regular *E-ZPass* lane, which is about three times that of a staffed toll booth lane. With our higher-speed *E-ZPass* lanes we are processing 300-400 *more* vehicles per lane during peak travel times than regular *E-ZPass* lanes."

[1] According to the TTI 2001 Mobility Study, congestion in the 68 largest urban areas of the U.S. results in the annual waste of 6.8 billion gallons of gasoline. If ITS can mitigate 15% of this waste in ten years, an achievable goal, it will save 1.02 billion gallons of gasoline per year.

A new bold transportation vision is needed to set the direction of the next years. This new bold vision is based on information management and availability, on connectivity and on system control and optimization—in short, the creation of an integrated national network of transportation information.



Overview of Major Theme Areas

THE PRINCIPAL TOOL USED BY THIS PLAN TO EXPRESS ITS VISION OF THE FUTURE IS THE STATEMENT OF A SERIES OF THEMES WHICH, WITH A BROAD BRUSH, PAINT A PICTURE OF AN ACHIEVABLE FUTURE, MADE POSSIBLE BY APPLYING ITS TO THE PROBLEMS AND OPPORTUNITIES OF SURFACE TRANSPORTATION.

Evolution and Consensus

>>Under the guidance of a Joint ITS America and U.S. DOT Steering Committee of public, private and academic stakeholders (see Appendix A for membership), the themes arose through a process which included:

- Soliciting short issue papers from the industry as a whole – over a hundred were received, read and considered.
- Commissioning a series of environmental scanning papers covering the major application areas of ITS.
- Working cooperatively with related efforts undertaken by the Institute of Transportation Engineers, the Transportation Research Board and the National Science Foundation.
- Conducting a Visioning Session with invited industry experts to think imaginatively about the future of transportation and ITS' role.
- Forming a Writing Team to craft a preliminary collection of themes based on stakeholder input and to refine them as events unfolded.
- Convening a National ITS Summit, attended by over 250 ITS stakeholders, to explore and expand on preliminary themes.
- Reviewing themes with the full spectrum of interested parties at the 2001 Annual Meeting of ITS America.

Each theme area describes a significant portion of the transportation landscape where the tools provided by ITS can make a difference, including:

- A statement of current status and future opportunities in terms of the goals.
- The benefits to be achieved by the fulfillment of theme area opportunities.
- The challenges that must be overcome to realize these opportunities.
- The research, program and institution-changing actions that need to take place to meet these challenges and reap the available benefits.

The themes fall into two major, interdependent categories:

Programmatic Themes

Programmatic Themes reflect opportunities to apply technology to the problems and priorities of surface transportation. This is the traditional pursuit of ITS, but with novel approaches to addressing the high-profile problems that industry stakeholders have identified. These themes are:

- An Integrated Network of Transportation Information.
- Advanced Crash Avoidance Technologies.
- Automatic Crash and Incident Detection, Notification and Response.
- Advanced Transportation Management.

Enabling Themes

Enabling Themes lay the groundwork for the application of ITS technology to surface transportation. These enabling themes are integral to and supportive of the programmatic themes. It has often been observed that the truly difficult issues in ITS are not technical, but social, institutional and political. These themes address these difficult issues:

- A Culture of Transportation Systems Management and Operations.
- Public Sector Roles, Relationships and Funding.
- Federal Policies and Initiatives to Achieve Extensive Private Sector Product Deployment.
- Human Factors.

Each theme is described briefly below and in detail in the next section of this Plan.

Programmatic Themes

P-1 An Integrated Network of Transportation Information

The new vision for surface transportation is based on information management and availability, on connectivity and on system control and optimization – in short, the creation of an integrated national network of transportation information. The information to be gathered and managed includes real-time information on: the physical state of the infrastructure; how it is being built, used, maintained and kept secure; its environment, including relevant weather conditions and expectations; and users of the system, including their safety performance and compliance with

legal and administrative requirements. This vision depends on forging new forms of cooperation within and between the public sector at all levels and the private sector in its broadest sense, including manufacturers, carriers, service providers and travelers in all modes. An Integrated Network of Transportation Information will promote:

Seamless Travel for People For the traveling public, the network means making travel reasonable and convenient for all users, regardless of age or physical disability. ITS seeks full coordination between urban bus and rail transit, railway, highway and arterial systems and the elimination of missed connections, confusion during detours and diversions, degradation in service based on jurisdictional boundaries and secondary delay and connectivity problems throughout a trip. Information will be made available on all media including via web-, radio- and phone-based services for automobile and transit travel. Other information services will include online mapping and driving directions, en-route variable message signs and kiosks and personal subscription services, as well as real-time information for pre-trip planning, ride-sharing and en-route modifications, covering the current and expected conditions for all relevant modes.

Seamless Freight Movement Shippers will be provided with door-to-door shipping across carriers and modes without reference to the vehicle or the driver. Freight shipments will be visible across multiple modes and through all stages in the supply chain. A major focus of attention is at the points where shipments transfer from one mode of transportation to another and where they cross jurisdictional boundaries. Additional enhancements in data collection, storage and analysis tools will enable carriers and state agencies to most effectively use this data in an environment that protects data privacy and security.

Impact of Weather Weather is a common threat to the performance of all transportation modes. While the weather information currently provided by both the National Weather Service and private sector providers is well developed, it is not sufficient to aid in effective operations of the surface transportation system. Significant benefits result when the operators are provided with tailored weather products, i.e., pertinent information about the impacts of weather on the system and the tools and techniques to deal with them.

Detecting and Responding to Emergencies and Crises An Integrated Network of Transportation Information helps the public agencies who manage the transportation system and who respond to crises detect and understand the nature and extent of a threat, the condition and availability of available resources for response and mechanisms to help the public get to safety and out of harm's way. Such an integrated network will help to provide coordinated regional responses to crises and to deploy resources in the quickest and most effective manner.

P-2 Advanced Crash Avoidance Technologies

ITS can help to eliminate a large number of crashes and reduce the severity of those which do occur. Unprecedented levels of safety, mobility and efficiency will be made possible through the development, integration and deployment of a new generation of in-vehicle electronics, vehicle and infrastructure automation and selective automated enforcement, including the determination of fitness to drive.

In-Vehicle Electronics, Vehicle-Infrastructure Cooperation and Infrastructure-Based Technology Four kinds of in-vehicle electronics products are of interest: information products, diagnostic/prognostic products, driver assistance products and active safety products. All help drivers and vehicles to perform better and more safely. Performance of in-vehicle systems can be further improved through a connection with the infrastructure that provides information on road and traffic conditions. In addition, infrastructure-based warning and guidance technology can help improve safety for all vehicles, even those that are not specially equipped.

Driver Qualification Ensures that drivers will be medically fit, knowledgeable, alert, appropriately licensed and able to operate vehicles and related equipment safely, efficiently and comfortably.

Automated Enforcement Automated enforcement, if carefully and legally applied, also has the potential to eliminate many crashes. Automated enforcement encourages safe and responsible driving behavior by warning and imposing sanctions on drivers whose driving is not safe or responsible.

P-3 Automatic Crash and Incident Detection, Notification and Response

Getting emergency response teams as quickly as possible to the scene of a crash or other injury-producing incident is critical to saving lives and minimizing the consequences of injuries. To achieve this timely medical care, public safety providers must receive timely notice of the incident including its severity and precise location, be provided with information for developing efficient routings to the scene and to the hospital and be aware of and able to convey the nature and degree of the injuries.

Automatic location information from wireless enhanced 911 or telematics services can speed public safety notification and response to an incident. Traffic-sensitive route planning software within public safety computer-aided dispatch systems can identify which public safety response unit, among those available and appropriate for this kind of incident, is the shortest travel time from the accident site. Route guidance software can efficiently direct the unit to the scene, with the way cleared and the trip speeded by traffic signal preemption and other traffic control mechanisms. Coordination with in-vehicle systems allows public safety operators to arrive

with some prior knowledge of the potential victims and the situation, including cargo, if commercial vehicles are involved. At the scene, direct audio and video communication with the trauma center provides the public safety team with instructions on immediate treatment.

P-4 Advanced Transportation Management

Advanced transportation management intelligently and adaptively manages the flow of vehicles (automobiles, public transit vehicles and trains) through the physical infrastructure, often across multiple jurisdictions and modes, even under adverse conditions including crisis situations.

Advanced Transportation Management Systems These systems enable area-wide surveillance and detection, rapid acquisition of traffic flow data, real-time evaluation of traffic flows, predictive capabilities regarding near-term, real-time operational responses to traffic flow changes and evaluation of the operational responses to traffic flow changes. They also provide for effective response and recovery in times of emergency or crisis.

In order to achieve the most benefit in improving mobility, effective system capacity and response time, regional transportation networks need to operate seamlessly across jurisdictions and across modes. Control and management systems from various jurisdictions can be networked together and staff can be shared to reduce the total number of staff required at any given time and provide enhanced network coverage throughout the day. The integration of data between operations centers will help operations become more efficient by enabling a more comprehensive view of the system. In addition, successful transportation management depends on effective public safety operations, from rescuing crash victims to helping prevent crashes to coordination and response during times of major disaster (natural or human-made). At the same time, by providing information about emergencies, the transportation management system supports public safety operations and can even play a potential role in law enforcement investigations. To perform at their best, transportation and public safety professionals need accurate, timely and well-integrated information.

Advanced Transportation Automation Systems Research is already in progress on Cooperative Vehicle-Highway Automation Systems (CVHAS) that help to automate all or part of the driving task for private automobiles, public transportation vehicles, commercial vehicles and maintenance vehicles through cooperation with an intelligent infrastructure. In this context, the infrastructure may include instrumented roadways or dedicated lanes, or the logical infostructure created by a public or private information provider. The primary objective is to safely increase the capacity and flow of existing infrastructure. Research in infrastructure–vehicle transportation automation will include the exploration of automated public transportation systems including precision docking of public transportation

vehicles, dedicated lanes for automated trucks, automatic guidance of snow removal and other maintenance vehicles and potentially in the future, fully automated passenger vehicles.

It is also important to remember that ITS itself contains many systems and components (physical and data) that require protection. The information and regulatory traffic control activities managed by infrastructure-based ITS solutions must not be vulnerable to physical or electronic invasions or terrorism which could endanger personal privacy, public safety and national security.

Enabling Themes

E-1 A Culture of Transportation System Management and Operations

In the past ten years, the ITS program has been focused on technology and systems development and deployment. The next ten years will be increasingly focused on security, customer service, systems performance and safety management. The technology and systems that were developed and deployed over the past 10 years are a foundation for achieving these goals. The demands of both the external and internal environments are generating changes in the culture of both service providers and users. This will be reflected in a shift in focus by transportation infrastructure and vehicle-related service providers from product and facility *outputs* to performance improvement *outcomes*. Outcomes will be defined in user-customer terms rather than products and projects. This outcome focus, in turn, will require taking active responsibility for the performance of the vehicle-infrastructure systems via focus on systems management.

This implies a profound change in culture that encompasses multidisciplinary staffing, high levels of cooperation, a focus on reliability and information, a multimodal approach and new ways of working together.

E-2 Public Sector Roles, Relationships and Funding

ITS presents both the opportunity and the need to redefine critical relationships among public-sector agencies at all levels and between the public sector and the private sector. New regional organizations or public partnerships have begun to emerge with either literal or virtual co-location of functions, enhanced by information and communications technology. A variety of new institutional roles and relationships need to be developed to support the management and operations of secure, integrated, regional and multimodal transportation systems and services.

Institutional arrangements for systems operation and management will be very different in the future. This will include integration of national and regional security agencies that previously had little concern with efficient and responsive traffic movement.

While public funding for ITS projects continues to grow and ITS continues to be adopted throughout the United States, the widespread deployment of ITS depends on mainstreaming ITS into the basic funding/planning process and seeking creative alternative funding mechanisms. Over the next decade, increased funding for ITS programs needs to be available to plan and deploy new systems, to support operations of those systems and to hire and train the skilled personnel to manage the systems. Federal, state and local governments will provide much of this funding through traditional resources such as the Highway Trust Fund. However, innovative finance techniques including direct funding and user incentives, as well as private sector initiatives will also play an important role.

E-3 **Federal Policies and Initiatives to Achieve Extensive Private Sector Product Deployment**

The private sector plays a major role in developing and delivering advanced transportation services and in providing access to the social and economic benefits of these systems to all users, *including* state and local governments, public and private transportation system operators, other businesses and individual consumers.

Private-sector organizations recognize both the economic opportunity provided by a robust market and the social opportunity to enhance the well-being of citizens. However, for these opportunities to be realized, improvements in public-private cooperation are needed. Partnerships, common objectives, mutually generated program plans and joint long-term commitments need to be developed. Traditional business-government relationships need to be redefined to enhance private sector opportunities in the commercial marketplace.

In seeking profits in the ITS arena, industry continues to invest billions of dollars to research and develop new offerings that will appeal to buyers in terms of convenience, comfort, safety, mobility, economic advantage and efficiency.

Considering the estimated societal benefits that will be achieved through ITS deployment, government needs to help accelerate deployment by encouraging and endorsing the sale of appropriate products and services by the private sector. If the public sector can help clear the way for private-sector success, then this private-sector success can help advance public-sector objectives for a safer, more productive transportation system. There are several ways in which government could directly encourage consumer acceptance and use of ITS.

E-4 **Human Factors**

Understanding driver behavior and other human factors is a fundamental key to the effective delivery of the benefits of ITS. While the new information opportunities that ITS creates are clearly valuable – in many cases essential – the sheer volume of information can create potential problems: overload, distraction and confusion. Too much information, or information presented at the wrong time or in the wrong way, can create safety hazards. This can be true whether the recipient is the driver of an automobile or a professional driver (commercial vehicles, public transit vehicles, public safety vehicles and trains), or a staff member at a control center or operations center. Understanding human factors does not only mean avoiding overload; it means delivering information in the most effective, most timely way and constructing controls – both in vehicles and at centers – which are intuitive, consistent and easy to use correctly. With a greater focus on understanding human factors and by orienting ITS design in harmony with this understanding, ITS systems will be more effective and better accepted by their users.

DATA SECURITY

>>In conjunction with Privacy, as well as with regard to day-to-day operations, the integrity of system operations, communications and data must be protected. Data security can be impacted by both external as well as internal threats. ITS America has begun outreach work related to exploring practical issues involving system security and has recommended building on existing research initiatives involving the ITS component of *Critical Infrastructure Protection,* an Executive Order signed by the President in 1996.

Many system operators and designers either do not incorporate security requirements into their systems or find that their requirements are inadequate to cope with threats like improper internal access to their systems or external electronic invasions of their systems through viruses, worms, or manipulation of operations. A User Service for Information Security may be a useful addition to the National ITS Architecture. However, information security needs to be built into *all* systems designed for infrastructure-based control and operations, as well as for systems involving personal data or financial transactions.

In 1998, U.S. DOT's ITS Joint Program Office developed and published two important reports in this area: Report #FHWA-JPO-98-005 *"Protecting Our Transportation Systems: An Information Security Awareness Overview"* and Report #FHWA-JPO-98-009 *"Intelligent Transportation Systems Information Security Analysis."* The subject matter of these reports needs to be revisited and updated, to further develop ITS-oriented requirements and guidelines for the security of different ITS components, so that existing information technology solutions can be adapted and new solutions developed as necessary.

3M's lane awareness system combines magnetic tape, a sensor and an in-cab display to help snow plow drivers orient themselves to the road during winter conditions.

Metro's Smart Card is permanent, rechargeable and time efficient. The card is used for train travel and parking lot payment.

"As a working, single parent, I need to know if my bus to and from the office is going to be on time. Thanks to a bus tracking system, I can check the *actual* arrival time of my bus via the Internet or on electronic message boards at the bus stop. This system really takes the worry out of waiting!"

Programmatic technologies—advanced driver assistance systems, active safety systems and cooperative vehicle-highway technology—currently offer a greater promise of improved safety, enhanced mobility and greater efficiency in the near and medium term. The greatest impact will be in the safety arena, moving the safety emphasis from crash mitigation to crash avoidance.

An Integrated Network of Transportation Information

Current Status + Opportunities

>>The bold transportation vision of the mid-20th century – building the Interstate Highway System – set the directions and built many of the transportation institutions of the past 50 years. But now that the Interstate System is essentially complete, a new bold transportation vision is needed to set the directions and mold the institutions of the next 50 years. This new bold vision is based on information management and availability, on connectivity and on system control and optimization – in short, the creation of an integrated national network of transportation information.

The Integrated Network of Transportation Information, once built, will be the information foundation for multiple aspects of transportation and ITS, notably including infrastructure management (including traffic management, public transportation management, construction/workzone management and maintenance management), safety management, traveler information and freight management. It will permit public agencies to efficiently and productively manage the physical infrastructure and operations that use the physical infrastructure. It will enable drivers, carriers and public safety personnel to proactively identify safety risks and take appropriate steps to mitigate these risks. It will allow the traveling public to make informed choices on how best to plan and execute trips, both in advance and en-route, based on real-time and predictive travel information. It will help shippers, carriers and freight terminal operators to interact efficiently and provide comprehensive information on the status, location, routing and expected arrival times of goods in transit and on containers, trucks, trains, ships and airplanes and on the external events, including incidents, construction and weather, that affect freight movements.

The Integrated Network of Transportation Information is the infostructure that facilitates the operation of the entire transportation system, as vital a part of the operating transportation infrastructure as the roads and the rails.

Realizing this vision depends critically on forging new forms of cooperation within and between the public sector at all levels and the private sector in its broadest sense, including manufacturers, carriers, service providers and travelers in all modes. A primary purpose of this cooperation is to share, leverage and use information to make surface transportation safer, more efficient and universally available.

Realization also depends on getting access to and managing data on the structure, status, use and behavior of the entire transportation system, both to serve the needs of the people and organizations who operate the system and to serve the needs of the people and organizations who are its users. There are several major components involved in fulfilling data needs:

- Understanding what data is needed by the full range of stakeholders.
- Creating, operating, maintaining and updating the mechanisms that will gather, analyze, coordinate, extrapolate and store the data and interact with adjoining external systems. This will necessarily be done at multiple levels by a large number of organizations under consistent guidelines for information gathering, validating, sharing and coordinating.
- Insuring that the electronic communications infrastructure is integrated among all modes and agencies and operators in a reliable and high quality manner.

- Providing convenient, timely and affordable access to the data to both operators and users of the transportation system.
- Implementing appropriate policies, procedures and security technologies to ensure that the system is secure and that only authorized stakeholders have access to data.
- Developing a business model and sources of funding to sustain the other components.

An Integrated Network of Transportation Information is a grand and far-reaching vision. Its impacts will be enormous in terms of economic productivity, safety and customer satisfaction with the transportation system. This undertaking must not be taken lightly. It is, in fact, the ITS equivalent of building the Interstate Highway System: complex, expensive, difficult and enormously worthwhile.

None of the components identified above has an obvious solution. Indeed, understanding each component's requirements is itself a major under taking that is prerequisite to developing and deploying the implementing technology and to transforming institutions to use it well. However, determining these requirements, transforming the institutions and designing, implementing and deploying the technology is a vital necessity for the effective management and use of the transportation system of the future.

In some respects, building the Integrated Network of Transportation Information is more complex than building the Interstate System. The process can be guided and led from the center, but the activity will be highly distributed. Developing the standards and practices for building and managing the Integrated Network is a significant challenge in itself.

While there are some analogies between the development of the Integrated Network of Transportation Information and the Internet, the Integrated Network can probably not be left simply to develop on its own, even with a widely shared vision. There need to be checks on quality and completeness of information – an information confidence level – and access to information must be controlled, especially where the information is personal or security-sensitive.

Over the next ten years, an information base will be established that is integrated and national in scope. This information base will enable many of the themes that are identified in this Plan. The evolution from a data-poor to data-rich environment is the key enabling development of the next decade.

SEAMLESS TRAVEL for PEOPLE

For the traveling public, an Integrated Network of Transportation Information means:

- The ability to travel wherever and whenever desired without being limited by physical disability, age, or location.
- Full coordination between bus and rail transit, railroads, highway and arterial systems; eliminating missed connections, confusion during detours, diversions due to routine and emergency weather conditions and secondary delays.
- Full connectivity at the beginning, transfer points, or ends of a trip, making travel reasonable and convenient.
- Enhanced ability to make travel choices.
- Access to information for evacuating areas of danger.

An Integrated Network of Transportation Information, accessible to the traveling public, helps to create seamless end-to-end travel opportunities that are responsive to changing conditions and individual needs, which enables the following:

- Pedestrian services and management at intersections and terminals to assist in pedestrian safety, guidance and improved movements.
- Improved parking management to monitor parking spaces and facilities, provide advanced charging schemes and direct drivers to available lots, spaces, or stations in real time.
- Interfaces to private sector transportation service providers (e.g., taxi, subscription bus, airport shuttles and local delivery) and ride-sharing.
- Responsiveness to weather conditions, to resynchronize connections, update travel times and generally permit better advance and en-route trip planning.
- Single payment medium for regional and national travel.

The integrated network facilitates new transportation opportunities:

- Better access to the transportation system.
- High quality reliable transit in congested urban areas with accurate real-time information for consumers.
- Shared use of railroad right-of-ways between passenger and freight service where appropriate.
- Integrated transportation scheduling and passenger tracking systems to provide affordable services to travelers with special needs.
- Consistent, high-quality information as the traveler crosses jurisdictions.

For individual travelers, an integrated network implies the availability of several benefits:

- Historical, current and projected information on all modes and travel options in traveler information systems, including web-, radio- and phone-based services such as 511 for automobile and transit travel; online mapping and driving direction sites, en-route variable message signs and kiosks and personal subscription services.
- Real-time and predictive information for both pre-trip planning and en-route modifications, covering the current and expected conditions, including weather, for all relevant modes.
- Safety and security information to avoid danger areas and to evacuate safely in times of crisis.
- New information channels and services for both the public at large and those with special needs or impairments providing independent travel for all. The new 511 service is poised to become the foundation for national provision of traveler information services, in conjunction with telematics, wireless phone displays, wireless personal information devices and interactive web services that offer new opportunities just beginning to be explored. New information technologies offer the promise of travel information systems specially tailored for the visually or hearing-impaired.
- True multimodal trip and itinerary planning for urban, rural and intercity travel. System, agency and political boundaries should be invisible to users as they ask about their door-to-door trip.
- Coordinated multimodal connections that provide integrated bus and rail operations in order to coordinate seamless transfers between modes. The benefits of such a system would be improved schedule reliability, reduced slack time and improved operating efficiency on timed transfer routes and improved information provided to passengers.

SEAMLESS TRAVEL for PEOPLE, continued

- Personalized information services. The Internet, 511, telematics and cellular/wireless technologies offer new personalized information services that send out announcements of expected delays, help re-route travel around obstacles, or provide next-departure notification for scheduled transportation services. Their development and potential benefits (especially for the handicapped and elderly) need to be further explored, encouraged and monitored, including provisions for data security and privacy.
- Consistent national payment mechanisms for transportation and other services. As smart cards and other electronic payment media become more popular with consumers, there will be an opportunity to broaden both the types and the geographic scope of systems covered by electronic payment. Because travelers and consumers will be able to use electronic payment for more and more types of transactions, they will see the benefit of utilizing systems that can accept a universal electronic payment mechanism. As a result, they will utilize this method of payment more readily and often. Efficiencies in collecting payments will increase as more travelers use electronic payment. A consistent payment system for all transportation-related transactions would add convenience and reduce costs for both users and operators. While much of the development of electronic payment systems, including provisions for maintaining security and privacy, will be handled outside the immediate transportation community, this community must assure that its special needs are recognized and accommodated.

An Integrated Network of Transportation Information helps to personalize transportation for individual travelers by providing:

- Transfer connection protection and dynamic dispatch of services based upon the needs of those making the connections.
- En-route parking location guidance and reservations and/or just-in-time provision of shuttle and other services for access to/egress from one's origin and destination.
- Dynamic ride-sharing in personal vehicles, taxis/shuttles or other modes.
- Enhanced real-time scheduling of paratransit and flex-route transit services to meet their customer's travel needs as they occur throughout each day.
- New travel monitoring and support services for physically or otherwise impaired individuals, which provide increased mobility and independence.

SEAMLESS FREIGHT MOVEMENT

Moving freight more safely and efficiently from origin to destination both within and across modes is critical to the nation's well-being and economic competitiveness.

A critical enabler of improved freight safety and productivity is information sharing. The next 10 years will create an environment where timely and accurate commercial vehicle and freight data are shared electronically among authorized stakeholders to support safety, productivity, mobility and environmental goals. Key priorities include:

- **E-Safety** The public and private sectors will continue to integrate and expand motor carrier safety information systems to enable a coherent

overall approach to safety management. Greater attention will be given to identifying high-risk drivers, vehicles and carriers and orienting the operations of motor carrier fleet managers, roadside law enforcement personnel and administrative personnel to identify and implement strategies for reducing these risks. Safety systems will also expand to better track hazardous cargo. The current generation of safety information systems and decision support tools will be expanded to include all interstate, intrastate and foreign-based carriers operating in the United States. The contents of these databases will be expanded to include roadside inspection results as well as information on crashes, citations, registration and tax payment status and emissions tests.

- **E-Business** The deployment of electronic systems for application, processing, issuance and payment of registrations, permits and other motor carrier credentials will be expanded. These electronic credentialing capabilities will be integrated with existing motor carrier fleet-management software, with port and terminal management systems and with border crossing systems.
- **Cross-Modal Integration** Technology is being used within many freight and shipping companies. Cargo ships are tracked as they cross oceans. Containers are equipped with transponders to help manage port operations. Many large trucking companies track their vehicles as they move across the country. The greatest problem in tracking freight comes as a shipment transfers from one mode of transportation to another or as it crosses jurisdictional boundaries. Shippers and customers need better visibility of cargo throughout the trip. Information needs to be exchanged more efficiently with and among regulatory agencies. Access to this information will improve the reliability of the freight system for shippers and carriers; improve cargo safety and security; and create opportunities for load matching and other economies of scale.
- **NAFTA** Full implementation of the North American Free Trade Agreement (NAFTA) will increase the number of Canadian- and Mexican-based carriers operating in the United States and the number of freight shipments across the United States' northern and southern borders. Safety, credentials and other databases will need to be linked across the three nations to ensure that border checks are thorough and efficient and that only safe and compliant carriers have the privilege of operating in the NAFTA jurisdictions.

Information standards and communications networks are critical to enable improved data sharing within the freight industry. An Integrated Network of Transportation Information that includes freight considerations as an integral element will help provide the freight industry with tools to help track equipment and shipments from origin to destination and plan and execute trips and transfers that move freight.

Although improved access to information would bring more efficiency, a more difficult issue is getting all parties in the supply chain to make fixing the situation a priority. There is an urgent need to establish a far more cooperative environment between transportation modes, adapt the physical infrastructure to better respond to information-driven requirements and reduce time that is currently lost in documenting the fulfillment of regulations.

THE IMPACT of WEATHER

Weather is a common threat to the performance of all transportation modes. While the weather information currently provided by both the National Weather Service and private sector providers is well developed, it is not sufficient to aid in effective operations of the surface transportation system. As demonstrated by the winter road maintenance community, significant benefits result when the operators are provided with tailored weather products that provide all users and operators with pertinent information about the impact of weather on the transportation system and the tools and techniques to deal with them.

