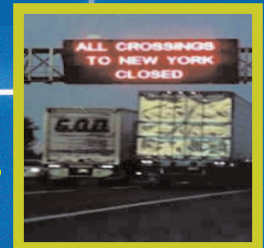
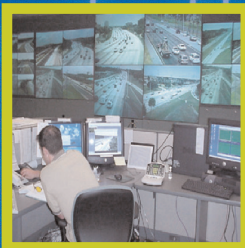


Intelligent Transportation Systems: A Summary of Progress and Results



U.S. Department of Transportation
Research and Innovative Technology Administration
ITS Joint Program Office

November 2008



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Intelligent Transportation Systems: A Summary of Progress and Results

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The Federal ITS Program

The Federal Role in ITS

The Federal Intelligent Transportation Systems (ITS) Program began in response to a directive from Congress to employ advanced technologies in transportation in order to keep the transportation industry in lockstep with the nation's move toward use of these technologies in everyday life. Congress and U.S. Department of Transportation (USDOT) envisioned that the technologies could:

- Provide significantly more efficient, safer travel through the delivery of critical safety and mobility information and increasing levels of automation of standard/daily/typical transportation operations.
- Enable the seamless integration of multiple transportation modes, thereby providing travelers with a wider range of travel options and greater accessibility to transportation.
- Integrate systems operations across agencies to allow for regional and cross-jurisdictional operations and decision-making, thereby greatly improving systems performance for travelers and commercial freight movement.

The Federal ITS Program was officially established under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The federal program was to be directed and coordinated through the ITS Joint Program Office (ITS JPO).

The directive from Congress to USDOT was reinforced with funding for ITS research, development, and testing in the Transportation Equity Act for the 21st Century of 1998 (TEA-21) and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users of 2005 (SAFETEA-LU).

ITS Deployment: Leveraging Federal Dollars for National Benefits

From 1991 to 2009, Congress provided the USDOT ITS Program with \$3.45 billion in federal funding to research the application of advanced technologies to transportation and to facilitate the deployment of ITS across the nation. Although these funds represent less than 1 percent of the \$746 billion budget allocated to USDOT during the same 19-year period, the ITS funds have produced an array of benefits for the nation's transportation system, including important improvements in safety and mobility, reduced congestion, and enhanced productivity.

With focused, targeted use of these funds, the relatively small federal investment has had a multiplier effect:

- State, local, and regional agencies have been incentivized to match federal funds with their own funding and to engage private-sector partners who offer matching funds.

How much has been spent on the Federal ITS Program (1991 – 2009)?

Total U.S. DOT Budget:
\$746.1 billion

Total Federal ITS Funds:

- \$3.45 billion
- \$11.50 per capita* over the 19-year period
- 61¢ per capita* per year



*Based on a U.S. population of 300 million

Source: 65 / 109