Weather contributes to many adverse transportation conditions that can be responded to by transportation operators and users via ITS. For instance, snowfall can be removed, ice can be treated, fog can be warned against, ozone episodes can be mitigated by travel reduction, flooded routes can be avoided, hazardous material dispersion can be predicted and severe storms can be avoided by evacuation. But knowing about these threats in detail (e.g., predicting when ice will form on a bridge, or when a thunderstorm will shut down a highway) means having to distinguish general weather from "surface transportation" weather. Dealing with these impacts means getting the right information to the right people at the right time and place, as well. ITS provides the means by which this information delivery can be achieved.

The path from generic weather to surface transportation weather requires new approaches to public/private coordination. The market potential for surface transportation weather products from the private sector is enormous, but will only be realized if the ITS community embraces the public/private challenges associated with building this market.

Meeting these challenges affects almost every function in ITS and most of the themes in this Plan. Accordingly, this Plan proposes two major activities: A dedicated Surface Transportation Weather Applications Research Program, to emulate the program in aviation and a National Surface Transportation Environmental Observing System, as part of the ITS infostructure, but also integrated with the general weather observing system.

RESPONDING to EMERGENCIES and CRISES

One of the most unsettling aspects of emergencies and disasters, whether from natural causes or terrorist attacks, is uncertainty. From a transportation system viewpoint, this uncertainty ranges from uncertainty about the ability to get home to uncertainty about the location and deployment of emergency response teams. An Integrated Network of Transportation Information will help the public agencies who manage the transportation system and who respond to crises understand the nature and extent of the threat, the condition and availability of available resources for response and mechanisms to help the public get to safety and out of harm's way. Such an integrated network will help to provide coordinated regional responses to crises and to deploy resources in the quickest and most effective manner.

BUILDING the INTEGRATED NETWORK

Transportation engineers and infrastructure managers have always worked to collect and use information about the transportation system. ITS has provided additional tools and perspectives for expanding information collection and use. However, at present, information about the transportation system as a whole remains sparse, fragmented and uncoordinated.

The next decade holds the promise to eliminate this information gap in a number of important ways, although, as always, the institutional barriers – including forging new ways for the public and private sectors to work together – will be more complex and daunting than the technical challenges.

- **Transportation System Structural and Historical Data** With appropriate planning and incentives, a database of foundational information will be built. This foundation starts by organizing and integrating, from multiple sources, basic data about the transportation system: what roads, rails, transit routes, freight terminals, commercial vehicle checkpoints, toll collection facilities, roadside/wayside field equipment and historical safety trouble spots exist, where they are located and what their basic structural/descriptive characteristics are. This will be augmented with historical performance data (including, for example, system behavior and crash statistics) to the extent that such information can be located, gathered, translated and stored.

- **Transportation User Performance Data** A second key element of the Integrated Network of Transportation Information is the identity and performance of transportation system users. This is particularly important for commercial vehicle operators, since better information on the identity and performance of carriers, vehicles and drivers could help motor carriers, public safety agencies, shippers and insurance companies more effectively identify and manage safety risks. This data includes basic identifying information with links to integrated databases of inspection, accident, citation and credentials data, as envisioned by the Commercial Vehicle Information Systems and Networks (CVISN) initiative. In addition, this information has the potential to play a greater role in law enforcement initiatives related to homeland defense than might have been considered before the events of Sept. 11, 2001.

- **Real-Time Performance Data** Once the basic database is built and the historical database started, the network can be expanded to incorporate real-time information on what the system is doing and how it is performing across all modes. This will include speed, volume and travel-time data, weather conditions, incidents and events.

  While infrastructure-based surveillance will be important (especially for transit information), vehicles of all kinds offer the greatest potential for gathering data on system performance. Vehicles can provide detailed travel time and speed profiles, serve as mobile weather probes and gather and provide information about incidents as they occur. 511, wireless communications and the Internet make real-time use of such data feasible. Collectively, this data will improve both operations and capital planning for transportation systems. On-vehicle crash event recorders will provide valuable post-occurrence data for characterizing crashes. Strong links will exist between the real-time data collection system and the historical database system, with historical information augmented and refined through actual experience and real-time predictions made in the context of historical experience.

- **Information Delivery Mechanisms** No matter how brilliantly collected, coordinated and organized, information is valuable only to the extent that it can be promptly and economically accessed and used by the traveling and shipping public and by infrastructure planners and managers. Providing access to the national network of transportation information in a way that is useful to drivers of passenger cars, transit riders, commercial vehicle operators and companies, railroads and their customers, emergency response services, infrastructure managers and transportation planners at all levels is a daunting, but clearly necessary, ingredient. 511 services will utilize this information in a wide-scale distribution and will likely enable billions of calls accessing this information.

Physical and Electronic Security The principal benefits of data security are realized in the continued and consistent effectiveness of ITS deployments, as well as reductions in downtime due to viruses, invasions, or physical damage to systems and communications links. Traffic and transit control systems, if damaged or malfunctioning due to tampering or physical damage, pose safety threats. For rail control systems in particular, system shutdowns or slowdowns may be required due to the design of the physical systems and the speed of normal rail operations. Economic loss to individuals and businesses may occur through bad actors' intercepting financial data and transactions. Loss of economic competitiveness may occur through damaging systems that expedite freight movements or assure that intermodal transfers occur in a timely fashion. Tampering with communications to vehicles with respect to incident detection, mayday communications and other activities, may result in decreased safety, increased response time and potential increased risk to the traveler.

The Integrated Network of Transportation Information requires the active cooperation of a wide spectrum of public and private stakeholders both as information providers and consumers. It involves a massive requirement analysis to understand the needs of these stakeholders, notably including the traveling public.

The success of the Integrated Network of Transportation Information depends most fundamentally on marshalling a national commitment to cooperate, to participate, to contribute and ultimately to share in the benefits. This Plan suggests that in the next few years, the successful pursuit of the Integrated Network, like the Interstate Highway System, requires a Congressional mandate to make the network a national priority, marshal the necessary national commitment, outsource functions to the private sector wherever possible and provide the bulk of the necessary funding.

While it is critical to maintain the levels of interoperability and data exchange to support nationwide and regional integrated information and management systems for transportation, resources must be made available to provide adequate interoperability between these ITS components. However, securing such a Congressional mandate requires much groundwork to be laid first, for which at least initial leadership must come from the U.S. Department of Transportation. This groundwork includes:

- Documenting, at the "thorough outline" level, the scope and characteristics of the Integrated Network of Transportation Information.
- Conducting a preliminary cost/benefit analysis, with attention to the alignment of costs and benefits for particular stakeholders.

- Securing at least preliminary buy-in from principal stakeholders, including organizations and influential members of infrastructure-oriented organizations like the American Association of State Highway and Transportation Officials (AASHTO), the American Public Transportation Association (APTA), the International Bridge, Tunnel and Turnpike Association (IBTTA), the Institute of Transportation Engineers (ITE); advocates for drivers like the American Automobile Association (AAA) and other individual travelers; spokespeople for state regulatory agencies like the Commercial Vehicle Safety Alliance (CVSA) and the American Association of Motor Vehicle Administrators (AAMVA); commercial carrier associations like the American Trucking Associations (ATA), the National Private Truck Council (NPTC) and Owner Operator Independent Drivers Association (OOIDA); the Association of American Railroads (AAR), the American Railway Engineering and Maintenance-of-Way Association (AREMA), the railroads and their suppliers; vehicle manufacturers and the Alliance of Automobile Manufacturers (AAM); telematics suppliers; the Consumer Electronics Association (CEA) and its members; advocates for privacy and environmental protection; and telecommunications associations like the Cellular Telecommunications and Internet Association (CTIA) and the United States Telecommunications Association (USTA).

This Plan suggests that the first two items above (at least a 1–2 year effort) provide the basis for convening a national summit under the auspices of ITS America that can serve as the vehicle for securing the preliminary stakeholder buy-in, among many other useful potential outcomes. Assuming that such a buy-in occurs, one additional outcome of the summit could be a National Steering Committee for the Integrated Network of Transportation Information. With ITS America as its secretariat and working arm, the principal initial responsibility of this National Steering Committee would be generating Congressional support and the necessary mandate to proceed.

Once the mandate is forthcoming, the Steering Committee can guide and oversee the necessary research, planning and staged development and deployment required to create, operate and maintain the Integrated Network of Transportation Information. This responsibility would most effectively be achieved under a Congressional charter or the establishment of a Presidential Commission. In either format, ITS America would continue to serve as secretariat and working arm of the Committee or Commission.

Caltrans's Interactive curve warning signs combine speed-measuring radar with changeable message signs.

An Integrated Network of Transportation Information

Benefits

>>Information by itself does not deliver direct benefits. This information, however, can support nearly an unlimited array of applications – only some of which we can describe today – that will deliver efficiency, convenience, cost, safety and environmental benefits. In all cases, the principal benefit will be based on taking the guesswork out of the system. All parties in the transportation system will benefit from the following positive impacts of the Integrated network:

- **System Efficiency** An Integrated Network of Transportation Information improves the efficiency and effective use of the overall transportation system by providing for the adjustment of the each component as conditions change and ensuring that intermodal connections are coordinated and maintained. Because travelers will make better decisions and avoid traffic congestion, delays and problem areas demand on the transportation network will be more balanced. Reduced congestion and delay may in turn moderate the demand for new facilities and services.
- **System Management** Real-time information will enable more effective operations of roadways, transit systems and railroads. Benefits will accrue in all regions of the country, both urban and rural and to both passenger and freight movement. This data will enable consistent nationwide performance measurement, facilitating more effective policies and programs to continue improving the transportation system as a whole.
- **Traveler Information** Travelers will have access to good information for planning trips and for adjusting trips en-route if circumstances change. Travelers will be able to complete their door-to-door trips making connections and crossing system boundaries easily and conveniently. Both the integrated transportation network and new personalized services will adjust to conditions improving reliability and ensuring that the trips can be completed as planned. 511, with its availability before and during a trip, will improve conditions on the systems as a whole allowing drivers and travelers to make better-informed decisions.
- **Crisis Management** Disasters, human-made or natural, are unplanned events that take a tremendous toll on the surface transportation system. ITS has played a vital role in disaster response and crisis management. As technology continues to evolve, ITS will play an increasing role in the prediction and prevention of disruptions to the surface transportation system. Information is the key ingredient. The ability to gather information quickly as situations evolve can often spell the difference between successful crisis management and chaos. The ability to gather information in greater depth can play a critical role in predicting and mitigating the impacts of disasters. The implications cross multiple boundaries, including societal, economic and technical.

- **Reduced Stress and Uncertainty During Travel** The increased knowledge of system conditions, reliability and the ability to adjust to new events, combined with the ability to make reservations and personalized itineraries, will make travel more convenient and predictable. It will also reduce unexpected and unpleasant surprises as travelers are alerted to abnormal conditions and, via 511, telematics and the Internet, are able to adjust their plans or routes to accommodate them.

- **Greater Mobility and Access** Travel information will increase independence, mobility and mainstreaming into society for those with limited travel capabilities. These include those with physical and other impairments as well as our increasing elderly population. New services and better information will enable independent travel for those previously unable to travel unassisted, or extend safe driving and travel for all of us as we age. Information on accessible transportation facilities and the ability to highlight obstacles to accessible transportation will be especially helpful to travelers with physical disabilities. The new information and services will allow the physically challenged and the elderly to continue to be productive members of society. Both the personal and overall societal costs of providing transportation to these individuals are reduced.

- **Freight Shipping** Coupled with complete transparency of the location of freight, better information on system status will enable logistics managers to optimize the movement of goods, reroute and/or redirect shipments as needed and reduce the overall costs of operating just-in-time systems. Businesses and consumers will enjoy a reduction in the cost of goods as a result of improvements in freight movement efficiency and economy. An integrated network of transportation information will add far greater reliability to the manufacturing and distribution processes that currently depend on "just-in-time" arrivals. The time it currently takes to apply for and receive credentials will be reduced, improving utilization of trucks and railroad cars. This will effectively increase the capacity and throughput of the system. Shippers will be able to optimize their routing choices through access to better information on shipping characteristics, costs and alternatives. This will encourage more effective competition among shipping modes.

- **Safety** Drivers, commercial vehicle operators, shippers, insurers and public safety and law enforcement personnel will be better able to identify safety risks, whether related to the driver, the vehicle, the roadway, or the environment (e.g., traffic flows and construction activity). Drivers will be able to make informed decisions about how to respond to safety risks in the roadway or on board the vehicle. Carriers will be able to reduce risks by screening driver qualifications in the hiring process and managing driver and vehicle routing and dispatching based on the roadway and traffic environment. Shippers and insurers will have information on carrier safety records that will, in turn, provide incentives for good performance from carriers with whom they do business. Public agencies will be able to focus on enforcement resources on the highest safety risks.

An Integrated Network of Transportation Information

Challenges

- **Leadership and Vision** Building the consensus, the relationships, the funding and the process for building, maintaining and operating an Integrated Network of Transportation Information will require a shared national vision and a national commitment. The truly difficult part of making the integrated network a reality is developing the common perception of need and the common will to proceed. Leadership and vision are the most crucial ingredients.
- **Security** An Integrated Network of Transportation Information can add great robustness to the overall transportation system. However, dependence of the public and of infrastructure managers on this network creates great potential vulnerability if the network is disrupted, whether through human error, natural disasters, sabotage, or cascade effects from disruptions to other parts of the national information infrastructure.
- **System Integration** Combining public-sector data from multiple agencies and private-sector data from multiple sources will be both organizationally and technologically difficult. It needs to be done in a manner that does not erode the opportunity for successful business models for private companies.
- **Customer Satisfaction** Success in delivering transportation system information to customers depends upon understanding the needs and responses of these individual customers, both private and commercial. Many current transportation information systems suffer from a lack of user acceptance for reasons ranging from lack of customer awareness that the systems exist to lack of system relevance. Customer satisfaction evaluation data is needed to ensure that transportation information delivery systems are developed with up-to-date insight into customer needs and continue to evolve as customers' needs evolve.
- **Professional Capacity** Professional disciplines will need to emerge and evolve if information is to be obtained and used properly. The ITS community needs to look to other industries, including factory automation, communications and information technology as guides.
- **Legal, Privacy and Perception Issues** Great care must be exercised regarding information that relates directly or indirectly to individuals. Safeguards against inappropriate collection and use of personal data are an absolute social and legal prerequisite to the success of the integrated network.
- **Human Factors** The best ways to organize and display multimodal information is not well understood. Tailoring systems and devices to overcome individual liabilities and challenges and be understandable by all, also needs to be investigated. In addition, in-vehicle information systems have been targeted as potentially distracting to drivers. Mechanisms to allow the driver to communicate with these systems in a safe and non-distracting manner require significant work.
- **Database Management** The technology for managing an Integrated Network of Transportation Information, most especially the real-time aspects, will break new ground in information system magnitude and complexity. While technical issues will not be as complicated as institutional issues, their difficulty and cost should not be underestimated.
- **Institutional Data Sharing** Models and incentives do not presently exist through which institutions can see the value of sharing their information.

CHALLENGES, continued

- **Funding/Business Models** A successful Integrated Network of Transportation Information depends on the successful development of new funding and business models and mechanisms. The integrated network will be a very expensive undertaking and much of the expenditure will need to take place before many of the benefits will begin to appear. Fundamental questions include who owns and operates the network (U.S. DOT, a government chartered corporation, a university consortium, or private enterprise) and how it is to be funded (user fees, taxes, or perpetual endowment). Issues also include providing appropriate considerations to data suppliers, including operators of private automobiles and their 511 and telematics suppliers.
- **Weather Issues** Many surface observing systems are fragmented and closed. Their coordination and finding a balance between surface and remote systems, has to be achieved for efficiency. In addition, weather knows no jurisdictional boundaries. Environmental information needs to be viewed as a common operational thread that leads to new coordination requirements among jurisdictions and activities within ITS.
- **Coordination with Public Safety Systems** No generally accepted mechanism is currently in place to allow basic operational information about the transportation system to be readily shared, when needed, with public safety systems.
- **Coordination with National Security Agencies** Particularly in times of crisis, there is a clear need for transportation organizations to coordinate activities and information with security-oriented organizations. However, mechanisms for doing so are not currently in place.

An Integrated Network of Transportation Information

Actions

RESEARCH

- Conduct research into other industries that gather multiple types of information and provide that data in an integrated national picture to identify existing approaches that can be used in ITS information collection and management. Weather information is an example.
- Conduct research and development to assure that the Integrated Network of Transportation Information is made as invulnerable as possible to disruptions, whether due to natural causes, inadvertence, or attack.
- Conduct a regional demonstration project that would include all surface transportation modes such as rail transit (light rail, heavy rail and commuter rail), bus, passenger rail (Amtrak), freight rail, emergency response vehicles and others. This research would involve the linkage of data across modes into an Integrated Network of Transportation Information that would demonstrate the benefit to transportation operations managers and the traveling public.
- Research traveler behavior and requirements, including priorities, responses to new types of information and personal services and the types and quality of data needed to be useful to travelers and to affect their travel patterns and behavior.
- Research the needs of and the benefits to be accrued by, sharing transportation management information with other public agencies.
- Create a Surface Transportation Weather Applications Research Program that will harness meteorological and transportation expertise to close the gap between weather information and effective action on specific, surface transportation environmental threats.
- Conduct policy and opinion research regarding in-vehicle event recorders and systems to support vehicle probes, including an exploration of the incentives that will encourage vehicle operators to participate.
- Determine the most cost-effective data for identifying high-risk commercial drivers, as well as the carriers that tend to employ these drivers.
- Establish an applied research initiative to develop and implement methods of downloading data from vehicles involved in a crash. This effort should incorporate all parties that need and could benefit from crash data, such as insurance companies, vehicle designers, trauma specialists and highway designers. The initiative should also determine how to integrate human-entered crash reports with vehicle-based data.
- Catalyze private sector research and efforts to integrate cross-modal transportation and information systems and optimize operations. For example:
  - Create a demonstration project to track location of shipments and monitor their conditions globally. This research would establish the value of technology and information sharing. It would also provide a testing ground to determine the data, data formats and information-sharing mechanisms needed to provide shipment visibility origin-to-destination, anywhere in the world.

RESEARCH, continued

- Develop appropriate uniform mechanisms for **identifying shipments** at multiple levels (e.g., parcel, pallet, container, truckload, railcar and train) and to standardize the information associated with shipments. Research is needed to:
  - Determine the best **mechanisms** to electronically identify shipments at levels smaller than containers. These mechanisms will need to be **standardized** across companies, so a broad involvement of stakeholders will be needed.
  - Determine the **information** and its format needed to be included in the flow of information that goes along with the shipment of freight.

PROGRAM

- Convene a national summit under the auspices of ITS America that can serve as the vehicle for securing the stakeholder **buy-in** for an Integrated Network of Transportation Information.
- Accelerate the deployment of a national program to establish **baseline data collection and archiving** systems on the National Highway System, building on the Intelligent Transportation Infrastructure Program established by the Transportation Equity Act for the 21st Century (TEA-21). The program would emphasize data necessary to support traffic control/management, incident management, weather management, performance measurement, 511, traveler information and goods movement. Expand the program to provide incentives and subsidies for data collection, integration and sharing in the public interest. This program would have several objectives:
  - Establish data collection and information dissemination **guidelines** for the National Highway System at a minimum and preferably for all modes in typical urban and rural regions.
  - Provide **deployment incentives** for next-generation data collection and traffic management systems. In order to develop a national market for 511 and other traveler information, there needs to be a base level of data available in a majority of the major metropolitan areas across the country. An incentive program would speed the implementation of data collection systems and jump-start the 511 and national traveler information market.
  - Explore and test new applications and approaches to improve the quality/coverage of **travel conditions** data. Several new technologies (e.g., the Global Positioning System and geolocation via wireless telephones) may allow vehicles as probes to supplement current infrastructure-based data. These systems and their integration with traditional sources need further development and testing.
- Establish a program to evaluate **customer satisfaction** with individual traveler and commercial transportation information delivery systems to ensure that the systems are consistent

with customers' needs and evolve with the capabilities of the technology and customer expectations. Until such a program is self-supporting with revenue from the private sector, it may need to be directed and funded by U.S. DOT in the public domain so that results are accessible to all to improve systems nationwide.

- Continue to integrate and expand motor **carrier safety** information systems to improve service, enhance efficiency and enable a holistic approach to safety management that includes several priorities.
  - Use safety data to reengineer **enforcement strategies,** with a greater focus on high-risk enforcement (e.g., more frequent compliance reviews or denial of registration to carriers with poor safety performance records).
  - Develop a national **safety information** database through the SAFE initiative. Upgrade key federal systems including the Motor Carrier Management Information System (MCMIS), the Safety and Fitness Electronic Records (SAFER) system and the planned Unified Carrier Register (UCR).
  - Explore options for **exchanging safety data** at the state level, including further refinement of the Commercial Vehicle Information Exchange Window (CVIEW) concept that is being tested in selected states. Expand the scope of SAFER to store intrastate as well as interstate data. Link county and local enforcement personnel and data into these safety information systems.
  - **Expand** the **scope** of safety information systems and decision support tools to include interstate, intrastate and foreign-based carriers operating in the United States.
  - Expand the core **safety databases** (SAFER, CVIEW and the ASPEN inspection software) to enable electronic collection and exchange of data from roadside and terminal emissions tests of heavy-duty vehicles.
  - **Integrate** citation and conviction data into the Commercial Driver's License Information System (CDLIS).
  - Develop a **national crash database** to provide enhanced data on crash locations and causation factors; use this database to guide highway design, operations and enforcement decisions. Improve the frequency and consistency of crash reporting by state, county and local agencies. Expand crash records databases to include incidents and to record subjective factors (e.g., road rage). Integrate crash data into SAFER, CVIEW and other safety databases.
- Expand deployment of **electronic systems** for application, processing, issuance and payment of **motor carrier credentials**. Expand deployment of web-based systems for electronic credentialing over the Internet. Consider using new technologies and communication platforms, including the use of eXtensible Markup Language (XML) standards as an alternative to electronic data interchange. Integrate electronic credentialing capabilities into existing motor carrier fleet management software. Expand the scope of e-credentialing systems to include other credentials (intrastate vehicles, international vehicles, operating authority and insurance filings, hazmat and other special permits and toll and screening program enrollment).

PROGRAM, continued

- Complete development of standard protocols for the **paperless exchange** of **freight** movement information between companies, across modes and with regulatory agencies where appropriate. Coordinate this program closely with international standards efforts to ensure that results will be accepted globally.
- Encourage the development of **standards** for dedicated short-range communications (DSRC) to facilitate programs such as uniform electronic mobile payment and motor carrier public safety.
- Establish a program to encourage all modes of surface (and air) transportation to adopt a **uniform approach** for vehicle, rail car and container location, so that shipments can be located wherever they may be in the shipping pipeline. The program needs to include outreach to companies and associations to communicate the benefits of adopting this technology.
- Establish a program to make **transit information** such as routes, stops, fares and schedules and current status available for all major transit properties easily accessible, in a common format and using standard protocols. The program will also determine and implement the appropriate method for characterizing and communicating schedule adherence.
- Deploy a National Surface Transportation **Weather Observing System** that will coordinate current surface/subsurface observing systems to make them part of the Integrated Network of Transportation Information. The system needs to include fixed and mobile sensing. Its observations will be the basis for all surface transportation weather information, whether used directly for spot warnings or for prediction.
- Initiate a program to explore the potential of the Integrated Network of Transportation Information for **improving** the **mobility** of the transportation-disadvantaged. The program could include the development of new service concepts like personal travel trackers and information devices, audible signs and enhanced paratransit and health and human service transportation provider service integration. It would also include the testing, evaluation, deployment and support of the services and the preparation of best practices and guidance materials describing successes.
- Provide for the **integration** of rail ITS, ITS pedestrian support, weather, intermodal freight, public safety (emergency/disaster coordination, enforcement) and other new services into the definition of ITS. This needs to include the exploration and development of new User Services as appropriate, the incorporation of the new services into the National ITS Architecture and development of any standards needed for their implementation. It should also include additional case studies, evaluation and outreach for the modifications to the Architecture as they are made.
- Encourage forums to **resolve** the respective **roles** of public and private traveler information providers.
- Define guidance on using information technologies to meet **Americans with Disabilities** Act (ADA) requirements.
- Bring together the automotive and location technology industries with users of the data to create a common standard for **communicating** vehicle-based **information to the infrastructure.** This program will define the types of data to be collected and communicated, the quality attributes of that data and the frequency and format of data sharing.

PROGRAM, continued

- **Government,** at all levels, should take a **leadership** role in installing ITS technology in the vehicles it buys and uses. Such equipment will save lives, time and money for the users of the vehicles and their employers/sponsors. It will provide a significant part of the vehicle base for gathering probe data. It will help jump-start the market for private installation of ITS equipment, both by setting an example and by advancing the cost learning curve for this technology more rapidly.

- Where private telematics suppliers can serve as suppliers of information that would otherwise need to be gathered at government expense, government should consider **defraying the cost** of this data collection, either through appropriate information purchases directly from suppliers, or by subsidizing the cost of in-vehicle hardware.
- Revisit the ITS architecture with a view to the specific protection of personal **privacy.**
- Identify requirements for **interfaces** between operational transportation systems and public safety systems.

INSTITUTIONAL

- **Build** the national **consensus** that recognizes the necessity and value of an Integrated Network of Transportation Information. This involves building a coalition of public sector planners and infrastructure managers, commercial vehicle operators, major shippers, public transit authorities, automotive manufacturers, automotive electronics manufacturers, railroads and advocacy groups for automobile drivers and individual travelers in all modes.
- Establish guidelines for deployment of **black boxes,** including, for example, their use for assignment of responsibility for accidents and protection of privacy. This may require legislative changes.
- Determine the **privacy policies** needed to assure cooperative buy-in to participation in an Integrated Network of Transportation Information.
- **Reach out** to companies and organizations in the freight industry that have not been involved in ITS. Institutional barriers are the primary stumbling blocks to seamless, end-to-end, efficient freight movement. These barriers cannot be effectively overcome until all the sectors involved come together to resolve the issues.
- Reach out to the public safety community to assure a high level of communication and interface to support emergency and **disaster response.**
- Reach out to national security agencies to assure effective **coordination** of activities and information, especially **in times of crisis.**

ARCHITECTURE and STANDARDS

>>ARCHITECTURE The National ITS Architecture has been a cornerstone of the ITS program, providing a common frame of reference for the development of ITS. The architecture has been widely imitated by ITS programs in other parts of the world, providing considerable global consistency in terms of subsystems, centers, information flows and external interfaces. Federal rules are now in place mandating the development of and use of regional architectures based on the National ITS Architecture, in order to draw on Highway Trust Funds for ITS projects. Now approaching its fourth version, the National ITS Architecture is one of the few true "living documents" in the ITS world.

The National ITS Architecture is updated to reflect ITS as it evolves. This Architecture evolution is possible because of its functional nature and technology independence making it flexible and applicable for technologies of today and tomorrow. As a result of the existing Federal rules and the application of the National ITS Architecture in support to regional and local ITS planning and deployment, it is important that the National ITS Architecture continue to evolve and support ITS stakeholders. This continued evolution will continually focus the ITS industry's vision on the future and make possible the integrated and interoperable foundations that will make this Plan successful.

>>STANDARDS The ITS standards program has been notably successful in turning out industry consensus standards relevant both to public sector infrastructure concerns (e.g., NTCIP) and private sector technology development (e.g., ITS Databus). In a very multidisciplinary environment, there has been excellent cooperation and synergy among multiple standards development organizations (SDOs), with the support of ITS America.

However, in recent years, federal support for ITS standards development has begun to shift to funding for standards deployment and outreach and private sector participation has diminished in some areas, due to the downturn in the economy and, at least sometimes, in response to the relatively slow speed of standards development. American ITS standards efforts on an international level have been challenged by a playing field that many feel is seriously tilted to our disadvantage. The industry needs to explore the standards development approaches that are most appropriate for pursuing interoperability and lowering system lifecycle costs, with particular attention to re-engaging automotive manufacturers and first-tier suppliers in the process and to actively pursuing an international standards environment in which American interests are fairly considered.

Advanced Crash Avoidance Technologies

Current Status + Opportunities

>>Transportation-related safety is clearly more than safe driving. Constant, ongoing attention is needed to improve safety for pedestrians, cyclists, train and transit system riders and the operators and occupants of all kinds of vehicles from farm equipment to high-speed trains. However, the sheer number of fatalities and injuries related to road travel makes a strong argument for a coordinated national initiative to make driving safer.

Significant progress has already been made in reducing the number of deaths and injuries on the nation's highways. More than a quarter of a million lives and over $700 billion have been saved over the last four decades through vehicle safety improvements and fundamental changes in driver behavior. However, despite this progress, more than 40,000 Americans die in six million crashes each year. Driver error remains the leading cause of crashes, cited in more than 80% of police crash reports. ITS can shift the paradigm from helping occupants to survive a crash to helping the vehicle operator avoid the crash in the first place. In-vehicle and infrastructure cooperative systems can help drivers avoid hazardous mistakes by minimizing distraction, helping in degraded driving conditions and providing warnings or control in imminent crash situations. ITS can also encourage better driver behavior through automated enforcement of driver licensing and traffic laws.

Making driving safer will require a high level of productive cooperation between all sectors of the economy:

- Vehicle manufacturers and their suppliers are actively at work developing in-vehicle products to make the vehicle safer, with electronic devices whose reflexes are quicker than people's and which can compensate for at least some driver error. Map database vendors are working on the digital maps that are needed, in the short and medium term, to enhance the performance of safety and convenience devices like adaptive cruise control, self-aiming headlights, curve warnings, vision enhancement and road/lane departure warnings; and in the long term for collision and road/lane departure prevention.
- Infrastructure managers and their suppliers are actively engaged in providing better traffic control and information devices and in creating better networks to link these devices to traffic control centers and to link control, operations and response centers to one another. (See Programmatic Theme 4, "Advanced Transportation Management," for additional discussion.)
- The federal government, in cooperation with public- and private-sector organizations, is sponsoring research to better understand driver behavior, ensure the safety of in-vehicle information systems and improve the effectiveness of advanced crash avoidance technologies.

CRASH STATISTICS

Run Off Road - 30% of all fatalities
Intersections - 50% of all crashes
Pedestrian/Bicycle - 14% of fatalities
Speed - involved in 30% of all crashes
Human Factors - drivers a causal factor for at least 80% of all crashes

A collision warning sensor with a lighted graphic link to the rear view mirror detects obstacles in the adjacent lane.

There are a variety of potentially fruitful avenues to pursue safer travel through advanced technology for which additional research is needed.

U.S. DOT is focusing attention and resources on evaluating the effectiveness and operability of advanced crash avoidance technologies for passenger cars, commercial vehicles, transit vehicles and specialty vehicles through the Intelligent Vehicle Initiative (IVI). Field operational tests are being conducted on numerous technologies:

- Forward collision avoidance and adaptive cruise control.
- Rollover stability warning and control.
- Obstacle detection and infrastructure-assisted hazard warning.
- Use of radio-navigation, including the National Differential Global Positioning System (NDGPS), to help precisely locate vehicles.
- Lane departure warning.
- Alternative mechanisms to deliver warnings to drivers including head-up displays and warnings that are heard or felt as well as seen.
- Electronic braking systems.

In addition, various standards-making organizations like the Society of Automotive Engineers (SAE) and the International Standards Organization (ISO) are currently undertaking or planning to develop operational standards or guidelines for the use of such advanced vehicle control and safety systems. In a few cases, standards development is moving ahead before the widespread introduction of these systems to the market, but this is not true in all cases. Due to the proprietary nature of product development and wariness of producers toward regulation, it is sometimes difficult to achieve timely consensus on standards for these advanced systems. Additional areas where further gains can be made include understanding consumer acceptance for automated or partial-control systems, system usability, integration of multiple interfaces and systems, alternative modality warnings, privacy concerns and infrastructure oversight and maintenance for cooperative systems.

This Plan contends that because of the magnitude of the potential public good – the saving of thousands of lives and billions of dollars each year through safer road travel and preventing millions of injuries – concerted national action and cooperation are recommended. Great care and selectivity must be exercised in identifying areas for cooperation, especially among private sector competitors. Competition fuels too many advances in productivity and quality to be lightly trifled with. However, the careful identification of technologies and approaches that can be placed in the precompetitive arena can go a long way to realizing the safety benefits that are invariably at the top of the list of ITS priorities.

In addition, this Plan contends that once technology for enhancing safety is reliably available, the public sector has a strong fiscal and moral obligation to take the lead in adopting this technology and in creating incentives for its adoption by others.

In recent years, motor vehicle crashes have resulted in more than 40,000 fatalities and over 3 million injuries each year. ITS can help to eliminate a large fraction of these crashes through several techniques:

- The development, integration and deployment of a new generation of in-vehicle electronics.
- Better vehicle-infrastructure cooperation.
- Mechanisms that can determine fitness to drive.
- Selective automated enforcement.

IN-VEHICLE ELECTRONICS, VEHICLE-INFRASTRUCTURE COOPERATION and INFRASTRUCTURE-BASED TECHNOLOGY

Individual in-vehicle products are already coming to market, but realizing the full benefit of this electronics revolution will require significant advances in system integration, in our current understanding of human factors and in practices and institutions which currently impede universal product consistency and rapid, widespread product deployment.

To guide further consideration, there are at least four kinds of in-vehicle electronics products that are of interest:

- Information products (e.g., route guidance, traffic advisories, in-vehicle signing).
- Diagnostic/prognostic products (e.g., low-tire pressure or fluid-level warnings, engine monitoring, cargo security and stability).
- Driver assistance products (e.g., curve speed warning, collision warning, adaptive cruise control, stability control, traction control, lane departure warning).
- Active safety products (e.g., forward and rear collision avoidance, intersection collision avoidance, lane departure prevention), many of which will be facilitated by vehicle-vehicle cooperation.

Many of the applications provided through these products depend on or will perform better given an inbound stream of information on traffic conditions, roadway conditions, weather from a central facility or from other nearby vehicles. In many cases, these same applications and vehicles are the most reliable, most cost-effective and most readily deployed means to gather the raw data that feeds the creation of the information streams. With appropriate sensors on board, road vehicles serving as probes will often be the best single source of information on current road and traffic conditions and weather. Other sources, including road instrumentation, general surveillance and conventional weather reporting, will round out this data.

More generally, the performance of at least some of these in-vehicle products can be enhanced or leveraged by infrastructure-based sensors and information exchange:

- Cooperative intersection decision support, intersection collision warning and avoidance.
- Cooperative highway-rail intersection (HRI) warnings and crash avoidance.
- Cooperative lane departure warning, lane guidance and lane keeping.
- Use of the Nationwide Differential Global Positioning System (NDGPS), now being rolled out, for better geolocation.
- Use of dedicated short-range communications to support infrastructure-vehicle and vehicle-vehicle communications, particularly in the 5.9GHz band allocated by the Federal Communications Commission (FCC) for ITS safety applications.
- Use of on-board diagnostic systems as input to the roadside inspection process for commercial vehicles.

In addition, recognizing that it will probably be many years before an appreciable fraction of the overall vehicle fleet is equipped with advanced electronics, safety can be enhanced by purely infrastructure-based technology that provide better and more responsive information, warning and traffic control messages to all vehicles via dynamic message signs and other roadside devices.

DRIVER QUALIFICATION

The majority of crashes are ultimately attributable to operator failure, ranging from simple misjudgment to dozing off during a monotonous trip to driving while drug-impaired. A large fraction of fatal crashes include at least one driver who is alcohol- or drug-impaired. A disproportionate number of crashes involve a driver who is unlicensed or whose license has been revoked or suspended.

Technology is also available, though largely undeployed, to assure that an operator is appropriately licensed, unimpaired and alert. Appropriate licensing can be assured by positive identification techniques (fingerprint recognition, retinal scan, voiceprint) cross-checked in real-time against licensing authority records. More simply, but less reliably, engaging the ignition could require the insertion of a valid, machine-readable operator's license in a dashboard slot. Drug-free, alcohol-free, adequately alert conditions can be enforced through simple in-vehicle tests ranging from "push the buttons in the right order" to breathalyzers. Alertness and fitness can be monitored enroute by such techniques as tracking eye movement and steering behavior.

Social issues are more difficult. Technology for preventing drug/alcohol impaired people from operating a vehicle requires no particular scientific breakthroughs (although cost is clearly an issue). So while alcohol/drug impairment is implicated in nearly half of all fatal accidents, a social commitment strong enough to overcome the funding issues has not yet been fully realized.

AUTOMATED ENFORCEMENT

Automated enforcement of traffic laws via surveillance and sensing, if carefully and legally applied, also has the potential to eliminate many crashes. Automated enforcement encourages safe and responsible driving behavior, by imposing sanctions on drivers whose driving is not safe or responsible.

Often, crashes result from the violation of some motor vehicle code by at least one driver. The most common violations are speeding, tailgating, traffic-signal and stop-sign violations, driving under the influence of alcohol and crossing a highway-rail intersection while signals are flashing and the gates are down. Spot enforcement programs aimed at these and other violations have been effective, but they divert police personnel from other public safety priorities and are costly.

Advances in technology for vehicle detection and surveillance make it possible to automate aspects of enforcing motor vehicle laws. For example, cameras at signalized intersections can capture images of motorists running red lights, which can accompany citations sent to the offending motorist. Similar systems are available to enforce highway-rail intersection restrictions and speed limits.

While much of this needed technology already exists, there continue to be opportunities for further advances and applications. New and better technology will come from private industry. Federal and local governments will have to define boundaries for deployment.

Advanced Crash Avoidance Technologies

Benefits

IN-VEHICLE ELECTRONICS, VEHICLE-INFRASTRUCTURE COOPERATION and INFRASTRUCTURE-BASED TECHNOLOGY

>>Advanced driver assistance systems, active safety systems, cooperative vehicle-highway technology and infrastructure-based warning and information systems currently offer a greater promise of improved safety, enhanced mobility and greater efficiency in the near and medium term. Of these, the greatest impact will be in the safety arena, moving the safety emphasis from crash mitigation to crash avoidance. This will be accomplished through a combination of sensors, driver assists and selective operational intervention to provide such functionality as: stability control, traction control, vision enhancement (including night or fog assistance), driver drowsiness alerts, adaptive cruise control, self-aiming headlights, curve warnings, lane departure and road departure warnings and prevention, forward, side and rear obstacle detection, collision warning and prevention systems, intersection collision warning, construction zone, pedestrian crossing and highway-rail intersection warnings and aids to compensate for the slower reflexes and less acute eyesight of elderly and physically impaired drivers and for the lack of experience and potential lack of seasoned judgment of younger or newer drivers. Some of this technology will be particularly valuable for preventing single-vehicle rural crashes and crashes involving commercial vehicles.

Getting the maximum benefit from these products depends on their ability to adapt to the general characteristics and current condition of individual drivers and to the current driving environment. Safety systems need to respond differently for an alert and experienced 30-year old driver on an open road in good weather than for an elderly driver on crowded urban freeways during an after-dark snowstorm. This kind of adaptability can potentially provide additional access and mobility for elderly, disabled and other special situation drivers. In addition to creating a safer driving experience for these drivers, such aids also empower elderly and physically impaired drivers to travel in their own vehicles at times and in circumstances (e.g., night, winter) that might otherwise be daunting, unacceptably stressful, or physically impossible. It should be noted that by developing systems that improve usability for challenged drivers, the performance of all drivers would be enhanced. This can be accomplished by gaining an understanding for humans' fundamental capabilities and limitations in the driving task.

Adaptive in-vehicle electronics can also help to save fuel and reduce emissions by smoothing acceleration and deceleration (particularly for commercial vehicles and transit vehicles), automatically handling stop-and-go driving, anticipating and adjusting the throttle and transmission for varying road conditions and terrain and

by safely enabling small platoons of tightly spaced trucks, transit and other vehicles. In the long run, safer vehicles could permit lighter-weight vehicles for greater fuel economy. Route guidance products which help drivers to plan and follow an optimal route can significantly reduce miles driven (thereby saving fuel and helping to mitigate congestion), reduce the stress of unassisted route-following (safety and quality-of-life benefits) and help drivers avoid sudden maneuvers and unfavorable traffic or road conditions (safety benefits). It is clearly undesirable, however, for drivers to lose their situational awareness in the driving environment because of distraction or overload from these in-vehicle systems. It would be similarly undesirable for drivers to become overly dependent on an automated system to the extent that they engage in risk compensation behavior by assuming that the system will always keep them safe. A primary challenge, then, is to balance the safety benefits and the risks of these driver-assistance systems.

The basic premise of ITS is that it saves lives, time and money. The safer driving technologies described above have enormous promise to enable savings on all three of these scales, especially if the public sector *adopts* safety-enhancing systems on the vehicles it uses and creates incentives for the adoption of such systems by others. By doing so, they will save themselves time and money and help to safeguard the lives and well-being of their own staffs.

DRIVER QUALIFICATION

Development and rigorous application of driver/operator qualification measures could, in principle, result in the elimination (or at least a reduction in severity) of 50% of fatal crashes. While this level of rigor is unlikely, at least in the foreseeable future, qualifying commercial and public transportation drivers is both feasible and likely to have some positive benefit.

AUTOMATED ENFORCEMENT

Crashes could be significantly reduced through automated enforcement. The proper intent of these systems is to reduce violations by modifying driver behavior. If motorists know they will be reliably caught and fined for violating a traffic rule at a particular location, they are less likely to commit that violation at that location. In addition, carry-over behavior modification is expected in similar situations even where there is no automated enforcement. Early evaluations of red-light-running camera programs indicate that violations decrease over time and related crashes at intersections are reduced by about 15 percent.

Advanced Crash Avoidance Technologies

Challenges

- **System Integration** An increasing trend over the past several years is for vehicle manufacturers to acquire standalone turnkey products from first-tier suppliers that can be independently incorporated into the vehicle to increase its functionality. This trend is likely to continue. However, the role of the vehicle manufacturer as system integrator becomes particularly important when multiple independent suppliers provide the multiple active safety systems that are intended to take temporary control over critical vehicle functions (e.g., steering and brakes). Products need to be integrated into an environment which includes an overall control structure to mediate among competing products (e.g., in an emergency situation when stability control, traction control and collision-avoidance products are all attempting to use the brakes) to produce a uniform, sensible response. Interfaces, controls, displays and warnings also need to be consistent across systems. For example, an urgent auditory safety alert in one system must not be confused with a ringing cell phone.

  In addition, for reasonable economy, components (like sensors and external communications devices) must not be duplicated for each product. Rather, a single instance of each relevant device must be present for consistent as-needed use by multiple information, warning, assistance and safety products. This kind of system integration is a technological, organizational and commercial challenge.

- **Information Requirements** It will be a challenge to acquire and deliver sufficient information about the status of the roads for in-vehicle systems to perform successfully. Infrastructure-based sensors will be valuable where already installed and some expansion of this sensor base can be expected. However, the burden of information gathering can most readily be borne by vehicle-based sensors (probes), especially along primary and secondary arterials. This raises issues of information integrity, data sharing and privacy. Anticipating terrain changes, not just responding to them upon arrival, requires an accurate three-dimensional digital road map. Anticipating road conditions requires widespread collection, analysis and retransmission to approaching vehicles of probe data.

IN-VEHICLE ELECTRONICS

- **Standards** A critical factor for successful deployment of these systems is the development of standards for vehicle-to-vehicle and vehicle-to-roadside communications, as well as standards for on-board placement of equipment and driver message sets. In addition, for this information to most effectively influence commercial vehicle operations, standards are needed for sharing traffic, weather, roadway and other information with the dispatcher as well as the driver.

- **Adaptability** An important aspect of the user interface is to make it "environmentally adaptive," so that driver condition and driving conditions are taken into account in determining the discretionary functionality and the information streams that are made available to the driver. The electronic control logic and messages provided by the vehicle need to be carefully adjusted to the specific requirements of the driver as well as to the driver's situation. This applies generally, but it is particularly important when dealing with ranges of abilities and disabilities. Vehicle electronics must be capable of being dynamically retuned for varying environmental circumstances (e.g., day vs. night, dry vs. wet vs. slippery pavement, low sun directly ahead or behind), varying driving circumstances (e.g., rural vs. urban roads, congested vs. freely flowing traffic, straight driving vs. complex exit/ramp configuration) and for different drivers of the same vehicle.

- **Sensing in Cluttered Environments** Collision avoidance in urban environments can be especially difficult because of "clutter" in the scene. It can be difficult to distinguish collision hazards (vehicles, pedestrians and obstacles in the roadway) from nearby safe objects (roadside signs, pedestrians on the sidewalk, parked cars). Collision warning and avoidance systems for urban areas will need sophisticated in-vehicle sensors that can detect objects around the vehicle, characterize them and predict their trajectories along with the trajectory of the equipped vehicle. Reliable, high-speed algorithms will have to assess the likelihood of collision and either generate appropriate warnings or take evasive action.
- **Human Factors 1 — User Interface** A primary challenge for the new in-vehicle products is incorporating an overall in-vehicle user interface that informs, supports and assists but does not overwhelm or overload the driver. At present, the "Driver Distraction/Driver Focus" issue is a hot topic, but its solution is not known and approaches to pursue solutions are not coordinated. Multiple state and local jurisdictions are addressing various aspects of driver distraction in a totally uncoordinated and, too often, uninformed fashion. Although standards development organizations (SDOs) are addressing this topic, the standards development process can be lengthy and frequently follows products' introduction to market. This issue is further complicated by the number of vehicle, driver and environmental variables that affect safe driving behavior, as well as concerns about proprietary product design and personal freedom. Only by following sound human-factor principles of consistency and usability can the challenge of interface design be successfully addressed.
- **Human Factors 2 — Compensation, Acceptance** Introducing products with the potential to compensate for driver limitations, driver errors, or adverse conditions has the potential to encourage risk-taking behavior by drivers. In addition, introducing products that assume some amount of control of the vehicle will require significant consciousness-raising to be accepted. The transition between automated and manual control also needs to be evaluated more thoroughly. A safe balance must be struck between a system assisting the driver and its completely taking over from the driver. Ultimately, the vehicle operator must retain some degree of control and responsibility.
- **Human Factors 3 — Consistency in Human Interface** There is a compelling case for consistency across vehicles in the behavior of at least some classes of in-vehicle safety products. While it is probably not necessary for all information (e.g., route guidance, traffic information, routine traveler information) to be presented identically, some interactions should always be consistent and predictable. Otherwise, making use of multiple in-vehicle systems (perhaps sharing a common display), or changing from one vehicle to another, means potentially being confronted with a different suite of safety-critical, time-critical cues. The behavior of active safety systems in specific circumstances, the form and meaning of warnings, whether visual, audible, or haptic, must be consistent from model to model, make to make, country to country. Vehicle manufacturers must be persuaded that for critical human factors aspects of safety systems (in particular), the need for consistency outweighs the need for product differentiation.

- **Exploiting Gathered Data** Over the next 5–7 years, telematics providers will start to collect a large volume of data from their customer vehicles both on traffic status and on the condition of the roads, to support active safety products. A large amount of information will be collected, with many potential side-benefits. For example, condition-of-the-roads data will include air temperature, pavement temperature, pavement slipperiness and roughness and precipitation. This could be the source for much of the information needed by the new Maintenance and Construction Operations (MCO) User Service of the National ITS Architecture as well as the source for very precise, micro-area weather forecasting. However, no mechanisms are currently being contemplated for developing the relationships through which road-responsible and weather-responsible public agencies can have this information made available to them. It is critical to maintain a philosophical and program-management connection between the Integrated Network of Transportation Information and Advanced Crash Avoidance Technologies.
- **Antitrust Concerns** Antitrust concerns may be an obstacle to vehicle manufacturer cooperation and to the establishment of joint multi-company research and development efforts to assure the uniformity of behavior of and user interface to the systems.
- **Liability Concerns** Liability concerns may be an obstacle to the prompt, responsible deployment of the new generation of in-vehicle electronics, unnecessarily postponing their benefits, including the reduction of fatalities. This is generally recognized as being a far more acute problem in the United States than elsewhere in the world.

Improving safety and quality of life for all citizens.

DRIVER QUALIFICATION

- **Driver Qualification Issue is Social, Not Technical** Are we prepared to demand that drivers, whether of private passenger cars or of commercial vehicles, public transit vehicles, or trains, demonstrate their credentials and unimpaired status on a routine, proactive basis? So far, the answer has been "no."

  Although there are laws and regulations forbidding the impaired operation of a vehicle and providing, in many cases, significant sanctions for doing so, enforcement is always after the fact of driving impaired, either via observation of driving behavior or, too often, in investigating a crash. It does not presently appear to be socially viable to check operator credentials on the fly, or to do real-time verification that the operator is unimpaired by drugs or alcohol.

  While it would potentially be easier to get professional operators to agree to the introduction of qualifying technology as a condition of employment, they are arguably not the driver group that presents the greatest problem either in terms of behavior or relative strength in the population. At minimum, different standards should exist and different opportunities probably will exist for implementing driver qualification technology for professional drivers (of commercial, public transit and public safety vehicles) vs. private drivers of passenger cars.

- **Complicating Factor** The driver-qualification issue is complicated by a number of potential extenuating circumstances. Should an unlicensed or arguably impaired driver be allowed to drive in an emergency (e.g., to escape from a tornado, to get a badly injured person to a hospital where ambulance service is not readily available)? How is the state of emergency to be determined? In addition, level of qualification can change en-route, for example through drinking while driving or through the onset of a medical condition (seizure, heart attack). Mechanisms for the safe and reliable resolution of these situations are even less obvious.

AUTOMATED ENFORCEMENT

- **Public Acceptance of Automated Enforcement** The deployment of automated enforcement systems will be limited by the level at which the public accepts them. The "Big Brother is Watching" syndrome is likely to play heavily in the mind of the public and of legislators who can prevent their deployment. Already some states are limiting and even forbidding automated photo-enforcement programs at red lights. The public and their legislators may be more willing to accept automated enforcement systems if a direct correlation between these systems and their safety can be made.

Advanced Crash Avoidance Technologies

Actions

RESEARCH

- Establish a concerted program of joint public-private sector **pre-competitive research** through which vehicle manufacturers and suppliers can explore industry-wide approaches to safely **integrating in-vehicle electronics** (including passenger cars, transit vehicles, commercial vehicles and specialty vehicles). Addressing manufacturers' proprietary and competitive concerns is an important component of this effort.
- Establish a concerted **international** program of **research** that comprehensively addresses driver behavior. Such a program must be aimed at prescribing a **consistent human interface** both within a single vehicle and across vehicle lines and models. The program must address such issues as situational awareness, driver distraction, focus and workload and mechanisms to discourage risk compensation. Such research needs to be conducted primarily by vehicle manufacturers from at least the United States, Europe and Japan, with the participation and assistance of appropriate academic, private and government research establishments. In many cases, the United States may find that other global sectors are far ahead in pursuing this kind of research and that the primary orchestration may be of our own participation in these efforts. U.S. DOT may need to engage the assistance of other executive departments (notably State and Commerce) as well as national research leaders (the National Science Foundation, the Transportation Research Board and the National Institute of Science and Technology) to help create an effective international program.
- Explore the institutional and societal **impediments** to automated enforcement, including public acceptance, costs, benefits and technical issues. The object of the research is to develop guidelines for state and local agencies for deploying automated enforcement systems, including the continued development of a model program for integrating the efforts of the highway/traffic, police and judicial departments.
- Undertake a formal study of **attitudes** toward the introduction of driver/operator **qualification technology.** To be viable, such a study would probably need to respond to a congressional mandate. Study the actual costs and benefits of introducing various kinds of operator qualification technology.
- Determine the most cost-effective data for identifying **high-risk** commercial **drivers,** as well as the carriers that tend to employ these drivers. Develop algorithms for using commercial driver's license convictions, prior personal driver's license convictions, citation data and inspection report violations to evaluate driver performance. Explore legal and privacy issues related to development and sharing of these commercial driver's profiles.
- Develop **on-board technologies** to alert commercial and passenger car drivers about passenger cars that are not operating safely around large trucks.
- Research the characteristics and viability of **cooperative collision warning** systems that include both vehicle and infrastructure elements (such as intersection collision warnings).

RESEARCH, continued

- Explore the technical and social aspects of developing and implementing automated recording systems for violation enforcement.
- Continue and expand the current Intelligent Vehicle Initiative program to evaluate future applications and generations of advanced ITS systems. The U.S. DOT program should include participation by relevant public and private organizations and should complete several actions:
  - Continue to collect baseline driving data under naturalistic conditions. This will provide critical information to assist developers of advanced driver assistance systems.
  - Continue research on driver distraction and the performance specifications for next generation crash avoidance systems.
  - Continue Field Operation Tests (FOTs) of Next Generation Crash Avoidance Systems. Complete the current FOTs and start a new series of FOTs that explore infrastructure cooperation, vehicle-to-vehicle communications and other technology advancements.

PROGRAM

- Mount a campaign of public outreach and education on the safety, efficiency and mobility benefits of the new ITS products and how to use them properly. Among other things, the program should discourage risk compensation and encourage the acceptance of electronic co-pilot assistance.
- Encourage public agencies to lead by example and help jump-start the market by specifying the inclusion of safety-, efficiency- and economy-enhancing ITS products in the Federal fleet and by creating incentives for state and local public agencies and for companies operating van pools to do the same.
- Encourage deployment and adoption of safety-enhancing ITS technologies via direct subsidies or by reducing taxes on vehicles that are purchased with appropriate safety products. Encourage insurance companies to consider ITS safety-enhancing technologies in determining premiums.
- Determine specific data needs and establish the sensor, software and communications structures for the widespread collection of probe data relating to traffic conditions, road and weather conditions and work with map database suppliers to create the three-dimensional data needed to refine and enhance data collection. Mechanisms need to be established to assure the quality and promote the sharing of this data. Where the gathering of such information clearly advances the development and maintenance of a national Integrated Network of Transportation Information (or serves other worthy public purposes), U.S. DOT should consider defraying the cost of such data gathering, especially if the private collection of this information reasonably obviates an otherwise expensive public sector undertaking.

PROGRAM, continued

- The **cost-justification** for widespread inclusion of in-vehicle safety systems often depends on recognizing the **collateral economic benefits** of the suite of in-vehicle electronics, like better vehicle performance and economy. Therefore, consider the reformation of the Corporate Average Fuel Economy (CAFE) calculation to provide credit for the inclusion of ITS products that produce real-world fuel economy benefits that would not show up on traditional dynamometer tests:
  - **Fuel economy** benefits of in-vehicle electronics, which anticipate terrain changes and smooth acceleration and deceleration.
  - Fuel economy benefits of route guidance products which reduce non-optimal route-planning and route-following, potentially **saving** up to 10% of **miles driven** and proportional amounts of fuel consumption.

  As part of this reformation, consider the use of advanced driving simulators as a way to estimate real-world fuel economy.
- Ensure that **requirements for** vehicle-infrastructure and vehicle-vehicle **communications** are well represented in the standards organizations and consortia that are developing relevant wireless protocols.
- Explore the possibility of creating **incentives** or subsidies for the deployment and use of safety devices, to advance the price learning curve and make safety devices available more quickly and more broadly.
- If automated enforcement is shown to be an effective tool in reducing crashes, develop a comprehensive **program to inform** the motoring public and legislators of the value of automated enforcement and provide model programs for their deployment.
- **Update** the National ITS **Architecture** to improve the areas of Highway-Rail Intersection (HRI) Safety and Automated Traffic Enforcement. HRI safety can be expanded to cover better coordination between the train and road traffic. Automated Traffic Enforcement is currently not in the architecture. Both issues will require stake-holder buy-in that has traditionally been hard to achieve.
- Conduct a campaign of education on the **costs of** permitting **unqualified drivers** to operate vehicles and the benefits of containing this behavior.
- Undertake pilot programs on the use of **operator-qualification** technology to determine efficacy and acceptance.
- Encourage the coordination of **Intelligent Railroad Systems** activities with the ITS program and the incorporation of freight, intercity passenger and commuter railroads as new categories to be addressed in the ITS program and architecture.
- With an appropriate Congressional mandate, initiate the development of specific systems for **operator identification** and **license verification** to be made available to the states.

INSTITUTIONAL

- Formulate and conduct a campaign to address **adjustments to antitrust rules,** as needed to enable vehicle manufacturers and their suppliers to engage in research that will lead to a robust, consistent, well-integrated system of in-vehicle electronics to promote safety, efficiency and mobility.
- Formulate and lead a campaign to contain the risk of introducing safety-enhancing in-vehicle electronics into the marketplace. It is understood that no product is perfect and that people suffering damages are entitled to be made whole. However, the absence of **reasonable constraints** on **product liability** will result in delaying the introduction and widespread deployment of ITS products that are demonstrated to have a significant net-positive effect on safety.
- Build **mutually beneficial relationships** between the public sector and telematics providers. Public agencies can assist telematics providers in gathering certain varieties of traffic and road planning data. Telematics providers will be able to provide public agencies with a wealth of data on traffic conditions, road conditions and weather conditions. Getting effective relationships built sooner rather than later will help to advance the programs of both the private and public sector.

Lane tracking devices with magnets along a test route.

3M's lane tracking hardware.

Automated Crash and Incident Detection, Notification and Response

Current Status + Opportunities

>>Getting to the scene of a crash or other injury-producing incident by emergency response teams as quickly as possible is critical to saving lives. The shorter the time to medical treatment, the greater the likelihood of recovery. To speed the delivery of medical care, it must be possible for public safety providers – police, fire, emergency medical services, both on-scene and at hospital emergency centers, to:

- Receive timely notice of the incident, including its precise location and other characteristics.
- Be efficiently routed to the scene and to the hospital.
- Be aware of and able to share the apparent nature and degree of the injuries to tailor the response.

In addition, an effective response includes safely managing the flow of traffic at the scene of an incident while the injured are being tended and the site is being cleared and completing the clearance to return traffic to normal as rapidly and safely as possible.

New information technology options, growing public and political support and new funding mechanisms create unprecedented opportunity for more integrated public safety and transportation operations. Transportation and public safety agencies can dramatically improve community emergency response and incident management capabilities while saving money and improving transportation efficiency.

ITS technologies coupled with computer-aided dispatch, wireless communications, records management systems, private call centers and web sites can be used to achieve these objectives. ITS technologies both external to the vehicle (i.e., surveillance systems) and within the vehicle (crash sensors and mayday systems) can be used to immediately detect and locate a crash or other incident. The information about the event, including its precise location and its severity, can be automatically and immediately communicated to emergency medical service (EMS) providers.

Traffic-sensitive route planning software can identify which EMS unit among those available and appropriate for this kind of incident is the shortest travel time from the accident site. Route guidance software can efficiently direct the unit to the scene, with the way cleared and the trip speeded by emergency vehicle signal preemption and other traffic control mechanisms.

At the scene, direct audio and video communication with the trauma center and wireless diagnostic devices can provide the EMS team with instructions on immediate treatment. These technologies exist and are being further developed. In addition, however, interagency operations and communications must be made seamless to avoid unnecessary delays or confusions. Linkages are also needed between private sector telematics providers, public safety answering points (PSAPs), EMS providers and traffic management centers.

When an incident involves hazardous materials, similar technology can be brought to bear to identify the cargo, speed appropriate response teams to the site, reroute traffic, conduct evacuations where needed and contain and clean up spills. Technologies and systems being developed by the individual modes can be integrated to ensure that hazardous cargo is visible throughout the freight system and that the contents of hazardous spills are identified as soon as possible following incidents.

Broader partnerships among transportation and public safety agencies are the key to realizing communications and information system integration opportunities through which better incident response will be achieved. Several partners will participate:

- Traffic management agencies.
- Emergency medical services.
- Fire and rescue agencies.
- Emergency communications agencies.
- Carriers of hazardous materials.
- Law enforcement agencies.
- Towing and recovery companies.

Transit also plays a significant role in emergency responses, particularly in disaster or terrorist-induced situations. Transit has played significant roles in necessary evacuation caused by hurricanes, floods and earthquakes.

"Interagency cooperation has been our biggest ally in putting together our incident management and response program. It has improved cooperation among agencies by 100 percent. Response times have decreased by 40 percent with cooperation among agencies."

Jerry Althauser, Washington State DOT

Automated Crash and Incident Detection, Notification and Response

Benefits

>>Automatic crash detection and response systems can save lives and reduce the severity of injuries by enabling faster, more situation-sensitive response, more responsive assessment and treatment at the scene and prompt appropriate transportation to and from fixed emergency-care facilities.

Public safety personnel and equipment can be deployed more efficiently through automation and coordination of activities across different agencies, reducing the overall costs of providing these services.

A variety of secondary benefits will also be realized. Knowing incident specifics (e.g., severity, nature of injuries, location relative to traffic) helps to initiate the appropriate response level (e.g., using lights and sirens only when needed). Getting to and clearing an accident scene more swiftly, without compromising the care of the injured, minimizes additional congestion and helps get traffic back to normal more quickly. This has the effect of reducing the risk of collateral crashes and the exposure of responding personnel, shortening delays and ameliorating congestion-related fuel consumption and air pollution. Similarly, containing and clearing spills of hazardous materials more swiftly helps to reduce dangers to life and property and minimizes the impact on the environment.

Specific technologies currently being developed, tested and evaluated can improve:

- Incident detection and notification.
- Incident response time through more efficient dispatch operations and more efficient movement of emergency vehicles through traffic.
- Emergency medical services (EMS) through real-time voice, visual and data communications linking:
  - Crashed vehicles.
  - Dispatchers.
  - Ambulances, fire and rescue, law enforcement and other emergency responders.
  - Emergency physicians, hospitals and trauma centers.
- Management of traffic at the scene of an incident and the incident's prompt clearance.

Automated Crash and Incident Detection, Notification and Response

Challenges

- **Cost of Surveillance** Current surveillance and detection systems use combinations of closed circuit television surveillance, video image analyzers, microwave radar detectors and imbedded loop detectors that are connected to traffic management centers. However, the high deployment cost of these sensors has generally restricted their use to heavily-traveled, limited-access highways in urban and suburban areas. Lower-cost approaches are needed for other areas that will facilitate automatic collision notification.
- **Wireless E-911 Deployment** The full potential of wireless emergency access is limited by the inability of the current wireless phone system to automatically locate callers – an essential piece of information for dispatchers. The national wireless telecommunication system needs to be upgraded to provide location information without compromising the privacy of wireless users.
- **Better Technology Needed** Current surveillance technology is generally not sensitive enough to detect incidents and crashes, except by inference (i.e., traffic unexpectedly slows) and the information that can be relayed to control centers is limited. In-vehicle technologies, personal wireless communications and satellite surveillance systems may be more efficient and eventually provide broader coverage, but this technology is not yet well established; it is only sparsely deployed.
- **Public-Public and Public-Private Cooperation** The public agencies involved in emergency response include law enforcement agencies, emergency medical services, fire departments and traffic management departments. Each may have its own separate communications systems and protocols and different, although sometimes overlapping, responsibilities. The key to operational success is information sharing across system, organizational and jurisdictional boundaries. The National ITS Architecture, regional architectures and related ITS standards can provide the backbone for such interoperability, especially when coordinated with their public safety counterparts.

  Private sector telematics and information providers need to communicate with public emergency responders; at present this is handled mainly by ordinary telephone conversations. A variety of efforts is underway to encourage coordination and communication within and between the public and private sectors. At present, while models exist for this kind of coordination and cooperation, none has been generally accepted. The challenge is to develop systems and system components that can plug-and-play in unique configurations to accommodate unique needs of specific regions. Electronic public-private communications that can integrate with existing emergency response systems (e.g., the national 911 system) and systems that conform to open communications standards are needed.
- **Hazmat Identification** Until standards are developed and technologies implemented that cut across modal and jurisdictional boundaries, the contents of hazardous cargo will not be immediately visible to emergency response personnel.

Automated Crash and Incident Detection, Notification and Response

Actions

RESEARCH

- Continue research on refining and linking in-vehicle and external technologies for the automatic detection and reporting of crashes and incidents. Continue research that will help to predict and characterize the nature of the crash and injury severity. Similarly important research is needed to develop protocols for data exchange and privacy issues regarding the location, scope and nature of the incident. Vehicle manufacturers and telematics providers should be actively engaged in this research, along with public safety agencies and emergency medical services.
- Continue research and field testing of network-scale signal preemption systems.
- Support research that can measure benefits of this new technology as it is developed, tested and deployed. This is important for supporting decisions about how best to steer and fund future research and deployments, as well as demonstrating benefits for completed efforts.
- Develop and test procedures and technologies to facilitate on-site coordination among all traffic incident responders and speed clearance by secondary responders.

PROGRAM

- Develop programs and funding mechanisms to stimulate cooperation among public and private communications organizations and steer progress toward a nationwide wireless enhanced 911 network.
- Develop programs and funding mechanisms to equip public safety first-responders with in-vehicle technology to facilitate quick response, potentially including route guidance, traffic-signal preemption and other mechanisms, plus devices for quick assessment and relay of this information to care facilities.
- Develop programs to provide incentives and subsidies that encourage the prompt, widespread deployment of advanced collision notification and response systems.
- Develop protocols for exchange of data and protection of privacy issues when information is transferred regarding the location, scope and nature of the incident. Engage the participation of vehicle manufacturers and telematics providers, along with transportation, public safety and EMS agencies.
- Support programs, research and standards setting activities that promote interoperability of incident notification and response systems.
- Develop a national system for providing emergency response personnel with information on the contents of hazardous cargo involved in incidents. Link this system with ship stowage management systems, terminal inventory management systems and carrier asset management

PROGRAM, continued

systems to track the flow of hazardous materials containers and cargo across modes. Develop appropriate standards and communication protocols.

- Foster increased **cooperation** between public safety agencies and transportation management agencies in **urban** areas to better coordinate rescue and treatment efforts with the activities needed to manage traffic at the scene of an **incident** and return it to normal as quickly as possible.

- Foster increased **coordination** among public safety agencies in **rural** areas to enable alternative responders (e.g., rural public works employees) to be trained in EMS and to be permitted to respond to rural medical **emergencies** when location technology identifies them as the closest available responder.

INSTITUTIONAL

- Develop **model cooperative arrangements** to harmonize interagency activities in detecting and responding to **incidents**—interagency activities that can be widely and consistently employed. Consistently architected arrangements of this kind will help to encourage the development of software and systems to support the implementation of these arrangements, lowering costs and improving consistency of operations.

- Develop and exploit technology for **geolocation** via wireless telephones. This includes encouraging cooperation among wireless service providers, technology providers and emergency response centers, plus a key element: Federal Communications Commission approval.

Advanced Transportation Management

Current Status + Opportunities

>>Advanced transportation management involves using advanced technology to intelligently and adaptively manage the flow of goods and people through the physical infrastructure. There are two basic modes of advanced transportation management:

- **Advanced Transportation Management Systems** in which the focus is on direct management of the infrastructure and the communication of useful information to travelers and vehicles. The highest-profile systems monitor and control the roadway infrastructure, but these systems also include the use of guideways utilized by public transportation and railroads as well.
- **Advanced Transportation Automation Systems** in which the infrastructure and vehicles communicate and interact. Cooperative Vehicle Highway Automation Systems (CVHAS) are being actively researched, primarily for the purpose of safely increasing the effective capacity of the roadway system. Other research and development focuses on automating commercial and public transportation vehicles in dedicated guideways and providing mechanisms to help guide road maintenance equipment (e.g., snowplows) accurately and quickly, especially under adverse conditions.

Advanced transportation management is not simple, involving a number of factors:

- A complex interaction of vehicles and their (individual and system-level) operators and the infrastructure.
- The physical infrastructure and related management and control facilities and equipment.

IN-VEHICLE ELECTRONICS and COOPERATIVE VEHICLE INFRASTRUCTURE AUTOMATION

- The institutions and organizations that own, build, operate and maintain the transportation system.
- The data that is collected, analyzed and disseminated as raw data or transformed into information.

The security of physical and electronic systems and ITS communications impact the traveler, public agency and private service provider alike. Security violations can:

- Impact the ability to manage and operate transportation facilities (highway and transit) in a safe and efficient manner due to tampering with control functions and information flows.
- Negatively impact the quality and timeliness of data necessary to support credible (and profitable) traveler information services.
- Reduce the security and integrity of personal and agency financial transactions.
- Reduce the traveler's peace-of-mind with respect to privacy and personal security within the transportation network.
- Impact the efficient movement of freight and create opportunities to tamper with private business activities.

ADVANCED TRANSPORTATION MANAGEMENT SYSTEMS

Over the next ten years, progress will be made in understanding these complex relationships and in achieving many of the benefits possible from application of advanced transportation management.

Whether for roads, transit, or rail, advanced transportation management relies on systems that enable several actions:

- Real-time surveillance and detection.
- Rapid acquisition and analysis of flow data (traffic movement, rapid transit and rail operational data).
- Continuous capability during times of crisis or infrastructure destruction.
- Prediction of near-term transportation system conditions.
- Real-time operational responses to current and projected flows and conditions.
- Flexible commercial vehicle enforcement strategies that reflect evolving freight flow patterns.
- Flexible management and operation of ports, terminals, rest stops and other freight gateways.
- Evaluation and adaptation of operational responses based on historical experience.
- Continuous training and cross-training of Traffic Management Center staff using archived data and simulation.

Several factors typically characterize such systems:

- Integrated control of various facilities.
- Data sharing among transportation management centers and public safety operations centers.
- Collaborative actions across agency, jurisdictional and modal boundaries.
- Cooperative incident management strategies with rapid detection and response capabilities.

In order to achieve the most benefit, regional transportation networks need to operate seamlessly across jurisdictions and across modes. Control and management systems from various modes and jurisdictions can be networked to provide enhanced network coverage throughout the day. Improved control concepts, such as adaptive control and signal priority, can be applied on a large-scale intermodal basis. The result would include a management system that responds to real-time changes in conditions, including traffic and weather and provides a powerful tool to meet the transportation goals of a region.

In addition, successful transportation management depends on effective public safety operations, from rescuing crash victims to helping prevent crashes. At the same time, by providing information about emergencies, the transportation management system supports public safety operations. To perform at their best, transportation and public safety professionals need accurate, timely and well-integrated information. Transportation management operational centers must become better integrated with public safety centers.

The Federal Railroad Administration and the Federal Transit Administration are working together on the development of Intelligent Railroad Systems. Intelligent Railroad Systems will incorporate new sensor, computer and digital communications technologies into train control, braking systems, grade crossings and defect detection and into planning and scheduling systems as well and will

ADVANCED TRANSPORTATION MANAGEMENT SYSTEMS, continued

apply to freight, intercity passenger and commuter railroads. Work has begun on the development of the architecture for Intelligent Railroad Systems.

The shared use of existing freight railroad services and rail transit on the same line offers the potential of rapidly and economically expanding the scope of high-quality passenger transit service. Demand for commuter rail service is increasing in parallel with increased highway congestion and suburban population growth. Train control, monitoring and signal system design requirements are currently specialized for each operator, further outlining the future need for integrated automation systems.

In the railroad world, advanced transportation management is enabled by positive train control (PTC) systems. PTC systems are responsible for tracking the location and speed of trains using radionavigation systems like the Global Positioning System, primarily for the purpose of increasing rail system throughput and safety by optimizing the use and maintenance of track. However, this capability has significant implications for increasing the safety and effective capacity of the road vehicle system as well, especially at and around highway-rail intersections, by networking rail operations centers with traffic management centers, transit management centers and others. PTC is regarded as an important component of an overall Intelligent Railroad System.

In the future, transportation control centers will collect and disseminate information with an emphasis both on local control and on data integration with adjacent or national data centers. Within these centers, ITS technology can continuously collect data on current conditions, continuously predict near-term behavior and continuously act to optimize safety and throughput. Modal facilities can be monitored for incidents and predicted impacts on related infrastructure. The system can use real-time simulation combined with adaptive and predictive real-time modeling technology to foresee future conditions and adjust to operate with much greater efficiency, safety and performance reliability.

Similar technologies can be applied to evacuation modeling and operations during severe weather events or other incidents and to help predict vulnerabilities in critical infrastructure in support of homeland defense. ITS must play a critical role in preparing to respond during times of crisis and in helping to prevent or mitigate the consequences of natural and human-made disasters.

The sharing of data among multiple adjacent operations centers will allow transportation and public safety operations to be more efficient. Data access will be seamless across jurisdictions. Responses to an incident will be based on the impact to the local and adjacent regions. Centers will electronically coordinate the responses of recurring and non-recurring incidents and on a large regional basis divert traffic or recommend modal shifts to avoid further backups in the vicinity of the incident. Advanced transportation management is essential to provide at least a portion of the information that will flow to the telematics-equipped vehicles of the future.

ADVANCED TRANSPORTATION AUTOMATION SYSTEMS

Over the next decade, research and development will be conducted on mechanisms through which the traffic management system can take an active role in controlling selected vehicle types, increasing the capacity of controlled lanes and producing a variety of operational efficiencies. Several modalities are now being researched:

- Automated transit systems in dedicated rights-of-way to increase the operational efficiency of transit systems.
- Automated precision docking of vehicles to improve service to transit patrons, particularly the disabled, the young and the elderly.
- Automated trucks in dedicated lanes of urban and/or intercity corridors to facilitate quicker, safer and more cost-effective goods movement.
- Automatically guided snow removal vehicles for regions affected by winter weather to increase the efficiency of clearance operations in all weather conditions.
- Automated on-board monitoring and inspection systems for clearance of commercial vehicles in such areas as vehicle safety, cargo clearance and weight.

This research will lay the groundwork for evaluating the costs and benefits of fully automated passenger vehicles and for conducting research and development in the area of Cooperative Vehicle-Highway Automation Systems (CVHAS).

Advanced Transportation Management

Benefits

>>As the science of advanced transportation management improves, it is expected that these outcomes will result:

- System operators will know the current status of their part of the transportation system, whether the focus is transit, commercial vehicles, trains, or automobiles. They will also have a better understanding of how their part of the transportation system integrates with the transportation system as a whole.
- System operators will have enhanced ability to predict and optimally manage traffic flows, including the ability to incorporate current and forecasted weather conditions.
- Transportation and public safety operators will be able to respond to and manage traffic incidents more safely, efficiently and effectively. They will have reliable tools to help mitigate the effects of major disasters, whether human-made or natural.
- System operators, their managers and the public will be able to evaluate the actions taken to determine their effectiveness, providing better accountability and a more robust sense of system performance.
- Travelers and freight carriers will be better informed as data is collected and disseminated to them.
- Research on vehicle-highway automation can lead to greater efficiency and greater roadway capacity without greater construction and provide safety benefits as well. Travel times will not be only shorter, but also more reliable and predictable because automation reduces variability of traffic conditions. It may also be possible to reduce lane widths for light-duty vehicles.
- Automated vehicle operations can eliminate the stop-and-go transients that waste energy and generate excessive pollutant emissions today. If the vehicles are operated at the very small separations that have already been publicly demonstrated, their aerodynamic drag can be reduced significantly, further reducing fuel consumption and emissions.

These outcomes will lead to a number of benefits. Enhanced management of the transportation system can enable better system reliability and safety, more effective

incident response, better coordination of traffic and travel across modes to reduce travel times and congestion. Savings from reduced delays can benefit all travelers. More freely flowing traffic also reduces energy requirements and will lead to better air quality.

Safety can be enhanced. Advanced management systems and vehicle-highway automation can help prevent incidents by:

- Reducing congestion and keeping traffic flowing freely.
- Making work zones and highway-rail intersections smarter.
- Managing travel speeds in anticipation of and in reaction to changing weather conditions.
- Clearing incidents more quickly, thereby reducing secondary incidents and the resultant congestion.

Advanced transportation management can provide information to fleet managers regarding their fleets and how best to utilize and direct them. The efficiency and economy of transit buses can be significantly enhanced through technologies such as automatic vehicle location, remote engine monitoring and regional transit signal priority systems. The mainline screening of large vehicles and other automated regulatory enforcement tools can speed freight traffic, especially trucks, resulting in substantial savings. Better transportation management can help to moderate congestion around major sports and musical events and other mass gatherings of people. Positive Train Control can enable better scheduling of train movement and track/wayside maintenance to optimize and increase the safety and effective capacity of the rail system.

Along with the necessary capital infrastructure investment, the improved coordination required for advanced transportation management can lead to improved efficiency in regional traffic, transit and incident management and more comprehensive traveler information. Coordination among relevant agencies also leads to improvements in efficiencies as agencies share capital, staffing, operations and maintenance resources.

Advanced Transportation Management

Challenges

- **Policy and Institutional Support** Each jurisdiction needs to be able to answer to its own constituency, making shared responsibility and control more difficult. Consensus building is time-consuming and staffing-intensive and support is required at the policy level.
- **Scarce Resources** Many jurisdictions and agencies are struggling to keep up with standard transportation management and daily operational requirements, (e.g., coordinating traffic signals on a regular basis.) Building out, operating and maintaining regional public ATMS will require funding in addition to existing resources. Also, securing the needed commitment from partner agencies for long-term management, operations and maintenance of the regional system is essential. This may include identifying an agency willing and equipped to serve as the lead agency in operating the system. Getting a sufficient number of staff allocated to the system, recruiting and retaining staff with the needed skill sets and providing sufficient training to maintain and improve staff skills are also imperative.
- **Willingness of public agencies to invest resources** The principal challenge has been the availability and willingness of public agencies and staff to invest in data security relative to the other costs and challenges inherent in deploying integrated ITS. Historically, it has been felt that existing Information Technology industry solutions to security problems have been satisfactory, although there has been increased recognition of the unique vulnerability of ITS components and communications links to tampering, scrambling and damage. These include Global Positioning System (GPS) satellite communications supporting vehicle location systems as well as the more commonly recognized Internet viruses and "worms." The integration of various types of

ADVANCED TRANSPORTATION MANAGEMENT SYSTEMS

systems propagates the damage caused to one system. Additionally, because of the mix of public and private systems, plus traffic control, data collection and financial systems within an integrated ITS deployment, unique ITS security requirements may be needed.

- **System Development and Integration** Some transportation management technologies need further research, development and integration. Successful development and integration entails resolving both technical and institutional issues.
- **Data and Information** Advanced control algorithms, such as adaptive control, require significant amounts of data on the entire road, rail and public transportation network. Collecting, processing and sharing this data is a challenge. Transportation management systems will also generate much data and a number of parties may be interested in obtaining that data. System operators and managers must determine how and through what relationships, this data will be disseminated. Information will also be used to advise vehicle operators and travelers. That information must be presented in a way that achieves the system operator's objectives.
- **Lack of Interoperability** Communication among agencies is often difficult due to differences in radio format and protocols. Responders from neighboring jurisdictions frequently cannot reach one another by radio or need separate radios to share information with other agencies. Interoperability is critically needed among emergency communication systems, not only among police, fire and emergency medical services, but with transportation and public works personnel as well.

ADVANCED TRANSPORTATION MANAGEMENT SYSTEMS, continued

- **Predictive and Evaluative Capabilities** To control traffic flows in real time, operators need the ability to predict and understand what will happen to traffic flows given current conditions and under various control strategies. Operators also need the capability to evaluate the effects of their actions and to re-adjust as necessary. In many instances, these capabilities are currently immature or non-existent.

ADVANCED TRANSPORTATION AUTOMATION SYSTEMS

- **Vehicle-Infrastructure Relationship** As vehicles become smarter and as the ability to manage and control the infrastructure and traffic flows improves, practitioners must better understand the relationship between vehicles and the infrastructure under various circumstances including time of day, season and weather and put in place management strategies and technologies reflective of this relationship.
- **Chicken-and-Egg Dilemma** It may be difficult to justify the high cost of infrastructure technology for vehicle-highway automation until a large number of vehicles are capable of participating. However, selling the vehicle technology for vehicle-highway automation will be difficult until large amounts of infrastructure are ready for this interaction. This problem may be less severe for special cases like transit automation. Incremental deployment plans need to be developed to show benefits exceeding costs at each stage of deployment, so that decision makers can be comfortable with each successive investment decision.
- **Physical or Logical Infrastructure** There is still considerable controversy about whether the infrastructure side of vehicle-highway automation should focus on instrumenting physical roadways or on developing a software-based infostructure that communicates to vehicles via telematics services providers. Research and market evolution over the next ten years will probably resolve this controversy.
- **Public perception** Public perception of feasibility and desirability of Cooperative Vehicle-Highway Automation Systems (CVHAS) varies widely across the population and there will always be some that are frightened by or simply dislike the prospect of vehicle automation.
- **Legal issues** Liability and insurance issues need to be addressed throughout the development process, since CVHAS represents such a significant change from current driving conditions.

Advanced Transportation Management

Actions

RESEARCH

Advanced Transportation Management Systems

- Continue to research and develop surveillance and detection tools that can assist in providing travel times and the calculation of delay in real time; enhanced adaptive roadway control algorithms that incorporate freeways and arterials and are scalable across an entire region; enhanced adaptive rapid transit and rail control algorithms, including their physical and logical interactions with travelers and with other modes; predictive modeling capabilities that enable prospective actions by operators to manage traffic flows; better means of collecting, storing and retrieving historical traffic flow data; processes to unite and fuse data from different subsystems; and the best communications tools for moving transportation management-related data and information from collection points to centers, vehicles, travelers, third-party vendors of information and others.
- Review stakeholder security needs and concerns and identify where requirements need to be developed.
- Conduct research aimed at investigation of existing security standards, methods, protocols and tools in the IT industry and their applicability to ITS-related security needs.
- Conduct research aimed at developing guidelines and standards for specific ITS security requirements for each of the domain applications related to programs in this Program Plan. These applications should include, but not be limited to, market packages of the National ITS Architecture and common domain-specific ITS deployments that incorporate those market packages (e.g., public transit automatic vehicle location systems, electronic toll-collection systems and regional traveler information centers).
- Conduct research on the design of regional traffic management and integrated corridor management system concepts.
- Research and test the use of mixed rail corridor operations (commuter, light rail and freight rail) as a means of enhancing public travel.
- Test and as appropriate deploy, greater use of adaptive control systems, flow monitoring and balancing and dynamic messaging (e.g., develop systems that can be changed in real-time to reflect changing conditions and then develop guidelines or standards as appropriate).
- Study specific linkages between a more robust ITS infrastructure and:
  - Safety requirements (e.g., roadside alert systems, pedestrian warning systems).
  - Emergency preparedness needs (e.g., natural disaster response, evacuation and mobilization).
- Continue to research and test the use of pricing strategies as one element of advanced transportation management.
- Develop strategies to prepare for and manage responses to weather emergencies, natural disasters, terrorism, labor disputes and other causes of major swings in transportation demand.

RESEARCH, continued

Advanced Transportation Automation Systems

- Continue to research the appropriate relationship between the vehicle and infrastructure and appropriate advanced transportation management and control strategies.
- Explore in depth the costs and benefits (including private sector return on investment) of various levels of transportation automation and of various mixes of responsibility between the vehicle and the infrastructure.
- Establish a mechanism for cooperation among public agencies, private industry and the research community to pursue research on Cooperative Vehicle-Highway Automation Systems (CVHAS), perhaps building on the existing eleven-state regional pooled-fund program. This mechanism should include the traditional infrastructure community, both public-sector organizations (e.g., the American Association of State Highway and Transportation Officials [AASHTO], the American Public Transportation Association [APTA], the International Bridge, Tunnel and Turnpike Association [IBTTA]) and private transportation design and construction. Also, automotive manufacturers and suppliers, the insurance industry and the telecommunications and information technology industries should participate. Finally, user communities such as the trucking industry, AAA and AARP should be involved.
- Further explore the development of tools to automate infrastructure construction and maintenance.
- Establish linkages with the U.S. Department of Defense to facilitate technology transfer and resource leveraging on Cooperative Vehicle-Highway Automation Systems (CVHAS) research.
- Establish linkages with the U.S. Department of Energy and the Environmental Protection Agency to extend CVHAS research into its effects on fuel efficiency and the environment.
- Establish linkages with the U.S. Department of Justice, Federal Bureau of Investigation and the Office of Homeland Defense to promote advanced transportation management capabilities for use both in crisis management and in critical infrastructure protection and disaster prevention activities.
- Explore policy issues related to successful CVHAS deployment, including liability, public perceptions and desires and funding. The effort must identify and recommend courses of action on all issues that might impede the operational use of CVHAS.
- If cost-justified, institute a coordinated national effort of research and development on the key technical, deployment staging and societal and institutional issues relevant to transportation automation.
- Develop more innovative commercial vehicle enforcement strategies. Use vehicle identification technologies and wireless communications systems to unbundle enforcement activities from weigh stations and other fixed sites. Expand mobile screening on secondary routes, or in areas where congestion, high land prices, or sensitive environmental conditions impede weigh station operations. Demonstrate remote enforcement through virtual (staffless) weigh stations. Focus enforcement activities around high-accident or high-risk trouble spots. Enable pre-trip permitting and weight or safety inspections at ports, terminals and border crossings. Deploy next-generation technologies for identifying vehicles, focusing on the growing population of small and medium-sized trucks supporting e-commerce and small package deliveries.

RESEARCH, continued

- Automate vehicle, driver and cargo **identification and clearance** at port and terminal gates. Streamline driver and cargo processing at international border crossings. Enhance international trade processing systems using inland distribution hubs and more efficient drayage processes. **Optimize truck flows** into and out of seaports, airports, rail yards and other freight terminals by linking terminal gate management systems to on-board asset tracking systems, regional traffic operations centers, traffic signal control systems, weigh station screening systems and electronic toll collection systems.
- Identify and **share real-time information** about the availability of parking spaces and loading zones at truck stops, rest areas, staging areas, public warehouses and central business districts.
- Deploy **on-board** container and trailer seals and **monitoring** systems. Link on-board systems with terminal inventory management systems, carrier asset management systems and customs and gate clearance systems to improve the security of goods in-transit.

PROGRAM

Advanced Transportation Management Systems

- Provide **funding** for planning and implementing state-of-the-art advanced transportation management systems across the United States.
- Coordinate and fund the **transformation of research results** into guidelines, best practices and industry consensus standards as rapidly as possible and widely disseminate to decision-makers and system designers.
- **Solicit feedback** from designers, stakeholders, operators and owners at the initiation of the process and as the research process is completed, with an eye toward implementation. Provide feedback loops into the process, providing an iterative flow of information/feedback between researchers (originators of the requirements and guidelines) and designers (users of the requirements and guidelines) is facilitated.
- Continue to develop **approaches and standards** that enhance integration capabilities, center-to-center data sharing and data dissemination to other parties (e.g., third-party information vendors, travelers).
- Continue the build-out of the **Nationwide Differential GPS System** (NDGPS) to assist in the accurate geolocation of all types of vehicles.
- Develop **incentives** for the private sector to utilize their control, sensing and other advanced technologies and other expertise and resources to support transportation management.
- Develop a multilevel program (from executive management and elected officials to operators and technicians) to promote **regional** transportation **management** systems. In addition to traditional peer-to-peer exchanges, awareness raising and training, develop an ongoing program to engage agency personnel and build consensus to implement a regional system.
- Develop an incentive program to support implementation of **regional systems.** This goes beyond existing incentives for integrating systems. The focus needs to be region-wide.
- Develop a program to **address** critical **staffing shortages.** The program needs to be comprehensive and multidimensional. Activity areas need to include primary and secondary

PROGRAM, continued

education to develop an interest in transportation at a young age, support for university and college programs and training and education for existing staff. The critical nature of staffing requires that a more comprehensive and coordinated effort be launched.

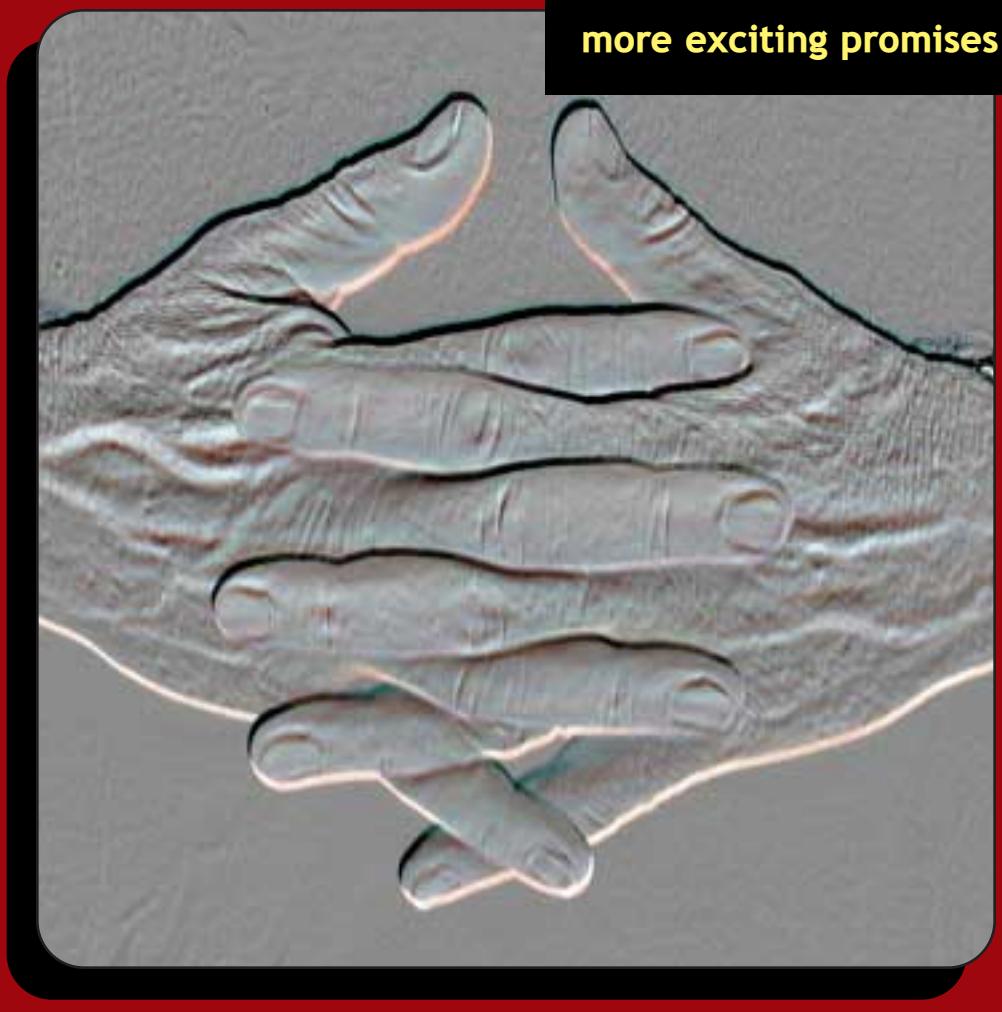
Advanced Transportation Automation Systems

- Establish linkages with the U.S. Department of Defense (U.S. DOD) to facilitate technology transfer and resource leveraging on issues relevant to transportation automation. As the nation's largest shipper, U.S. DOD is an important potential user and beneficiary of transportation automation.
- Establish linkages with the U.S. Department of Energy and the Environmental Protection Agency to extend transportation automation research's effects on fuel efficiency and the environment.
- Conduct operational tests of strategies for managing truck flows in urban areas using area-wide, small-scale, portable and lane-based systems. These may include efforts to:
  - Optimize truck routing and scheduling to reduce conflict with passenger traffic and manage truck travel through congested or high-risk areas.
  - Manage truck-only lanes, including both those operated on a permanent basis and those operated during peak periods only.
  - Use variable pricing techniques to encourage truck drivers to operate on less congested routes or during evenings, weekends and other off-peak periods.

INSTITUTIONAL

- Make the study of transportation and ITS-related data security requirements an issue of national concern and importance, to focus attention and resources and to move the exploration forward as aggressively as possible.
- Build upon work completed by other organizations, including the ITS America Data Security and Privacy Task Force, in developing a national coalition of public and private stakeholders to take responsibility for directing the development of requirements and guidelines for ITS-related data security.
- Encourage dialogue among parties who are, or should be, interested in advanced transportation management to develop a better understanding of the need for better approaches to transportation management and the need for collective effort among a number of players in transportation or related arenas.
- Identify and resolve institutional barriers specific to advanced transportation management. Identify ways to involve all stakeholders in advanced transportation management (e.g., police and others in the emergency response community, airport authorities and weather agencies). Explore effective ways to institutionally link agencies with interests in transportation management.
- As appropriate, consolidate traffic management functions across jurisdictional boundaries.

As institutional relationships move across the spectrum of communication, cooperation, coordination and consolidation, an increased level of interjurisdictional effectiveness is possible. The higher levels of coordination are essential to capitalize on many of the more exciting promises of ITS.



A Culture of Transportation Systems Management and Operations

Current Status + Opportunities

>>The construction of additional conventional roadway and rail infrastructure will clearly continue for a long time, particularly in growing population centers, but generally in diminishing amounts. The construction of new specialized infrastructure, for special purposes (including transit and dedicated lanes for automated commercial vehicle traffic) may increase. The maintenance and renewal of existing infrastructure will continue at a significant pace indefinitely. However, it is widely recognized that regardless of need, opportunities for building new infrastructure are decreasing and the ones that remain are increasingly costly. In both fiscal and social terms, it is never again going to be possible to meet the growing demand for capacity simply by building physical infrastructure.

The Texas Transportation Institute's 2001 Urban Mobility Report on the 68 largest urban areas in the United States reported that the 1999 cost of congestion in these areas exceeded $78 billion and that:

"Over the 17-year period [1982-1999], less than half of the roadway that was needed to maintain a constant congestion level was actually added. These percentages are actually a little higher than the amount that was "constructed," since they also include roadway mileage that was added through shifting urban boundaries and not just new construction."

Experiments in road pricing and other demand management strategies will continue, but on the whole, the most readily available alternative for enhancing system capacity and throughput is the more efficient and effective use of the existing infrastructure. Fundamentally, this means changing the emphasis from building more infrastructure to operating it better. If this shift in emphasis does not take place, demand will overwhelm supply and congestion will become unmanageable.

Fortunately, on many fronts, the need to focus on operations is already being recognized and important initial steps in this direction are under way.

Transportation is moving out of the Industrial Age into the service economy. In the past ten years, the ITS program has been focused on technology and systems development and deployment. The next ten years will be increasingly focused on safety, customer service and systems performance. The demands of both the external and internal environments are generating changes in the culture of both service providers and users. Stimulated by experience with other public services, informed customers are demanding increased accountability for transportation service improvement. This will be reflected in a shift in focus by transportation infrastructure and vehicle-related service providers from product and facility *outputs* to performance improvement *outcomes*. Outcomes will be defined in user-customer terms rather than products and projects. This outcome focus, in turn, will require active responsibility for the performance of the vehicle-infrastructure systems via focus on systems management.

These changes imply a profound change in culture:

- From an engineering-dominated environment to multidisciplinary staffing.
- From fragmented jurisdictions to high levels of cooperation.
- From a focus on construction to a focus on reliability and information.
- From independent vehicles and infrastructure to new level of coupling.

- From a modal focus to a multimodal approach.
- From arms-length public and private sectors to new forms of cooperation.

Within the public sector, infrastructure owners and operators will focus on new coalitions of state and local systems owner-operators using systems management and user information to achieve maximum reliable, efficient and safe travel on the existing regional systems. Management and control facilities will be coordinated locally, regionally and/or nationally, across modes and by private as well as public service providers. This implies the smooth flow of information from one facility to the next (i.e., a high level of integration in information exchange). This may also imply flows of information between the public and private sectors. This institutional shift will be reflected across the board in resource allocation, organizational structures and relationships. Policies and programs will be in place to support this institutional integration. Management and staff will be charged with the service mission and will be given incentives to meet it. Their commitment will be measured in terms of real-time performance to maintain maximum customer service levels and equipping facilities with the necessary infrastructure for systems management.

In the private sector, new business models will develop around consumer markets within a competitive setting based on the customers' perception of value and willingness to pay. The conventional vehicle manufacturers' dominance will evolve into a broader set of alliances among product and service suppliers with a focus on common issues of interoperability. In ten years, institutions and organizations that build, operate, or maintain the infrastructure will evolve to include a customer-service mode and form new alliances with private entities that provide vehicle-based services – to smoothly integrate those functions to ensure the best possible service to travelers.

The future ITS program will be designed to support the travel-related interests of the complete range of travel market segments. This includes the business traveler, shipper, tourist, physically challenged person and people who are not familiar with multiple modes of transportation. The demands of the "just-in-time" mobile society will require a strong focus on system reliability, personal security, in-vehicle navigation and traveler convenience information.

ITS also serves as a means by which to better manage the transportation system during times of crisis, including natural disasters and security breaches. This is exemplified by the terrorist attacks of September 11, 2001, which resulted in the most significant travel restrictions ever implemented in the United States. Restrictions on ground travel in New York, the mass evacuations of central business districts and several days of airport closures nation-wide forced citizens in general to consider the importance of managing and operating the nation's transportation system. The ability to provide timely information to travelers, as well as to monitor and manage traffic and public transportation services under all conditions, is fundamental to the national role of ITS in the new, less certain environment.

To assure that transportation services can support domestic security and emergency needs, ITS systems and infrastructure must be secure. Threats to external and internal abuse and tampering with control and information flows must be mitigated as fully as possible. With the public realization that the United States is not isolated from international events and terrorism, the incorporation of security measures into ITS design and deployment should be expected and not taken for granted. This is

of increased concern as ITS deployments have gained increased levels of standardization and interoperability, as well as accessibility through the Internet or other standard communications network interfaces.

Threats that undermine system operations objectives can be as follows:

- Denial of service: preventing a system from operating as intended.
- Disclosure: acquiring sensitive information through unauthorized channels.
- Manipulation: modifying information.
- Masquerading: posing as an authorized entity to access information.
- Replay: re-transmitting valid information under invalid circumstances.
- Repudiation: denying an action.

A number of security activities that could mediate possible threats include:

Authentication: verifying user identities.

- Confidentiality: protecting private and personal information.
- Integrity: maintaining information accuracy.
- Non-repudiation: preventing users from denying their actions.
- Access Control: limiting system resources to properly authorized users.
- Auditing: recording system operations and the users who perform them.
- Availability: protecting against denial-of-service attacks.
- System security management: providing physical, manual and automated controls.

The most readily available alternative for enhancing system capacity and throughput is the more efficient and effective use of the existing infrastructure.

There are some particular challenges. There is a clear need to better understand and to document what it means to provide good customer service through performance-oriented operations. There is a strong need to restructure the undergraduate curriculum for transportation and civil engineers to reflect the shift in emphasis from construction to operations and system management. There is a similar need to provide outreach and education to currently practicing transportation engineers and other professionals, to increase their skills and comfort-level with operations. There is a need to incorporate ITS-oriented projects and activities into the mainstream transportation planning process. There is a need to encourage regions to flexibly reconfigure their arrangements to reflect an operations perspective. Probably most important, there is a critical need to develop an agency funding and practitioner compensation structure that provides rewards for fielding successful operations that are comparable or superior to the rewards for successfully fielding capital construction projects.

All of these changes will require an effective coalition among U.S. DOT, the American Association of State Highway and Transportation Officials (AASHTO) and its membership of state DOTs, ITE and its membership of professional engineers, the American Public Transportation Association (APTA) and the transit operators, plus the engineering, construction and system integration firms that serve the industry. Coalitions also must involve vehicle manufacturers, commercial vehicle operators, freight terminal operators and port authorities, as well as the shippers, insurers and financial institutions that have a heavy stake in safe and efficient goods movement. In addition, the definition of a "transportation agency" must expand beyond state DOTs to include the state and local organizations with responsibility for vehicle registration, driver licensing, transportation user fee and tax collections, law enforcement, emergency response and related functions. There will be opportunities to leverage the work of these various agencies to meet common goals, but this will require removal of restrictions and the development of incentives for sharing funding, staffing and data across agency, modal, or jurisdictional boundaries.

Congestion and service disruptions continue to grow on much of the nation's surface transportation system. Many transportation systems elements do not consistently function as intended given increasing demand, unanticipated incidents and varying conditions. At the same time, the limitations on room to build new infrastructure, high costs and extended construction schedules suggest the need for maximizing the effectiveness of existing systems, including capitalizing on new technologies and emerging management concepts. Changing customer needs (passenger and freight) are placing greater emphasis on performance concerns, including reductions in delay and emissions, improvements in systems reliability and safety and convenience. At the same time, vehicles are rapidly being equipped with safety, security and information features that provide higher utility and convenience for travelers of all modes.

If the transportation system is to meet the future needs of travelers and shippers, changes are needed in the values, mission, programs and services of facility, product and service providers.

Benefits

ITS can help to enable many improvements:

- Managed congestion and improved safety under widely varying conditions.
- Coordinated agency traffic/transit operations.
- Reduced delays and adverse effects of incidents, weather, work zones, special events, emergencies and disaster situations.
- Optimized traffic flow in arterial networks.
- Informed travelers with timely and accurate information.
- Provision of priority services to special user groups and vehicles.
- Improved interfaces between modes for passengers and freight.
- Enhanced operational safety of vehicles.
- Provision of reliable and quick medical/security responses.

The outcome focus will reintroduce the concept of user costs and benefits to the transportation resource allocation process. Conventional means for delivering capacity improvements usually promised their delivery at some indefinite point in the future. ITS can help infrastructure managers deliver measurable improvements in the short run (1–2 years). These investments are likely to be lower in capital cost than traditional infrastructure improvements and have fewer negative impacts. However, they will require additional sustaining operating resources.

Facilitated by ITS, a new performance orientation will also produce reduced unit costs for an expanded mission. For public agencies, improved asset management will result in higher efficiency. For example, improved information on weather conditions will help an organization deploy its mobile assets more efficiently. For public transportation agencies, this means improved snow and ice control. For trucking companies, this means avoiding many weather-related delays. Technology-assisted or automated operation of equipment results in improved productivity, reduced resource requirements and safer operations.

An orientation to customer-based, performance-focused outcomes will enhance the relevance of transportation to the economy and to quality of life and increase public interest in transportation decisions. Better delivering information about travel and systems management that is responsive to immediate user interests will produce stronger public support for greater system investment. Furthermore, the availability of systems performance information will inevitably result in benchmarking of institutional effectiveness in systems operations.

A vital step in accomplishing this transformation is to enlist the support of state and local policy makers, including the National Conference of Mayors, the National Association of County Executives and the National Conference of State Legislators. Policy makers must be persuaded that the transformation is viable and valuable in order for it to succeed.

Challenges

- **Growth of Operations Constituency** The notion of significantly increasing attention to improved system operations is still new among policymakers and staffs. Moreover, while travelers may be concerned about their mobility, they may not understand or be organized to press for a larger public commitment to operations. In general, there is too little understanding of the benefits and stakes of more effective performance-oriented operations. Moreover, there is an important constituency mainly focused on system expansion through new construction. While not always adversarial, this constituency may prefer new construction to the enhanced use of existing capacity.

- **System-wide Nature of Security Issues** Security risks are not necessarily external to systems. Internal security measures within operations centers, such as multiple-level authorization to utilize specific system components, as well as limited access to operations centers, communications and computer equipment, must also be included and maintained. The solutions will involve both IT industry expertise as well as recognition of potential security issues from ITS operators, both public and private, from system integrators and from system users. ITS operations include specific security objectives:
  - Confidentiality (e.g., protecting personal records).
  - Integrity (e.g., providing accurate financial transactions).
  - Availability (e.g., guaranteeing timely services).
  - Accountability (e.g., tracing system activity).

- **Decision Maker Accountability for Performance** A focus on how well system performance meets the needs of people sometimes requires individual decision makers to take responsibility where they lack control. The owners of infrastructure in individual jurisdictions have limited influence over many of the variables that impact performance. Some performance control is the responsibility of neighboring jurisdictions (e.g., state, local) or other entities (e.g., police, fire, emergency medical services), drivers themselves, or entirely outside institutional control (e.g., weather).

- **Management and Operations Focus at the Scale of the Customers' Trips** Much of today's travel crosses many jurisdictional boundaries. Providing responsive transportation services requires resolving cross-jurisdictional and cross-agency issues. Effective deployment of ITS and including meaningful programs to optimize transportation system performance requires the establishment of sustained cooperative multi-agency and multi-jurisdictional efforts i.e., "regional institutionalization" of transportation system management and operations. Non-transportation agencies, such as police departments, must also be involved. These activities require sustained support from policymakers. Coordinating with all the affected groups and developing common goals and objectives, are critical to the success of building and maintaining operations programs.

- **Performance Incentives** Current incentives for public policymakers and their staffs mainly reward success in capital projects, not success in operations. An outcome orientation needs to reward a different set of management priorities. Physical infrastructure asset management will still be central, but the mix of investments needs to combine short- and long-term issues. In the absence of direct customer feedback, new types of warrants, cost-benefit measures and evaluation processes will need to be invented.

CHALLENGES, continued

- **Strong Modal Partnerships** Bringing all modes together is important to defining appropriate roles and relationships, but can fail if continuous involvement is not maintained. The National ITS Architecture has identified the modal partners. However, the regions must actively include all relevant agencies in ITS planning, cutting across modes, jurisdictional boundaries and traditional agency roles, so that law enforcement, fire and emergency response agencies are included in this process.
- **Limited Integration of Commercial Vehicle Operations** Commercial Vehicle Operations (CVO) planning and deployment too often occurs in isolation from the metropolitan and rural ITS programs, as well as from the rest of the statewide and metropolitan transportation and highway safety planning processes. These planning processes should be integrated to leverage funding, staffing, data and technologies.
- **Emphasis of Federal Law** The current Federal-Aid Highway Act (Title 23) as well as many state and local laws focus transportation funding on the construction of transportation facilities. Aside from Congestion Mitigation & Air Quality Improvement Program (CMAQ), Federal Aid funding programs do not focus on operations.
- **Attributing Benefits to ITS** Since ITS is only a portion of the deployment taking place, it may be difficult to measure the benefits specifically attributable to ITS.
- **Awareness** Policymakers and their staffs are not always well versed on the relevance of ITS and operations to customers, service and performance. Policymakers and their staffs, as well as the public, need to be made aware of the potential for ITS to enable improvements in transportation. As systems are deployed, operational staffs also need to understand how to operate and support those systems.
- **Limited ITS Training Opportunities** Transportation professional training programs for creating a skilled ITS work force are very limited. Although several universities have developed multidisciplinary programs to educate transportation professionals for the future, there are not enough of them.

"As soon as the collision warning systems were installed, our drivers started to open up their headway intervals. No Eaton VORAD-equipped truck has had an accident. We can probably pay for it with the fuel savings we've realized."

Pepsi-Cola General Bottlers

Experts note that as much as 50 percent of the harmful emissions from tailpipes comes from just 10 percent of the vehicles on the road. In Denver, a dynamic message sign alerted the vehicle's driver to the level of carbon monoxide emitted from tail pipes as measured by a roadside sensor. A follow-up study found almost 2 percent of motorists notified had actually done something in response to the sign and 8 percent planned to do something.

A Culture of Transportation Systems Management and Operations

Actions

RESEARCH

- Continue research to clearly **pinpoint** the **benefits** of improved operations and disseminate these results to public agency decision makers and staff, as well as the traveling public.
- Focus research on the means to describe and measure the **service attributes** of most interest to the contemporary customer. These include safety, security, reliability, traveler convenience, travel time, information, navigation and others. In order to make considered decisions about ITS, tools and techniques are required that enable a fair determination of costs and benefits which include matters of time frame, type of benefits, regional scale, information impacts, **user feedback** and other variables.
- Continue to support studies of the work force necessary to support more operationally focused organizations with a customer service orientation. Transit authorities offer a possible model. Based on these studies, develop and deliver **training programs** to help transportation policymakers and staffs upgrade their awareness and skills.
- Continue to support research to provide case studies and guidance on organizational structures and institutions to support **regional ITS development** and system management. The research might match different regional characteristics with appropriate organizational approaches. Analyze the institutional history of multimodal planning organizations to aid the development of the new organizations.
- Focus the ITS research agenda on how the technologies or applications can be **coordinated and integrated** effectively, as well as on the technologies to address specific problems. ITS technology research is usually high-risk and long-term, making it difficult for the private sector to undertake without public sector support.
- Continue to study ways in which ITS and operations can be incorporated in the **planning and programming** process. Reorient the planning process so that overall **system performance** is considered an important part of a region's success in transportation planning.
- Formal connections among federally funded research programs should be established, with immediate, effective **distribution of research findings** for **incorporation into curricula.** Research and evaluation of innovative delivery mechanisms should be undertaken, including web-based and distance-learning programs.
- Orchestrate and be prepared to fund research on the **impacts of ITS** systems on travel behavior and mobility on different types of travel and segments of the traveling public. This includes the impacts of different types of information and how it is delivered, the reliability of information, the changes in system reliability by mode and new personalized services yet to be deployed. Differences in the impact of ITS for different types of trips (work, shopping, pleasure) and by different types of travelers (e.g., old, young, those with disabilities, transit-dependent) are equally important. This research should include additional studies on the societal, institutional and environmental impacts of widespread ITS deployment. As the level of ITS deployment increases in regions across

RESEARCH, continued

the United States, distribution and equity issues, the digital divide and the long-term effects of ITS on land use and urban form will become more and more of concern. Research is needed now to begin to address these issues before they become roadblocks to further deployment.

PROGRAM

- Continue and expand support of the **ITS Deployment Tracking** Program. This should include the provision of additional resources for measuring ITS deployments outside the 78 largest metropolitan areas. It should also include an assessment of how ITS deployment indicators can be incorporated into other parallel government data collection efforts (e.g., Highway Performance Monitoring System, National Transit Database).
- If operations and **ITS** are to gain a larger share of attention and resources, a **commitment to system operations** needs to be developed through outreach and education. Key targets are public agencies and the traveling public, which broadly includes those traveling for personal, business, commercial and other reasons.
- The Federal Highway Administration's Biennial Report to Congress on Conditions and Performance needs to be reoriented to include measures of the **costs** of the lack of systems operations and management, as well as measures of the **benefits** of the level of operational performance that may be achieved by improved operations and management via ITS.
- Public agencies from the federal level to the local level need to develop **operations policies,** including warrants and state-of-the-practice standards. Models for how this might be done can be provided through documentation of existing practices and research. ITS needs to be an essential element of these programs. The policies need to be interpreted in terms of strategic plans and organizational configurations, staffing, performance measurement and assessment and financial resources to support sustainable operations.
- Develop a multilevel **professional capacity building** program that addresses the need to increase the emphasis on ITS and operations. At the top level, develop peer-to-peer exchanges, outreach and awareness-raising activities to garner high-level commitment to adopting these systems. At the middle level, provide training, outreach and awareness raising regarding the benefits of the systems. At the lower level, provide training to operators in how to use the system and the benefits that will result. Develop a national skill enhancement-training program for training maintainers and operators of these systems.
- Multidisciplinary ITS professional- and technical-level **education programs** should be underwritten across the nation. An appropriate degree program should be developed. In addition, training

programs for current transportation professionals and personnel need to be established. Such training programs should be defined and overseen in partnership between the agencies and firms that employ such persons and the institutions providing the instruction. Such a program should include a certification/testing regime for demonstration of necessary skills.

- Undertake a review of and modification to **Title 23** to eliminate administrative ambiguity regarding the **eligibility** of operations-related projects.
- Provide more help to the ITS and planning communities to adjust to an **operations orientation,** including practical methods of handling ITS capital and operating-resource issues.
- Develop an **integrated modeling tool** that identifies and quantifies ITS benefits in terms of regional ITS architectures.
- Finalize the Federal Highway Administration's rule concerning the **mainstreaming of ITS** into the planning process.
- Consider proposing the creation of a categorical funding program to support both an **operationally-oriented infrastructure** as well as day-to-day systems management. A range of **funding programs** is possible, including management-oriented funding incentives, a percentage set-aside of all federal highway and transit funding to pay for the ongoing existence of such integrating organizations and funds for system management planning.
- Establish **outreach** initiatives with industry (e.g., national freight partnership) to develop an understanding of services, identify emerging issues, campaign for technology deployment and create opportunities for the public and private sectors to work together to identify problems and devise solutions.
- For ITS to be taken seriously in the planning process, that process must be reoriented so that overall **system performance** is considered an important part of a region's success in transportation planning. This reorientation will also open the door to ITS and to an increased importance being placed on operations and ultimately the customer. Policy, programs and research are needed to support this reorientation. In particular, serious commitment must be made on a cost-effective method of measuring overall system performance. Benchmarking and audits are necessary to assess current practices and to serve as a baseline to measure progress.

A study in metropolitan Washington, D.C. showed that a traveler, when provided alternative routes and departure times, could reduce the time budgeted for commuting by 13 percent when compared to the option of always leaving early to ensure on-time arrival.

INSTITUTIONAL

- Identify and support **champions** who can lead their agencies to a greater focus on operations.
- **Develop** a new **constituency** for an operations orientation with ITS as a key component. This constituency potentially includes **better informed travelers** who are prepared to hold transportation agencies accountable for the quality of their operations and their use of ITS.
- Reconfigure existing regional arrangements and/or organizations to better reflect an **operations perspective.**
- Create a long-term strategy to examine institutional relationships and approaches for **regional ITS and system management.** This should include resolving issues, developing case studies and guidance and providing outreach. Study methods and practices for establishing such arrangements. Develop guidelines and resource materials. Give consideration to a financial incentive program for early adopters of new organizational approaches that provide customer-based operations. There is considerable risk for organizations to be the first to adopt technology and new ways of doing business. However, early adopters are needed to lead the way, learn important lessons and accrue information on benefits.
- Recognize that the **private sector** has a valid **interest** in many transportation decisions, including those related to operations. Moreover, the private sector may have i**nformation and** other **resources** to apply to this effort. Ensure that public sector agencies are aware of possible private sector roles.
- Develop **privacy guidance** for all ITS application areas, like that which has been done for Commercial Vehicle Operations. Develop such guidance through a thorough stakeholder involvement process.

Public Sector Roles, Relationships and Funding

Current Status + Opportunities

>>A variety of new institutional roles and relationships will be developed to support the management and operations of integrated, regional and multimodal transportation systems and services. In the future, the institutional arrangements for systems operation and management will be very unlike those of today. Changes will take place at four levels:

- Within and among the divisions of current infrastructure owner agencies.
- Between various levels of government agencies – state and local.
- Between public transportation (e.g., state DOTs) and public non-transportation agencies (e.g., law enforcement agencies).
- Between public sector and private sector entities, including both organizations and individuals.

New roles and relationships at these four levels will substantially help overcome the barriers to seamless, transparent operations presented by traditional, often historically exacerbated jurisdictional and agency boundaries. These barriers include contrasting cultures, conflicting mission priorities, jurisdictional fragmentation and uneven resource allocation.

ITS and the information management and communications capabilities that it brings, will support a new level of cooperative operations among multiple agencies, across boundaries and travel modes. Development of new ITS services and systems will not only encourage a reduction of internal organizational stove-piping, but also help forge new relationships, formal and informal, across jurisdictional and institutional lines. This may mean the creation of new ad-hoc virtual organizations that fill gaps between existing organizations until the formation of modified or new permanent organizations meets emerging needs.

ITS presents both the opportunity and the necessity to redefine critical relationships between the public and private sectors. Many of the functions which were originally envisioned as public-sector responsibilities in fact have been or are being implemented by the private sector, notably including provision of traveler and traffic information to vehicles and the widespread collection of data about the roadway system. The functioning of new on-board safety systems can be greatly enhanced through the use of information from both public and private sources. New public-private relationships are needed to maximize safety while optimizing both individual trips and the overall performance of the transportation system, within a sustainable business model.

An opportunity exists to improve the commerce transactions at the borders of the United States with Canada and Mexico. There exists a memorandum of understanding between the U.S. DOT and the Canadian Ministry of Transport to work together to coordinate their ITS architectures and ITS initiatives. Mexico is also working toward an ITS architecture. The borders of all these countries see a great exchange of commercial vehicle traffic and would benefit greatly from the application of ITS to improve border clearance.

After Abilene, Texas, began operating a computer-coordinated traffic signal system along heavily used corridors, the city reported a 37-percent reduction in delays, a 22-percent increase in travel speed and a 12-percent reduction in carbon monoxide.

FUNDING

Of the $100 billion for highway programs (federal/state/local), it is estimated that about 2–3% is being spent on systems operations and management. Less than $1 billion is spent on ITS from all sources of government.

Today, funding for ITS applications comes from a variety of federal and state sources. ITS capital is funded substantially through discretionary program earmarks and takedowns from the Congestion Mitigation & Air Quality Improvement Program (CMAQ) and the Surface Transportation Program (STP) funds where Metropolitan Planning Organizations (MPOs) have some discretion – or it is incorporated into routine facility improvement line items. Federal support also comes from the National Highway System program. Some ITS funds come from long-established programs. For example, snow and ice removal is typically funded with state maintenance funds. Other funds come out of highway project capital. ITS and operations are personnel-intensive and staffing levels have been under intense pressure at all levels of government. State DOTs are accustomed to funding staff and administrative costs from state funds and staffing is usually state-capped – regardless of costs.

Over the next decade, increased funding for ITS programs will be needed to plan and deploy new systems, to support operations of those systems and to hire and train the skilled personnel to manage the systems. Federal, state and local governments will obtain much of this funding through traditional resources such as the Highway Trust Fund, but innovative finance and the private sector will also play an important role through programs like the Transportation Infrastructure Finance and Innovation Act (TIFIA). Current funding categories and allocation processes will have to evolve to ensure that ITS is sustainable over the long term.

In most cases, system operations and management is not an independent program with its own budget line item. Few states have a separate business plan for "operations" that identifies and commits to a range of integrated activities. Operations is funded from other budgets and from resources accumulated project by project on an ad hoc basis. Equally important, many of the costs associated with operations – staffing, upgrades of operations hardware and software and maintenance of operation equipment – are buried in state and local budgets outside the Federal Aid process. Until the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), there was a long-standing federal prohibition against non-capital expenditure. However, this philosophy has evolved and the Transportation Equity Act for the 21st Century (TEA-21), along with changes in Title 23 have made operating costs, including labor, an eligible use of Federal Aid in most programs.

While public funding for ITS projects continues to grow and ITS continues to be adopted throughout the United States, the widespread deployment of ITS depends on mainstreaming ITS into the basic funding and planning process and seeking creative alternative funding mechanisms.

Public Sector Roles, Relationships and Funding

Benefits

>>As institutional relationships evolve, an increased level of inter-jurisdictional effectiveness is possible. Higher levels of coordination are essential to capitalize on the more exciting promises of ITS, especially those relating to the synergies between supply operations and demand management strategies. These include both program levels (combining resources to provide new services that were previously not feasible) and activity levels (using traveler information to reinforce systems operations management actions). In addition, agencies will have increased capabilities to respond to changing conditions, such as roadway incidents or other emergencies. Quicker responses will result in better utilization of the physical infrastructure. Better utilization will lead to an enhanced return on investment from that infrastructure.

Travelers (for commercial, business, personal, or other purposes) will benefit from more seamless management of the transportation system. Equally important, with responsibilities more transparent, travelers will understand where accountability resides for the operation of the transportation system.

Effective cooperative relationships between public- and private-sector organizations, especially relating to information sharing and management, will promote safety, efficiency and productivity of travel.

Benefit/cost studies consistently show ITS improvements providing returns of 5 or 10 to 1 (or better), compared to returns on conventional investments of less than 2 or 3 to 1. An increase in the level of investment in ITS will improve the cost-benefit balance of the transportation sector as a whole.

Increased funding for ITS and operations will lead to better management of the existing public investment in transportation infrastructure. More efficient and effective use of the existing system will lead to a higher return on that investment. At the same time, travelers (for commercial, business, personal, or other purposes) will benefit from improved system performance. Combining public and private investments may contribute to a mix of technology and operational infrastructure not obtainable through public or private sponsorship alone. Alternative pricing strategies may make the means of collecting revenues simpler, increasing overall revenues.

Public Sector Roles, Relationships and Funding

Challenges

- **Policy Support** The development of new institutional and organizational roles and relationships requires high-level policy support and an "authorizing environment" from elected decision-makers and legislature. New institutions and operational relationships are not "business as usual" and can therefore be difficult to fund and promote in the public policy arena.

  At the state and local level, political jurisdictions may place greater priority on internal needs rather than connecting to and serving constituents beyond their boundaries. Policymakers need to be shown the benefits to their constituents of a broader perspective. Differences in organizational policy relative to procurement procedures, labor relationships and other regulatory requirements may need to be changed. In many instances, effecting new roles and relationships requires support (including a steady source of financial support) from policymakers to amend laws and regulations.

- **Identification of Common Priorities** The perceived importance of ITS varies across and even within agencies. Differing priorities, resistance to ITS and non-participation by key agencies, agency components and geographically dispersed groups within organizations can seriously compromise efforts to plan and deploy ITS.

- **Regional Operating Organizations (ROOs)** The way these institutions operate, organize themselves and interact, both with one another and with the traveling public, is ultimately the most difficult and the most vital challenge that ITS must meet. With the exception of a small number of pioneering and some states supporting new public and private relationships, most ITS services and systems have been implemented within existing institutional and organizational structures and legislative mandates. A few states have taken important first steps on individual projects and other informal arrangements that have been negotiated.

- **Communication and Cooperation** Since operations and ITS tend to cross jurisdictional and agency lines, an organization with a regional view and charter is often needed to enable communication, cooperation and coordination. Metropolitan Planning Organizations (MPOs) have served this role in some locales, but may not be able to do so in all. Operations and ITS issues often require the involvement of non-transportation agencies (e.g., police departments). Communication with these agencies needs to be improved to enable the full benefit of ITS. Coordination and integration with and between traditional infrastructure and operational agencies and organizations are also critical. As a group, jurisdictions and agencies gather significant amounts of data and have significant institutional knowledge and information. When appropriate institutional arrangements enable this information to be shared, jurisdictions, agencies and the traveling public benefit.

- **Organizational and Institutional Integration** ITS typically falls within the purview of operations staff. Operations may not be a clearly recognized area of responsibility and operational functions are often split across departmental lines, making it difficult to achieve concerted operational policy and action. New crosscutting institutional arrangements – both within state and local agencies and between transportation agencies and other service providers – are necessary at various scales to ensure adequate organizational and institutional integration. Organizational and institutional integration is important in several ways:

- Routine capacity-preservation activities such as snow removal, the promotion of high-occupancy vehicle use and traffic signal improvements.
- Ad hoc public safety responses such as special event management, emergency plans and Commercial Vehicle Operations (CVO) regulatory automation.
- Planned construction disruptions such as work-zone traffic management and maintenance scheduling.
- Real-time system performance functions involving multiple jurisdictions, such as incident management.
- Initiatives for advanced traveler information systems, often in cooperation with the private sector, possibly involving weather information systems, Mayday and 511.

- **Accountability** The fragmentation of the ITS and operations function across jurisdictions and agencies or within agencies makes it difficult for the travelers to determine who is accountable for meeting their needs as customers. This can lead to frustration on the part of the traveler and the direction of that frustration towards the wrong parties.
- **Difficulty of Increasing Funding Base** Transportation improvements are funded from limited tax-based resources and there is considerable public resistance to tax increases. ITS and related systems operations and management capital programs must compete with conventional capital investments for resources. Highway and transit capital programs have a considerable backlog, as do traditional supporters and beneficiaries. Increases in expenditures for operating resources are strongly resisted at all levels of government.

Houston's TranStar ITS System includes a ramp metering system which saves 2,875 vehicle hours a day.

Public Sector Roles, Relationships and Funding

Actions

RESEARCH

- Continue research into the formation of **new institutional** and organizational **roles and relationships** in all areas and at all levels. The research should consider existing and developing institutions and organizations, identify successes and failures and study a number of such variables:
  - History and past organizational relationships.
  - Relation of system, user and political boundaries.
  - Legacy and developing modes and systems.
  - Environment and system conditions.
  - Public-private partnerships.
  - Types and makeup of coalitions that develop.
  - Laws, regulations, or other procedures or processes that were helpful or not.
  - Evidence of one or more champions.
  - Type and content of working agreements.
  - Use of communications techniques and mechanisms.
  - Organizational and staff capabilities.
- Examine the **benefits and costs** of the new roles and relationships, including their effects on travelers. Match different regional characteristics with appropriate organizational approaches. Explore incentives to motivate giving up individual jurisdictional control and working through broader arrangements.
- Research the **impacts** of establishing literal or **virtual interjurisdictional and multimodal arrangements** to manage and operate a region's transportation system in a seamless, integrated fashion. Study and develop methods, practices, guidelines and resource materials for establishing such arrangements. With advice from ITS America, U.S. DOT should implement such a policy.
- Study the **workforce requirements** to support emerging organizations and institutions.

PROGRAM

- Develop **materials** for a range of readers **describing** the new institutional and organizational **roles and relationships:**
  - Case studies reflecting successes and failures and critical factors.
  - Analyses of the benefits and costs.
  - Guidebooks for undertaking institutional and organizational change.
- Encourage the creation of new **regional operating organizations** (ROOs). Meeting the needs of the next generation of transportation system users and customers requires a comprehensive transformation of the fundamental institutions that plan, own, operate and fund the transportation system. New regional organizations or public partnerships need to emerge with either literal or virtual co-location of functions enhanced by information and communications technology.

- Continue to develop **training programs** for transportation and non-transportation agencies covering various institutional and organizational issues relative to ITS. Develop interdisciplinary training that cuts across departmental lines as well as agency lines to demonstrate the potential of an operations approach with ITS as a key component.
- Continue to **develop tools and techniques for** better **planning ITS** projects and for better conducting procurement.
- Develop a framework for implementing **regional ITS** and systems management, including legislative, regulatory, operational and other issues. Develop a **long-term strategy** to examine institutional relationships and approaches for regional ITS and system management including resolving issues, developing case studies and guidance and providing outreach.
- Rethink methods for **procurement** and management of private sector services by public agencies, identifying the interests of the public that must be protected, but seeking to establish conditions that encourage a high level of private sector **effectiveness and performance.** Seek and publicize examples and methods of establishing collaborative relationships with contractors that assure performance and propriety without slowing or micromanaging projects.
- Encourage state DOTs and metropolitan planning organizations (MPOs) to include **ITS mainstreaming** in transportation improvement plans (TIPs).
- Modify the Biennial Conditions and Performance Report to Congress to better **assess** the return on investment of **ITS projects.** This would involve modeling the impact of ITS-supported operations and management investments compared to conventional capacity-oriented investments.
- Consider revisions to current federal law and regulations relative to funding. Options should be considered to increase the **emphasis on ITS and operations:**
  - Major new formula program category for systems management initiatives.
  - A new categorical program for Bottleneck Improvements as a takedown from existing major formula programs.
  - A program requiring strategic segments of the National Highway System (NHS) to be upgraded with information systems.
  - A criteria-based program orienting a proportion of NHS and Surface Transportation Program (STP) funds to operations-oriented improvements as a condition of grants.
  - Expansion of the Intelligent Transportation Infrastructure Program, a private-public co-investment program, to instrument major metropolitan systems and provide traffic information.
  - An expansion of Congestion Mitigation & Air Quality Improvement Program (CMAQ) eligibility criteria and scope with a congestion focus.
  - A discretionary program supporting Traffic Operations Control improvements.
  - A discretionary program to stimulate non-transportation agency participation in incident management, emergency management, safety management and freight management activities.
  - An addition to state and local planning and research funds to support operations planning.

PROGRAM, continued

- A modification in the existing National Corridor Planning & Development Program and the Coordinated Border Infrastructure Program to support improved freight operations, including smaller-scale operations such as terminals and connectors.
- A dedicated funding program for supporting motor carrier safety and operations research, technology development testing and transfer and completion of Commercial Vehicle Information Systems and Networks (CVISN) nationwide.
- A discretionary pilot program to develop and test various approaches to operations-focused business planning.
- Higher match levels for operations investments from existing categorical programs.

- Ensure that operations "assets" are included or integrated within overall asset management systems. Conversely, ITS may also be used as a way to provide data to and manage, **asset management** systems. More broadly, information generated through ITS should be viewed as an asset.
- Create incentives for participating in pilot programs on **value pricing.** The key to increased adoption of alternative pricing is to get pricing into the toolkit of options that transportation planners consider, even in regions that are not yet ready to fully adopt ITS technologies and policies.

On June 11, 2001, Federal Highway Administration Deputy Executive Director Vincent F. Schimmoller joined Kentucky Gov. Paul E. Patton in placing the nation's historic first telephone call to 511 - America's traveler information telephone number.

Schimmoller commended the citizens of the Cincinnati and northern Kentucky metropolitan area for their vision and national leadership in connecting to 511. "While easy access to current local traveler information does not resolve congestion, it does return control to travelers who will be able to make informed choices about time, mode and route of travel. Ultimately 511 will lead to saved lives, time and money and improve the quality of life for America's travelers," he said.

In 1999, when the US DOT submitted its petition to create the 511 number, more than 300 traveler information telephone numbers existed nationwide. As area codes proliferated and American travel continued to increase, it became clear that a single three-digit national number would be useful in providing motorists with local traveler information - anytime and anywhere. The ARTIMIS system, covering the Cincinnati and Northern Kentucky metropolitan area, was previously made available via 211 in portions of its coverage area. Conversion to this original 3-digit access number resulted in 73% more calls received when compared to a 7-digit number.

INSTITUTIONAL

- Establish a **percentage set-aside** of all federal highway and transit funding to pay for creating and operating integrated organizations and operations services along with base cost of core ITS infrastructure and operations. This would be analogous to the percentage set-aside that is currently administered to support transportation planning. In general, modify federal, state and local laws and regulations to make innovative institutional and organizational approaches eligible for Federal Aid funds.
- Continue to develop **relationships between public and private sector** institutions. In many cases, a critical component of new institutional relationships is the recognition that the private sector has a valid interest in many transportation decisions, including those related to operations. Moreover, the private sector may have information and other resources to apply to this effort. Awareness is needed with regard to possible private sector roles.
- Organizations like U.S. DOT, ITS America, the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB), the Association of Metropolitan Planning Organizations (AMPO) and the Institute of Transportation Engineers (ITE) need to continue to engage in discussions with MPOs and other national associations about the need and appropriate evolution of new **operations-oriented institutions** and organizational arrangements.
- Work to reduce or **eliminate barriers** in the federal aid program to the creation of new **innovative institutions** and relationships for **regional ITS** and system management. Develop guidelines and resource materials for establishing such arrangements. Encourage establishment of integrated transportation management and operations and interjurisdictional organizations or partnerships analogous to the multimodal planning agencies and arrangements of the 1960s. There should be no bias against existing institutions (such as Metropolitan Planning Organizations) playing these roles.
- Encourage **state DOTs** to appropriately locate systems operations and management within its strategic priorities, as well as to develop business plans which adequately **support ITS.**

The Federal Railroad Administration and the Federal Transit Administration are working together on the development of Intelligent Railroad Systems. Intelligent Railroad Systems will incorporate new sensor, computer and digital communications technologies into train control, braking systems, grade crossings and defect detection and into planning and scheduling systems as well and will apply to freight, intercity passenger and commuter railroads. Work has begun on the development of the architecture for Intelligent Railroad Systems.

Federal Policies and Initiatives to Achieve Extensive Private Sector Product Deployment

Current Status + Opportunities

>>The private sector plays a major role in developing and delivering advanced transportation services and in providing access to the social and economic benefits of these systems to all users. Users include state and local governments, public and private transportation system operators, other businesses and consumers.

Private sector organizations recognize both the economic opportunity provided by a robust market and the social opportunity to enhance the well-being of citizens. However, for these opportunities to be realized, improvements in public-private cooperation are needed. Partnerships, common objectives, mutually generated program plans and joint long-term commitments need to be developed. Traditional business-government relationships need to be redefined to enhance private sector opportunities in the commercial market place.

The private sector is experienced in and committed to the ITS market and expects to contribute to and participate in its development and expansion. The private sector is prepared to be:

- **Providers** of products and services that will satisfy requirements of governments, businesses and consumers.
- **Partners** with government in the development or delivery of transportation services.

  ITS needs multi-jurisdictional services and the private sector has demonstrated its ability to simplify the delivery of these services. In addition, the rapid evolution of transportation-related technologies gives the private sector greater flexibility in selecting and incorporating technologies more quickly and effectively. This can lead to public-private partnerships that can benefit all. While the profit motive appropriately drives the private sector, profits can be realized in a context that is consistent with the government charter to assure access to services for all. 511 is an example of such joint effort.
- **Innovators** in designing new approaches to transportation issues through research and development of new products, systems, services, relationships and businesses to provide better transportation products and services.

In seeking profits in the ITS arena, industry continues to invest billions of dollars to research and develop new offerings that will appeal to buyers in terms of convenience, comfort, safety, mobility, economic advantage and efficiency.

Considering the estimated societal benefits that will be achieved through ITS deployment, government needs to help accelerate deployment by encouraging and endorsing the sale of appropriate products and services by the private sector. Each purchase of ITS products or services, whether by consumers, businesses or government, brings value to society, with benefits extending beyond the actual purchaser.

In the early years, government has focused on incorporating ITS in the transportation infrastructure. The private sector supported these efforts with products and services while educating itself on the requirements for next-generation capabilities. Other segments of the private sector focused on developing ITS products and services for sale to consumers and users.

Over time, industry will design marketing and sales programs to educate the buyers on the benefits of ITS purchases and achieve significant market penetration. The public sector can play an important role in accelerating this penetration. Helping to convey the benefits of ITS, initiatives to quantify and demonstrate these benefits to potential buyers and efforts to provide incentives to encourage purchases would shorten the time for product and service rollouts and accelerate realization of the societal benefits.

If the public sector can help clear the way for private sector success, then this private sector success can help advance overall objectives for a safer, more productive transportation system. There are several ways in which government could directly encourage consumer acceptance and use of ITS:

- **Endorsement** Government could use advertising campaigns to underscore the value of mobile information and communications (i.e., telematics) systems that promote safer and more efficient travel.
- **Public Access** Government can help defray the private sector's cost of creating information products and services (e.g., enhanced advanced crash data in standard formats).
- **Early Adoption** Where end-user products and services are demonstrated to have economic and safety value, government can be an early adopter of ITS technologies in its own fleets and offices. This creates a lower-risk environment for adoption by others and, by generating early sales volume, helps to lower the cost for the general public of adopting beneficial ITS technology.
- **Incentives** Government could give subsidies or other incentives to consumers who purchase ITS products and services.
- **Barrier Removal** Government should carefully review regulations and procedures and remove those which inhibit the efficiency of the ITS market, for example:
  - Removing antitrust obstacles to appropriate precompetitive cooperation, especially where consistency of human factors is important to assuring safety.
  - Carefully addressing the product liability issue to avoid unnecessary delays in introducing products that have been demonstrated to save lives.
  - Revising procurement rules to allow more efficient purchase of ITS products by government agencies.
- **Research Support** Public sector support of private sector research programs will enable the private sector to deliver safer vehicles more rapidly and more reliably.

There are other areas for fruitful public-private cooperation as well:

- New in-vehicle safety capabilities, enabled by a new generation of in-vehicle electronics, will only realize their full potential in the context of high levels of public-private cooperation. Automotive manufacturers and their suppliers will provide new in-vehicle electronics. Performance of these products will be enhanced by information, delivered by private information service providers, that originates from both public and private sources.

At the same time, effective operation of the transportation system will depend on gathering and delivering good real-time data about how the transportation system, particularly the roadway system, is performing. In communication with telematics services, providers' partnerships should be developed to explore best methods, such as vehicle data probes, for delivering accurate and useful real-time information, readily, quickly and widely.

The availability of this information can significantly reduce the need for roadway instrumentation (especially outside of city centers and on less major roads) and decrease the need for and cost of direct information gathering by the public sector. It is therefore in the public sector's self-interest to catalyze the rollout of in-vehicle ITS products through incentives and subsidies.

In any case, it is vital for the public-private relationships to be built that will allow for the sharing of transportation system information among all relevant parties. Such relationships will necessarily include appropriate provisions for maintaining the privacy of individual drivers.

- Traditionally, government has not been well positioned to procure information technology, which moves rapidly through product cycles developing new generations of typically less-expensive technology in matters of months. Since ITS is fundamentally the application of information technology to the problems and opportunities of surface transportation, traditional procurement practices need to be updated and accelerated. Otherwise, government procurement of ITS will be stuck in a cycle of buying older than necessary technology at higher than necessary prices.
- New models are needed as well to accommodate the trend toward private sector performance of traditionally public sector activities, including the operation of traffic management centers, private ownership and operation of toll roads. Some existing models like the Transportation Infrastructure Finance and Innovation Act (TIFIA) appear to be working well and could be expanded.

The #SAFE automated traveler weather information system has been successful in providing travelers in North Dakota and South Dakota with updated weather forecasts for their travel routes via their cellular phones. In a survey, over 42% of travelers said they changed their trip plans or slowed down because of information from the automated weather reports. The vast majority of respondents (94%) indicated they expected to benefit from the system in the future.

Federal Policies and Initiatives to Achieve Extensive Private Sector Product Deployment

Benefits

>>The ITS private sector is essential for realizing the promise of ITS to save lives, time and money. Where government is the customer, the private sector can have a major role in developing, operating and maintaining a modern, cost-effective infrastructure. Where consumers are the customer, the private sector will have primary responsibility for delivering the goods and services that promote safety, efficiency, productivity and a better quality of life.

Challenges

- **Investment** Much of the cost for ITS development is front-end loaded. That is, a sizeable investment is required before any significant revenues can be generated. However, the investment climate is not currently very favorable. Large self-investors like automotive manufacturers are not generating the profits of a few years ago that fueled their investments. Venture capital and other private capital that funded startups is now relatively scarce, especially for pre-revenue companies. Alternative capitalization mechanisms and incentives are needed to continue the expeditious development and deployment of ITS technologies and services.
- **Institutional Barriers** Private sector cooperation in areas like precompetitive research and the development of consistent user interfaces for safety systems is potentially being inhibited by antitrust concerns. Rapid deployment of safety-enhancing products is potentially being slowed, particularly in United States markets, by product liability concerns.
- **Procurement** The traditional public procurement methods used to acquire transportation infrastructure assets are not well suited for obtaining rapidly changing systems of technology and information and need to be changed.
- **Energy and Environment** The opportunity for ITS to mitigate energy and environmental impacts is not widely understood and therefore this opportunity is not being emphasized in seeking increased resources for ITS development and deployment.

Federal Policies and Initiatives to Achieve Extensive Private Sector Product Deployment

Actions

RESEARCH

- Study and recommend new models for large-scale cooperative private-sector precompetitive research, which can draw on federal funding resources without being unduly delayed either by contracting issues or by inappropriate government staff oversight of the process.
- Study the more successful European and Asian models used to support private interests in the quick development and deployment of ITS technologies and services.
- Research/development/tests to promote and ensure cooperation between vehicles and infrastructure and commonality of infrastructure which will have great potential safety benefits.

PROGRAM

- Establish collaboration among vehicle manufacturers, information service providers, commercial vehicle operators and infrastructure owners to define appropriate allocation of functions to maximize safety.
- Initiate efforts to further enable the private sector:
  - **Attract private sector capital and technology into both products and services** The public sector needs to develop innovative strategies that make participation in building the ITS infrastructure and the provision of appropriate technologies and related services attractive to the private sector.
  - **Clear national approach to a transportation system** There should be outlined and incentivized procedures for the private sector to follow. This will minimize conflict of interest that can prevent real progress and the development of seamless applications. For example, a common infrastructure is required to support safety applications. Without common infrastructure, ITS-equipped vehicles will not operate to their full potential.
  - **"Adaptive Traffic Management"** This comprises traffic management on the basis of traffic forecasts and also includes the forecasted effects of road work, large events and weather which can be used to define and execute preventive strategies for adaptive traffic management.
  - **Rethink methods for procurement and management of private sector services by public agencies** Rework methods of procurement and management of private sector services. For example, develop and use pre-qualified bidder lists and government-wide acquisition contracts to ensure quality

products and timely delivery at a fair price for the contractor. The interests of the public must be identified and protected, but at the same time, conditions that encourage a high level of private sector effectiveness and performance should be developed. Seek techniques for purchasing solutions or services as opposed to acquiring obsolescing assets. In the case of common and related services provided across state jurisdictions, where common data and processes are used, the Federal Government must establish a common framework that facilitates outsourcing rather than proliferation of multiple systems and operations. Government procurement of data should specifically permit contractor-owned ITS systems, as a way to leverage private investment. Publicly owned rights of way should be made available for private ITS sensor systems, provided safety is not compromised.

- **Recognize key arenas for private sector-public sector cooperation** Arenas for such cooperation include crash response (mayday), real time traffic/roadway infrastructure, vehicles as probes, telematics, in-vehicle signing, performance data acquisition, 511, electronic screening of commercial vehicles and human factors (driver distraction) research. There may be additional room for joint research, joint funding, or additional sharing of information. In the traveler information arena, both the public and private sectors have an interest in traveler behavior, traveler requirements, travel and traffic forecasts and the willingness of the traveler to pay for value-added services.
- **Reduce public sector regulatory constraints and processes that pose unnecessary barriers** After identifying potential markets for private sector participation, the public sector needs to consult with the private sector on barriers to participation – and then remove them. In the commercial vehicle regulatory arena, for example, the Federal Motor Carrier Safety Administration (FMCSA) must assure that its policies and implementation tactics with respect to use of technology are effectively understood and executed by its agents at the state government level. This requires careful balancing of efforts to encourage technology applications while maintaining privacy of information and insulating carriers from liabilities related to technology use.
- **Accommodate private sector time frames and business models** The public sector needs to consider how and under what circumstances to change its practices to accommodate private sector time frames and business models. Conscious and proactive steps must be taken across Federal and state jurisdictions to assure that private sector applications serving public objectives are supported by complementary policies and practices that provide opportunities for return on the risk capital invested in these applications. Support for development of car-to-car and car-to-infrastructure communication/sensor standards will play a crucial role in enabling ultimate solutions towards a crash-free transportation system.
- **Consider franchising operational management of upper-level systems** There are opportunities for the public sector to outsource more of its operations. One possibility is to arrange to acquire information on an ongoing basis, rather than acquiring information systems that must be frequently updated. By so doing, the public sector may be able to obtain a higher level of technological

PROGRAM, continued

and operational expertise, without having to substantially build its own workforce. Significant and profitable opportunities exist for outsourcing information system applications that are common across many jurisdictions. One such area is unifying commercial vehicle regulatory and credentialing information systems. The Federal government must facilitate such opportunities by focusing program efforts on the development of common data sets and protocols across jurisdictions.

- **Integrate private sector intelligent vehicle activities with the public infrastructure** Interaction needs to occur between the private and public sectors to determine how mostly private-sector-oriented intelligent vehicles will interface with a mostly public infrastructure. Support for these interactions must be developed. For example, we are at the threshold of vehicles with radar, vision systems, maps/position and communications. Wisely combined, these have the potential to revolutionize vehicle safety. This is one of the primary tasks for ITS, especially the maps and communications which will require infrastructure cooperation.
- **Encourage forums to resolve the respective roles of public and private traveler information providers** In the last decade, a number of forums have been established for stakeholders in the ITS arena to resolve issues. These forums, or new forums, need to be encouraged so that tough issues can be resolved.
- **Accelerate efforts to eliminate disincentives for technology use** Consumer and commercial use of ITS technology to save lives, time and money can be significantly encouraged by addressing concerns regarding data privacy and liability.
- **Lead by example** Help jump-start the market by specifying the inclusion of safety-, efficiency- and economy-enhancing ITS products in the government fleets and by creating incentives for state and local public agencies and for companies operating van pools to do the same.

INSTITUTIONAL

- Develop **improved legal and institutional arrangements** for cooperative efforts. The differences between public-sector and private-sector operating procedures and policies often make working together difficult. Both sectors need to investigate ways to improve working relationships, including adjusting policies affecting such areas as asset commingling, asset ownership and disposition, intellectual property and profit sharing.
- Consider and implement adjustments to **antitrust rules** so that appropriate pre-competitive research is not inhibited.
- Consider and implement adjustments to **product liability** legislation so that safety-enhancing products are not delayed in coming to market.

PRIVACY

>>Privacy has been identified as one of the greatest public concerns regarding application of information technology to our everyday lives. It is viewed as a potentially serious constraint to acceptance of many aspects of ITS. ITS services need to be developed, to the extent possible, without maintaining databases of personally identifiable information. Where such information must be collected, it should be protected in a way visible to the traveler and controlled by such.

The ITS community developed and adopted, through ITS America, a set of privacy principles designed to address public concerns regarding protection of personal privacy in the delivery of ITS services. The privacy principles of ITS America includes an "Anonymity Principle" that states: "Where practicable, individuals should have the ability to utilize Intelligent Transportation Systems on an anonymous basis."

Personally identifiable information in data bases has been likened to hazardous materials: Rigorous procedures and techniques are required to contain it, management and control require sophisticated skills not typically found in agencies and all too frequently it leaks, with unintended consequences.

The definition of new User Services and their incorporation into the National ITS Architecture needs to fully consider the issue of privacy during their development. A User Service on Data Privacy and Security may be a useful addition to the Architecture. In addition, however, ITS systems need to be more reliably designed from the beginning with preservation of privacy in mind. There is a clear need for a consistent national policy on ITS privacy that can guide the development of next generation products and systems in a way that encourages their adoption without imperiling privacy.

Human Factors

Current Status + Opportunities

>>ITS is ultimately about delivering information to and from operators and users of the transportation system to make the system safer, more productive, more efficient and more accessible. Information is used to guide behavior and decision-making. Information is used to manage, adjust and control vehicles and the infrastructure. Information is generated to provide status, to seek answers, to get help in emergencies and to interact with other participants in the transportation arena.

While the new information opportunities that ITS creates are clearly valuable – in many cases essential – the sheer volume of information also creates potential problems: overload, distraction and confusion. Too much information, or information presented at the wrong time or in the wrong way, can create safety hazards. This can be true whether the recipient is the driver of an automobile or a professional driver (commercial vehicles, public transit vehicles, public safety vehicles, trains) who is distracted from the driving task or misunderstands a warning signal; or a staff member at a control center or operations center who responds incorrectly, especially during a critical event. As such, ITS technology has the potential to be a double-edged sword for users: systems that are designed to assist in safe driving may also add mental workload, physical workload and confusion to the driving task, thus creating an unsafe driving environment.

The human factors literature distinguishes between two design approaches: technology-centered design and user-centered design. Technology-centered design is driven by the latest technological innovations and involves the application of new technologies simply because it is possible to do so. It is certainly arguable that some ITS technology has been so applied. In contrast, user-centered design focuses on the system's end users early in the design process and ensures that the needs and capabilities of the end user are addressed. The human-factor literature is full of examples that demonstrate that failure rates are high when designs do not consider the system's end user early in the design process.

ITS applications, particularly those that involve "secondary tasks" performed by the driver (i.e., tasks performed while driving that are not the "primary task" of driving) involve an interaction between the system and the driver. It is important for ITS designers to keep in mind that interaction with their design/product is not the driver's primary responsibility. Rather, the driver is first and foremost required to provide a sufficient degree of resources (e.g., visual, cognitive, manual) to safely operate the vehicle. Interaction with ITS technologies must be designed to supplement and aid this primary responsibility and not hinder, interfere with, or supersede it.

Because of the complexity of the interaction between drivers and in-vehicle systems in a moving vehicle, technology-centered designs are likely to fail (i.e., will be hard to use and may be unsafe). ITS designers must consider what the driver is capable of doing, while at the same time safely operating a vehicle. Put another way, an ITS designer must develop designs based on what the driver needs and is capable of using while driving and not simply to make use of the latest and greatest technology. User-centered design is a fundamental concept within human-factors engineering and is a proven method of promoting effective, successful and safe design.

User-centered design begins by defining and characterizing end-users. For in-vehicle systems, the end-users could be either (i) general drivers, or specifically (ii) drivers of commercial, public transit and public safety vehicles.

DRIVERS in GENERAL

By far, the highest profile area of human factors concern for ITS relates to drivers of private automobiles (e.g., passenger cars, minivans, sports utility vehicles). They are the greatest concern by virtue of their sheer numbers and because they are *not* professional drivers, who are more likely to go through more extensive training. However, most of the issues related to drivers of private vehicles apply to all drivers.

Driving is a dynamic activity. In some situations, the driver resources required to safely operate the vehicle allow for secondary tasks. For example, all drivers, at some point while driving, have adjusted the radio and talked with passengers. There are some situations, however, where the driver must devote considerable mental resources to operating the vehicle. For example, merging onto a busy freeway requires a substantial amount of attention. In this type of situation, the driver cannot easily perform secondary tasks and drive safely. The ITS designer must take into account the varying level of attention required of a driver and the difficulty of predicting the driver's workload. A substantial opportunity lies in developing the ability to determine a driver's workload in real time and manipulate secondary tasks accordingly.

A related opportunity is determining the level of workload associated with different secondary tasks. "Driver distraction and focus" has become a prominent issue in the surface transportation domain. Distractions can arise from the entire driving environment, both inside and outside the vehicle: for example, the radio, children and other passengers, weather, other cars, roadside warning and information signs, in-vehicle communications and electronics, wireless telephone, compact disc and cassette players, the driver's state of mind, the state of the driver's digestion and nerves. A research opportunity lies in finding the relative degree of distraction of various tasks that drivers perform and the impact that this distraction has on safely operating the vehicle in a variety of driving conditions (i.e., low workload, such as driving on an open highway with low traffic volume and high workload, such as merging onto a busy freeway).

The varying characteristics of different drivers must be carefully considered and researched in preparing ITS technologies for the marketplace. Consider, for example, the potential difference in capabilities of a 19-year-old driver compared to an 80-year-old driver, or a disabled driver. (Differences include relative maturity of judgment as well as speed of reflexes.) There are human factors opportunities in the ITS domain for examining the characteristics of different driver groups and studying their impact on system use. Designers should consider all drivers, including inexperienced drivers, older drivers and disabled drivers, so that systems can be developed for safe and effective use by the entire driving population.

Research has shown that improving the predictability of a daily commute is more important than the travel speed and total travel time in reducing commuting stress. A recent study based on historical travel time data for the commute between the two Washington, DC suburbs of Laurel, MD and Dale City, VA found that a pre-trip Advanced Traveler Information Service (ATIS) could provide an improvement in this predictability. The study showed that a traveler, when provided alternative routes and departure times, could reduce the time budgeted for commuting by 13% when compared with the option of always leaving early to ensure on-time arrival. Further analysis on data from the Washington area showed that ATIS users could reduce the number of late arrivals to home and work by 69% when compared with those who don't use ATIS.

DRIVERS of COMMERCIAL, PUBLIC TRANSIT and PUBLIC SAFETY VEHICLES

The needs, abilities and capabilities of professional drivers are far different from those of the general driving population. Professional drivers (such as operators of commercial vehicles, public transit vehicles, public safety vehicles and trains) are typically highly trained, monitored and routinely evaluated for performance. Because of their training and experience, the driving abilities of professional drivers are considered to be superior to those in the general driving population. As such, professional drivers are likely to behave differently in driver-ITS system interactions as compared to private drivers.

However, these drivers will typically be confronted with a larger range of on-board systems and information flows than the passenger car driver and represent cases where the costs of distraction can be much greater in terms of loss of life and property damage. More research needs to be directed at understanding the attention, workload and distraction issues for professional drivers and how these differ from those for private vehicle drivers. This is an important research area for designers working on ITS systems directed at commercial, transit and public safety vehicle drivers.

HUMAN-MACHINE INTERFACE

In addition to conducting research on the characteristics of the users of ITS technologies (e.g., drivers), substantial research opportunities exist in developing the human-machine interface (HMI) for ITS technologies. For example, while it is clear that computers in cars need a different type of HMI than computers on desks, it is not clear what this should be. Though some research has been conducted on HMIs, the style of delivering information to drivers and, equally important, the ways in which drivers will communicate to and direct on-board systems, is still largely uncharted territory. Opportunities abound in researching appropriate content and presentation methods (e.g., mode, format and timing) of information to promote ease of use and safety. A related opportunity involves clearly defining what ITS tasks could and should not be conducted while the vehicle is in motion.

Another important opportunity in this area is in regard to the implications of integrating multiple ITS applications inside, or inside and outside, a vehicle. How should individual systems be integrated? What is the impact with regard to driver distraction and work-load when multiple systems are integrated? How can systems and messages from systems and between systems, be prioritized? Consideration must be given to developing an integration and prioritization scheme that will be flexible enough to include ITS technologies that have not yet been developed.

OTHER HUMAN FACTORS CONCERNS

In addition to the human factors issues discussed above, there are several other human factor issues that require attention:

- Prioritization of multiple control and warning systems, or a hierarchy for managing which system has ultimate control in time-critical situations.
- Workload issues for center personnel, for example at traffic management centers, rail operations centers and emergency response centers.
- Signs and signals for cyclists and pedestrians.
- Harmonization of external signs and signals with in-vehicle signs and signals.
- Orchestrating consistency of in-vehicle warnings across all vehicles.
- Presentation of traveler information on the Web and at kiosks in a way that maximizes usefulness and minimizes potential confusion.

enabling theme 4

Human Factors

Benefits

>>The successful implementation of ITS technologies, particularly those systems used by drivers while operating their vehicle, is dependent upon addressing safety and human factor issues. More specifically, the ability for ITS to save lives, time and money clearly depends on deepening our understanding of how people interact with the vehicle, with roadway systems and with in-vehicle or other transportation-related information systems.

Understanding human factors issues associated with ITS technologies is a fundamental key to the effective delivery of the benefits of ITS. Only by gaining this understanding can the promise of ITS be fully realized. A better understanding of ITS human factors and the implementation of human factors design principles, guidelines and research findings, will facilitate the rollout of safe and usable ITS products and services for all users. ITS designs that do not consider the users' abilities and limitations are doomed to failure. In addition, addressing human factor issues in the design process will substantially reduce the liability concerns that designers and manufacturers face.

Human Factors

Challenges

- **Leadership** There are several organizations and agencies that are exploring ITS human factors issues. For example, the Society of Automotive Engineers has played and will continue to play, a major role in the development and implementation of design standards that impact ITS designs. The National Highway Traffic Safety Administration has been and continues to be, involved in research directed at "driver distraction." Good human-factors research will require a high level of cooperation among multiple levels of public agencies and private-sector organizations from multiple transportation sub-industries.
- **Funding** Ideally, both public and private entities should fund human factors research activities. It is acknowledged that findings from privately funded research may not be disseminated outside the funding organization for proprietary reasons. As such, so that the results from human factor studies remain in the public domain, the reality is that the federal government will be required to fund much of this research.
- **Competitive Issues** Automotive manufacturers conduct considerable human-factors research. However, the results of this research are usually considered proprietary and do not reach the public domain. The human-factors focus related to safety requires a cooperative effort, leading to overall consistency, not a competitive effort resulting in products differentiated by their driver interfaces. There are examples of successful cooperative initiatives, such as the Collision Avoidance Metrics Program (CAMP), that involves U.S. DOT and a number of auto manufacturers. Cooperative initiatives such as CAMP provide a successful model of how public-private initiatives can manage competitive issues. However, the intellectual property developed under cooperative agreements remains a contentious issue, which must be dealt with case by case.
- **Liability** Vehicle manufacturers continue to be concerned about who would be liable in case of a crash that involved a vehicle outfitted with advanced safety technology.

"Even in this winding neighborhood, the GPS (in-vehicle navigation) unit kept up with our changing speeds and winding terrain. . . and gave us plenty of advance notice with its voice prompts and zoom mapping."
Road test by WBNS-TV CH 10 of Columbus, Ohio

Human Factors

Actions

RESEARCH

>>The research outlined here covers a broad spectrum of human factor issues. It is important to point out that some of the items listed may overlap with research currently being conducted by multiple organizations. However, much needs to be learned on this very broad topic and the efforts of many organizations are required, including public agencies like the National Highway Traffic Safety Administration (NHTSA) and standards organizations like the Society of Automotive Engineers. (See also the driver behavior research called for in Programmatic Theme #2 - Advanced Crash Avoidance Technologies.)

- Explore the development of a national crash and critical incident database. This program would include instrumenting light and heavy vehicles with unobtrusive data collection equipment (i.e., "black boxes") to gather data on normative driving behavior and the interaction of normative driving behavior on ITS use. This program would serve to collect on-road performance and behavior data from drivers as they operate their vehicles. One of the many potential outcomes of this research would be that it would provide data on the safety benefits and implications of operating vehicles while interacting with ITS. Results from an ongoing NHTSA study should be augmented through additional research as necessary.

- Conduct research directed at identifying and defining methods, protocols and tools with which to measure and evaluate the safety benefits and safety implications of in-vehicle systems and other ITS. The development of a standardized method of identifying the safety benefits and implications of ITS design is critical to successful implementation of these systems. Though some research has occurred in this area, ITS innovation tends to be many steps ahead of the research community and ITS products come to market faster than the human factors and safety research community can conduct research and develop guidelines. As such, the proposed research program must involve a continuing effort to address new ITS technological innovations.

- Conduct research aimed at developing guidelines and standards for the design and implementation of in-vehicle systems and other ITS. Specifically, these guidelines should focus on the human-machine interface (HMI) and the content and presentation of information. Guidelines and standards should focus on ITS ease-of-use and safe operation while operating a vehicle. Once a guideline or set of guidelines has been developed, an ongoing program must be implemented to: (i) widely disseminate the information to ITS decision makers and system designers and (ii) solicit feedback from system designers with regard to the implementation of the guidelines. In addition, as appropriate, the output of this research program should be the development of standards by appropriate domestic and international standards development organizations.

- Conduct human factors research aimed at ITS and **Commercial Vehicle Operations** (CVO). The needs of CVO and the abilities of CVO operators differ from the needs and abilities of private vehicle drivers. As such, a research program aimed at CVO interests in ITS applications should be considered separately from ITS applications for private vehicle drivers. Efforts should be made to evaluate the impact of on-board safety technologies and other equipment and information on commercial drivers, including the impact of these technologies on driver workload and alertness and the potential for risk-adaptive behavior or over-reliance on safety systems. Based on these findings, priorities should be set among information flowing to and from the driver.
- Explore **driver distraction.** A wide range of ITS-related distractions should be included along with non-ITS distractions. The research should comprehensively include both ITS and non-ITS factors internal and external to the vehicle. Focus should be on exploring design interventions and countermeasures to driver distractions. Specific research issues would include how in-vehicle systems can be designed to accommodate the increased functionality and, at the same time, maintain safe levels of workload and attention.
- Develop a fundamental measure of **driver workload,** that can help in understanding drivers' limitations and the system characteristics that result in overload or distraction to drivers. Priority should be placed on systems that are closest to market introduction. The Intelligent Vehicle Initiative program's focus on the safety and usability of these products in commercial vehicles needs to be expanded to passenger vehicle applications.
- Plan and execute a program of research to explore **driver behavior,** response to guidance, risk-taking and attitudes toward on-board systems assuming partial or total control of driving tasks.
- Conduct human-factors research aimed at transit **bus operator** workstation designs as it relates to integration of mobile data terminals, fare payment, collision warning and other operator information systems.

The FAST-TRAC system of advanced traffic signal control also includes diagnostic capabilities. With traditional traffic signals, many problems could only be fixed by a crew driving to an intersection and physically fixing the hardware. With FAST-TRAC, many problems can be repaired, via computer, from the operations center - or even from a laptop computer with a modem.

PROGRAM

- Coordinate and fund the **transformation** of **research results into** guidelines, best practices and industry consensus **standards** as rapidly as possible. Research findings and guideline documents must be widely available and disseminated to decision-makers and system designers. The human-factor community has historically had problems in communicating research findings and guidelines to end users. Considering this legacy, special attention must be given to guideline presentation format. That is, guidelines must be developed and presented to designers in a clear and concise manner. The dissemination of research findings and guidelines must not be the end of the process. Rather, a program must be implemented to solicit feedback from designers with regard to the results of guideline implementation. The guideline development process should not be treated as a one-way flow of information from researcher to designer. Rather, feedback loops must be built into the process, where an iterative flow of information/feedback between researchers (originators of the guidelines) and designers (users of the guidelines) is facilitated.

INSTITUTIONAL

- Make the study of transportation and ITS-related human factors **an issue of national concern** and importance, to focus attention and resources and to move the **exploration** forward as aggressively as possible.
- Create a **national coalition of public and private stakeholders** to take responsibility for exploring and authoritatively stating **guidelines for ITS**-related human factors.

Personnel in Northern Virginia's traffic operations center (located near the Pentagon), were able to see and hear what happened on September 11th, 2001. Knowing that a massive evacuation would soon begin (and in spite of their own orders to evacuate), traffic controllers reversed HOV lanes and opened them to all traffic heading south on I-395 and I-95. The state-of-the-art traffic signal system was quickly moved into its "July 4th" mode to allow maximum traffic flow away from the D.C. and Pentagon areas. The Transportation Emergency Operation Center in Richmond assisted by distributing information directly to public safety units throughout the state. Updates were provided to the Internet and communication with commercial radio traffic reporters was constant, keeping the public informed.

The overriding responsibility of the public sector is to look out for the public good: to ensure that the transportation system serves the widest possible constituency effectively and safely, impacts the environment as little as possible and to foster a robust and productive transportation industry.

>> public >> private >> universities

Stakeholder Considerations

THE PRECEDING SECTION PROVIDED A BROAD COLLECTION OF HIGH PROFILE, HIGH IMPORTANCE THEMES AND ACTIVITIES FOR THE CONSIDERATION OF THE ITS COMMUNITY. AS ALWAYS, THESE ACTIONS ARE NOT ENDS IN THEMSELVES, BUT MEANS TO ACHIEVE THE VISION ARTICULATED EARLY IN THIS PLAN THAT FUTURE SURFACE TRANSPORTATION SYSTEMS:

> ...WILL BE TRANSFORMED INTO AN EFFECTIVELY MANAGED, UNIVERSALLY AVAILABLE AND AFFORDABLE SYSTEM WHICH PROVIDES FOR THE SAFE, EFFICIENT and ECONOMICAL MOVEMENT OF PEOPLE AND GOODS, A SYSTEM WHICH ENHANCES CUSTOMER SATISFACTION AND WHICH IS COMPATIBLE WITH ENVIRONMENTAL CONCERNS.
>
> ...WILL BE MANAGED AND OPERATED TO PROVIDE SEAMLESS, END-TO-END INTERMODAL PASSENGER TRAVEL REGARDLESS OF THE AGE, DISABILITY, OR LOCATION AND EFFICIENT, SEAMLESS, END-TO-END INTERMODAL FREIGHT MOVEMENT.

THE PURSUIT OF THE THEMES AND THE EXECUTION OF THE INDICATED ACTIONS ARE INTENDED TO MAKE THIS VISION A REALITY OVER THE NEXT TEN YEARS.

Stakeholder Groups

>>The primary purpose of this section is to identify, in brief, the general roles and responsibilities of major stakeholders. Over a dozen major stakeholders are identified and called on to contribute to the realization of this Plan. Most of these stakeholder fall into one of three macro-level stakeholder groups:

The Public Sector

The Public Sector includes government agencies at all levels that have responsibility for planning, building, maintaining, operating, overseeing and in many cases funding the transportation system, particularly the roadway infrastructure and public transportation. The overriding responsibility of the public sector is to look out for the public good: to ensure that the transportation system serves the widest

possible constituency effectively and safely, impacts the environment as little as possible and to foster a robust and productive transportation industry. Meeting this responsibility takes many forms, including leadership and funding for research which is either too risky or too long-range for the private sector to shoulder by itself, the direct provision of facilities and services to the traveling and shipping public through the development and management of the public infrastructure and the regulation of transportation especially in areas where public safety or welfare are at issue. Its regulatory role and the magnitude of the funds it controls gives the public sector enormous power for setting directions and for making programs happen (or not happen).

At the same time, the public sector is not monolithic. It is composed of thousands of agencies at multiple levels, each with its own constituencies and immediate problems to address. This Plan encourages both coordination and flexibility, working with one another and with the private sector to pursue common goals and realize the vision. For the most part, this Plan encourages the public sector to let the private sector develop and deploy as much of ITS as it reasonably can and to focus public sector resources on updating and transforming public institutions, managing and updating the infrastructure, spearheading high-risk/high-reward research and safeguarding the public welfare.

It also encourages the public sector to be early adopters of ITS technologies where these technologies have clear promise for saving lives, time and money. Such early adoption will not only allow these agencies (and the people they employ and serve) to be the beneficiaries of these savings, it will help to encourage the wide-spread rollout of ITS and its benefits to the general population more quickly and more economically.

The Private Sector

The Private Sector's primary responsibility is to create and deliver systems, products and services to business, government and consumers. In each case the business model is different. In both sectors, robust markets are a sufficient motivation to produce the stream of valuable goods and services that have made the United States the world's leading developer.

In addition, we are observing that there are a number of ITS areas (most notably emergency notification and traveler information) where the private sector is filling niches that had previously been assumed to require a public-sector presence.

This Plan encourages a high level of cooperation and a deeper and more interactive relationship between the private and public sectors, especially where there are opportunities for synergies in research and information sharing. It encourages initiatives that will enhance the acceleration of ITS markets. It encourages the public sector to help remove obstacles to cooperation.

The Smart Road, owned by the Virginia Department of Transportation and managed by the Virginia Tech Transportation Institute, is a unique, state-of-the-art, full-scale research facility for pavement research and evaluation of Intelligent Transportation Systems (ITS) concepts, technologies and products.

The Universities

The Universities will be responsible, as always, for carrying out a significant fraction of ITS research. A large number of research topics are listed with the themes above in which the universities will have a vital role.

However, this Plan identifies a far more important and far-reaching responsibility, if one that is not so high on glamour.

That responsibility is to reinvent the transportation profession for the 21st century to meet the challenges that a new focus on customer-oriented, performance-driven operations will present. A new curriculum is needed that pays due attention to traditional arts and practices, which will clearly continue to be needed, but which adds new focuses on operations management; systems, software and communications; and the new relationships that are being forged by fluid jurisdictional boundaries, wireless communications and new demands for mobility, security and access.

Stakeholder Roles

State and Local Government and MPOs

This Plan calls on state and local government and metropolitan planning organizations to:

Program

- Shift the emphasis of infrastructure management from construction projects to customer-responsive systems performance.
- Work together to create new cross-jurisdictional cooperation (virtual organizations) through which to manage the transportation infrastructure.
- Participate in the development and effective use of an Integrated Network of Transportation Information, including the collection of baseline data, the definition of objectives, the consideration of data security issues and the testing and evaluation of the network as it evolves.
- Participate in a campaign of outreach and education on the safety, efficiency and mobility benefits of the new ITS products and how to use them properly.
- Work cooperatively with U.S. DOT to equip public safety responders with dispatching, data sharing and in-vehicle technology for route guidance, traffic-signal preemption and other mechanisms to facilitate quick response and effective traffic incident management.

- Lead by example and help jump start the market by specifying the inclusion of safety-, efficiency- and economy-enhancing ITS products in the government fleets and by creating incentives for state and local public agencies and for companies operating van pools to do the same.
- Reengineer state motor carrier safety information exchange and credentials business processes to take advantage of new technologies. Work toward statutory and regulatory changes to support electronic issuance of credentials and electronic payment of fees and taxes.

Institutional

- Participate in a campaign of outreach and education on the safety, efficiency and mobility benefits of new ITS products and services and their proper use.
- Work with U.S. DOT, the American Public Transportation Association (APTA) and the American Association of State Highway and Transportation Officials (AASHTO) to develop operations policies, including warrants and state-of-the-practice standards. Help to interpret these policies in terms of strategic plans and organizational configurations, staffing, performance measurement and assessment and financial resources to support sustainable operations.
- Work with public safety, wireless carriers and federal agencies to ensure timely deployment of location-capable wireless E911 service across the National Highway System.
- Raise the visibility of commercial transport safety and strengthen partnerships among public and private organizations. Integrate commercial vehicle safety and operational issues in state and metropolitan transportation, ITS and highway safety planning processes.
- Work with U.S. DOT, the American Association of State Highway and Transportation Officials (AASHTO), the American Public Transportation Association (APTA), the Association of Metropolitan Planning Organizations (AMPO) and the Institute of Transportation Engineers (ITE) to develop a multilevel professional capacity-building program that addresses the need of the industry for professionals who understand and support the transition to an operations focus and who can make good use of ITS in delivering high-performance services to the public.
- Consider reconfiguring existing arrangements and/or organizations to better reflect an operations perspective. New regional organizations may be necessary for certain types of operational functions. In addition, the scale of operations – corridors, multi-regional and interstate – may require new institutions.

Federal Government

This Plan calls on the **U.S. Department of Transportation** to:

Research

- Continue research to clearly pinpoint those benefits emanating from improved operations and then use those benefits to demonstrate the value to public agency decision makers and staff, as well as the traveling public. Create the professional and financial incentives to shift the focus of infrastructure management from construction projects to customer-responsive system performance.
- Continue to study ways in which ITS and operations can be incorporated in the planning and programming process.
- Fund and oversee (but *not* manage) basic research in the integration and consistent behavior of in-vehicle electronics and on in-vehicle and external technologies for the automatic detection of crashes and incidents, especially to help characterize the nature of the crash and the state of the potentially injured.
- Help fund and encourage an applied research initiative by commercial-vehicle and automotive manufacturers to develop and implement methods of collecting/downloading and analyzing data from vehicles involved in a crash.
- Fund research initiatives by transit vehicle manufacturers to develop and implement methods of collecting, downloading and analyzing data from vehicles involved in a crash.
- Fund and encourage research on motor carrier safety technology applications, including systems on board the vehicle (e.g., self-inspection and diagnostic systems, driver assistance systems), at the roadside (e.g., smart inspections and flexible enforcement strategies) and involving driver performance. Emphasize new applications that link existing and emerging ITS technologies.
- Catalyze private sector research and efforts to integrate cross-modal transportation and information systems and optimize operations. Match public-sector infrastructure and infostructure investment with intermodal industry needs. Support standards and technology to improve the efficiency of freight movement, especially intermodal flows.
- Further explore the development of tools to automate infrastructure construction and maintenance.
- Work to establish a concerted *international* program of research that comprehensively addresses driver behavior. Such research should be conducted primarily by vehicle manufacturers from at least the United States, Europe and Japan, with the participation and assistance of appropriate academic, private and government research establishments.

- Support continued research and development of surveillance and detection tools that assist in providing travel times and the calculation of delay in real time.
- Establish a surface transportation weather research program.
- Support continued research and development of enhanced adaptive roadway control algorithms and transit signal priority that incorporate freeways and arterials and are scalable across an entire region. Similarly, continue to support research and development of enhanced adaptive rapid transit and rail-control algorithms, including their physical and logical interactions with travelers and with other modes.
- Sponsor research to explore in depth the costs and benefits (including private sector return on investment) of various levels of cooperative vehicle highway automation systems (CVHAS) and of various mixes of automation between the vehicle and the infrastructure. If cost-justified, consider reinstituting a coordinated national effort of research and development on CVHAS.

Program

- Support, in association with ITS America and other organizations, the development of ITS-related security requirements for the different types of systems represented in the National ITS Architecture and in this Program Plan. These requirements would provide a set of guidelines for all ITS deployments receiving Federal funding and would serve as the basis for eventual development of Federal and perhaps international standards for protecting ITS security.
- Work with state and local agencies, the American Public Transportation Association (APTA) and the American Association of State Highway and Transportation Officials (AASHTO) to develop operations policies, including warrants and state of the practice standards. Help to interpret these policies in terms of strategic plans and organizational configurations, staffing and financial resources to support sustainable operations.
- Fund and oversee the definition of an Integrated Network of Transportation Information, starting by building the national consensus that recognizes the necessity and value of an Integrated Network of Transportation Information, including public sector planners and infrastructure managers, commercial-vehicle operators, major shippers, public-transit authorities, automotive manufacturers, automotive electronics manufacturers, railroads and advocacy groups for automobile drivers and individual travelers in all modes.
- Establish a national program to establish baseline collection and archiving systems for the data necessary to support traffic, incident and weather management, performance measurement, traveler information and goods movement and provide incentives and subsidies for data collection, integration and sharing in the public interest.

- Develop programs to provide incentives and subsidies to encourage and enable public safety support of highway operations objectives, such as the prompt, widespread deployment of advanced collision notification and response systems.
- Develop programs to provide procedures, technologies and techniques to assist public safety agencies in functions related to highway operations.
- Work with state and local authorities, the American Association of State Highway and Transportation Officials (AASHTO), the Association of Metropolitan Planning Organizations (AMPO) and Institute of Transportation Engineers (ITE) to develop a multilevel professional capacity building program that addresses the need of the industry for professionals who understand and support the transition to an operations focus.
- Encourage the coordination of Intelligent Railroad Systems activities with the ITS program and the incorporation of freight, intercity passenger and commuter railroads as new categories to be addressed in the ITS program and architecture.
- Creatively engage the private sector in projects of mutual interest. This specifically includes improved legal and institutional arrangements for the public and private sectors to cooperate. Where there is potential gain, both sectors need to work together to investigate ways of improving working relationships, including more consideration to policies affecting asset commingling, intellectual property, profit sharing and others.
- Work with and help fund state and local authorities to equip EMS providers with in-vehicle technology for route guidance, traffic signal preemption and other mechanisms to facilitate quick response.
- Continue to support the National ITS Architecture and its evolution through the addition of new User Services.
- Develop strategies to prepare for and manage responses to weather emergencies, natural disasters, terrorism, labor disputes and other causes of major swings in transportation demand.
- Develop a national system for providing emergency response personnel with information on the contents of hazardous cargo involved in incidents.
- Develop a national safety information database through the SAFE initiative. Upgrade key federal systems including the Motor Carrier Management Information System (MCMIS), the Safety and Fitness Electronic Records (SAFER) system and the planned Unified Carrier Register (UCR). Explore options for exchanging safety data at the state level, including further refinement of the Commercial Vehicle Information Exchange Window (CVIEW) concept that is being tested in selected states as well as expansion of the scope of SAFER to store intrastate as well as interstate data.
- Expand the scope of commercial vehicle safety information systems and decision support tools to include interstate, intrastate and foreign-based carriers operating in the United States.

- Develop a national crash database to provide enhanced data on crash locations and causation factors. Use this database to guide highway design, operations and enforcement decisions.
- Maintain and refine the National ITS Architecture and standards for commercial transport, drawing upon the existing Commercial Vehicle Information Systems and Networks (CVISN) and International Border Clearance (IBC) architectures. Expand the architecture and standards requirements to address intermodal freight operations. Ensure the technical and programmatic interoperability of vehicle identification technologies used for screening, toll collection and port/terminal gate clearance.
- Increase the quality and quantity of data available to plan and optimize the freight system, particularly on major truck routes and access routes to ports and terminals. Develop systems for collecting, storing, sharing and analyzing freight data.

Institutional

- Develop materials for a range of readers describing the new institutional and organizational roles and relationships, including case studies, cost/benefit analyses and guidebooks for undertaking institutional and organizational change.
- Mount a campaign of outreach and education, in cooperation with state and local transportation authorities and traveler advocacy groups, on the safety, efficiency and mobility benefits of new ITS products and services and their proper use. Among other things, the program should discourage risk compensation and encourage the acceptance of electronic copilot assistance.

This Plan calls on the **Federal Executive Branch** in general to:

Research

- Cooperate in the exploration of vehicle highway cooperation and automation (notably U.S. Departments of Transportation, Defense and Energy).

Program

- Lead by example and help jump start the market by specifying the inclusion of safety-, efficiency- and economy-enhancing ITS products in the Federal fleet and by creating incentives for state and local public agencies and for companies operating van pools to do the same. Agencies that are early consistent adopters of ITS technologies in the vehicle will realize immediate benefits in the safety of their personnel and the efficiency of their operation. They will also encourage faster similar adoption by others by serving as an example and by helping to reduce the risk and cost of producing and

distributing safety-enhancing technology. Encourage deployment and adoption of safety-enhancing ITS technologies via direct subsidies or by reducing taxes on vehicles that carry appropriate safety products. Encourage insurance companies to consider ITS safety-enhancing technologies in determining premiums.

This Plan calls on **Congress** to:

Institutional

- Provide the funding necessary for successful ITS research and deployment.
- Consider the creation of a funding program to support both infrastructure as well as day-to-day systems management. A range of funding programs is possible, including operations-oriented funding incentives, a percentage set-aside of all federal highway and transit funding to pay for the ongoing existence of integrating organizations and funds for systems management planning.
- Consider revisions to current federal law and regulations relative to funding, incorporating options that increase the emphasis on ITS and operations.
- Consider legislative adjustments to antitrust rules to enable vehicle manufacturers and their suppliers to engage in the precompetitive research that will lead to a robust, consistent, well-integrated system of in-vehicle electronics to promote safety, efficiency and mobility.
- Consider legislative mechanisms to contain the risk of introducing safety-enhancing in-vehicle electronics into the marketplace. It is understood that no product is perfect and that people suffering damages are entitled to be made whole. However, the absence of reasonable constraints on product liability will result in delaying the introduction and widespread deployment of ITS products that are demonstrated to have a significant net-positive effect on safety.

Public Transportation Agencies

This Plan calls on Public Transportation Agencies to:

Program

- Seek opportunities to deploy ITS technologies where they can save lives, time and money.
- Establish a program to make transit information such as routes, stops, fares, schedules and arrival/departure status for major properties easily accessible and in a common format.

- Participate in the definition and development of the Integrated Network of Transportation Information.
- Encourage transit agency use of ITS technologies to enhance operations of urban transit rail systems in areas of rail/bus multimodal connections, highway-rail intersections, shared track/corridor operations and multimodal monitoring centers and to coordinate actively with the affected organizations.

Institutional

- Support development of technologies that foster seamless, end-to-end travel among the transit modes and between transit and auto users.
- Support development of technologies that provide efficiency in operations, enhanced customer satisfaction and improvements in safety and security.
- Participate in the transformation of infrastructure management from a focus on capital projects to customer-oriented, performance-driven operations.
- Work with the American Public Transportation Association, the Community Transportation Association of America and the National Transit Institute to build a professional capacity building program that addresses the need for systems integration and multimodal operations and information management.

Emergency Response Services

This Plan calls on the operators of Emergency Response Services to:

Program

- Broaden and tighten relationships with private telematics suppliers to assure swift, effective responses to mayday situations.
- Seek funding for additional acquisition of useful on-board ITS technology including, for example, route guidance systems tailored to emergency vehicle driving rules and on-board video.
- Work with standards development organizations and regulators to establish clear guidelines, practices and technology standards for traffic signal preemption.
- Work toward the standardization of (and therefore more readily available and affordable) telemetry and communications equipment.
- Participate with public planners on best practices for identifying and dispatching response units which are most appropriately configured and closest in travel time to particular incidents, including 911 integration and improved cooperation between transportation and law enforcement agencies.

Automotive and Electronics Manufacturers

This Plan calls on the vehicle and vehicle electronics manufacturing industries to:

Research

- In cooperation with U.S. DOT and appropriate research establishments, strengthen and coordinate fundamental research on driver behavior and the safe, effective integration of mobile information and communications systems (telematics) as well as advanced safety systems in the vehicle.
- In cooperation with U.S. DOT and telematics suppliers, strengthen and coordinate continued research on in-vehicle and external technologies for the automatic detection of crashes and incidents, especially in helping to characterize the nature of the crash and the state of the potentially injured.
- In cooperation with U.S. DOT, establish a coordinated research initiative to develop and implement methods of collecting/downloading and analyzing data from vehicles.

Program

- Work with the U.S. Departments of Transportation, Energy, Commerce and Justice and with the National Science Foundation to find new modes of creative cooperation for funding and conducting pre-competitive ITS research.
- Aggressively supply in-vehicle products and services that have been shown to save lives, time and money and that are attractive to users.

Telematics Suppliers

This Plan calls on mobile information and communication system (telematics) products and services providers to:

Research

- Participate in and help to guide research on driver behavior, particularly as it relates to interactions with telematics services.
- In cooperation with U.S. DOT and the vehicle manufacturers, conduct continued research on in-vehicle and external technologies for the automatic detection of crashes and incidents, especially in helping to characterize the nature of the crash and the state of the potentially injured.

Program

- Establish cooperative relationships with local and national transportation agencies for the collection and sharing of data about traffic, road conditions and weather.
- Participate in the definition and development of the Integrated Network of Transportation Information.
- Participate in standardizing telematics messages and data formats for probe message traffic.

The Motor Carrier Industry

This Plan calls on the Motor Carrier Industry to:

Research

- Seek and participate in cooperative research programs on driver behavior, driver focus and driver workload management.

Program

- Work cooperatively with the Federal government and the states to research, demonstrate and apply new approaches to safety management, building upon existing and emerging ITS technologies and information.
- Participate in the definition and development of the Integrated Network of Transportation Information and put it to effective use.
- Work toward uniform data sets and common information standards and protocols for electronic toll collection and automated border crossings.
- Aggressively adopt technology and practices shown to enhance safety.

The Railroads

This Plan calls on the Railroads to:

Research

- Encourage the coordination of Intelligent Railroad Systems activities with the ITS program and the incorporation of freight, intercity passenger, urban rail and commuter railroads as new categories to be addressed in the ITS program and architecture.
- Participate in human factors research, particularly as it relates to improving safety at highway-rail intersections.

Program

- Participate in the definition and development of the Integrated Network of Transportation Information and put it to good use.
- Participate in the development of a comprehensive and unified approach to advanced transportation management tools and technologies.
- Participate in the demonstration project to track and monitor shipments globally.
- Participate in the definition, development and deployment of National Surface Transportation Weather Observing System.
- Work with the transit industry to coordinate Intelligent Transportation System technologies of common interest, with the objective of increasing the overall efficiency and capacity of urban, freight and intercity rail systems.

The Transportation Profession

This Plan calls on the Transportation Profession to:

Program

- Take active part in the definition and development of the Integrated Network of Transportation Information.
- Develop the tools and techniques needed for better planning of ITS projects. These tools and techniques are needed to enable a fair determination of costs and benefits, which include matters of time frame, type of benefits, regional scale, information impacts, user feedback and other variables.

Institutional

- Work with state and local authorities, U.S. DOT and the Institute of Transportation Engineers to develop a multilevel professional capacity building program that addresses the need of the industry for professionals who understand and support the transition to an operations focus and who can make good use of ITS in delivering high-performance services to the public.
- Participate in the development of new transportation engineering curricula.
- Work with U.S. DOT and public agencies at all levels in the transformation of infrastructure management from a primary focus on construction projects to an expanded focus on customer-oriented, performance driven operations.

Academia

This Plan calls on institutions of higher learning and accrediting bodies, working in conjunction with the engineering profession and organizations like the Institute of Transportation Engineers (ITE), the American Association of State Highway and Transportation Officials (AASHTO) and ITS America to:

Program

- Reconfigure the curriculum for transportation-related engineers, managers and other professionals to incorporate and exploit new approaches and technologies for building and operating the transportation infrastructure, including: the ability of software to leverage the power of devices, the new focus on customer-driven performance and the needs for regional cooperation in transportation management.

University and Other Research Establishments

This Plan calls on university, public and private research establishments to:

Research

- Participate in the development of new models for funding and conducting transportation research related to technology development and deployment, human factors, institutional renewal and transformation and public policy.
- Conduct research, as directed by public and industry priorities, in all these areas and disseminate the results.
- Facilitate the translation of research results into public policy, professional practice and industrial action.

ITS America

This Plan calls on the Intelligent Transportation Society of America and its affiliated state chapters to provide the leadership and structure to:

Program

- Be the advocate for advanced technology in current and future transportation.
- Provide a private-public forum under which all ITS public and private sector interests can come together to advance mutual interests and resolve conflicts.
- Be responsible for public awareness and outreach.

- Coordinate the definition and development roadmap for the Integrated Network of Transportation Information. Serve as secretariat and working arm for the steering committee overseeing its development.
- Promote collaboration among vehicle manufacturers, information service providers and infrastructure owners to maximize safety.
- Promote collaboration between the transportation community and other communities to advance the interoperability and utilization of ITS, including the telecommunications, public safety and computing communities.
- Help to define and advance the private sector ITS marketplace.
- Continue to assure that the standards requirements of the overall ITS community are well identified and promptly conveyed to the standards development organizations.

Institutional

- Continue to advise U.S. DOT on critical policy and program issues.
- Advise U.S. DOT on fine-tuning anti-trust rules to facilitate pre-competitive research, especially where accelerating safety benefits is involved.
- Advise U.S. DOT on national policy regarding the establishment of responsive inter-jurisdictional and multi-modal arrangements.
- Advise U.S. DOT on mechanisms for maintaining and updating the National ITS Architecture to keep it responsive to current and future needs.
- Comprehensively address ITS-related privacy concerns, expanding current privacy principles from a primary focus on government action to include private sector company actions as well.

Standards Development Organizations

This Plan calls on standards development organizations to:

Program

- Focus on the definition of standard interfaces, data formats and communications protocols to promote the national integration and interoperability of ITS technology. Particularly notable needs include:
  - Marshalling the participation of vehicle manufacturers and telematics suppliers to establish standard sensor, software and communications structures for the widespread collection of probe data relating to traffic conditions, road and weather conditions and create a common standard for communicating probe vehicle-based information to infrastructure managers.

- Developing approaches and standards for transportation information integration, center-to-center data sharing and data dissemination to other parties.
- Expanding dedicated short-range communications (DSRC) standards to include appropriate consideration of roadside warnings (work zones, highway-rail intersections) and vehicle-roadway and vehicle-vehicle communications for cooperative vehicle highway automation systems.
- Developing standards for information associated with shipments and for the paperless exchange of freight movement information between companies, across modes and with regulatory agencies.
- Understand performance of and user interfaces for in-vehicle electronics.

- Work with the industry to define best practices that support the transition to an operations-oriented focus for transportation management.
- Continue to cooperate with other standards development organizations in ITS standards development, recognizing the interdisciplinary nature of the industry.

Advocacy Organizations for Drivers and Travelers

This Plan calls on advocacy organizations to:

Program

- Participate in a campaign of outreach and education on the safety, efficiency and mobility benefits of new ITS products and services and their proper use.
- Participate in and help to guide the development of the Integrated Network of Transportation Information with a particular view toward improving the mobility for all, regardless of age or disability.
- Define guidance for public transportation agencies, vehicle manufacturers and telematics suppliers on using information technologies to meet Americans with Disabilities Act (ADA) requirements.

Appendix A

Joint ITS America-U.S. DOT Steering Committee

Co-Chairs:

Mr. Jeffrey F. Paniati, ITS Program Manager, United States Department of Transportation

Mr. James Wright, ITS Engineer, Minnesota DOT

Steering Committee Members:

Ms. Frances Banerjee, General Manager, City of Los Angeles DOT

Dr. August L. Burgett, Chief, Advanced Safety Systems Research, National Highway Traffic Safety Administration

Ms. Kathryn Condello, Vice President, Cellular Telecommunications & Internet Association

Mr. Robert P. Denaro, Sr. Vice President, Rand McNally and Company

Mr. Steven R. Ditmeyer, Director, Office of Research & Development, Federal Railroad Administration

Mr. Jack Goldstein, Senior Vice President, ITS America

Mr. David J. Hensing, former President, ITS America

Mr. Michael Hulley, VP Global Transport Industry, IBM Research

Mr. Thomas F. Humphrey, Transportation Consultant

Mr. Jim Hunsaker, Assistant Fire Chief, Denver Department of Safety

Ms. Karen M. Jehanian, PE, Director of ITS Planning, Mobility Technologies

Mr. Stephen R. Kuciemba, Vice President for Programs, ITS America

Mr. Walter Kulyk, Director, Office of Mobility Innovation, Federal Transit Administration

Mr. Gary E. Larsen, Director, Office of Operations R&D, Federal Highway Administration

Mr. Greg Larson, P.E. Chief, Office of Advanced Hwy Systems, California Department of Transportation

Mr. Patrick McGowan, Vice President, PB Farradyne

Mr. Mark R. Norman, Division Director, Technical Activities, Transportation Research Board

Ms. Marcia Pincus, Director, Operations, Evaluation and Partnerships, ITS America

Dr. James H. Rillings, Research Fellow, General Motors Corporation

Mr. Jeffery Secrist, Transportation Specialist, Federal Motor Carrier Safety Administration

Mr. Lawrence Schulman, Project Coordinator, ITS America

Mr. Robert E. Skinner, Jr., Executive Director, Transportation Research Board

Mr. Edward A. Starosielec, Jr., President, Transportation Group, Veridian Corporation

Dr. Philip J. Tarnoff, Director, Transportation Studies Center, University of Maryland

Mr. Richard Taylor, Director, Information Systems, ITS America

Dr. Charles Wallace, Executive Director, ITS Florida

Dr. C. Michael Walton, Ernest H. Cockrell Centennial Chair, University of Texas at Austin

Mr. Richard J. Weiland, President, Weiland Consulting Co.

Mr. Oliver P. Yandle, Vice President for Policy, ITS America

An Executive Summary: *Delivering the Future of Transportation*
or an eight-page brochure can be obtained through
the Intelligent Transportation Society of America.

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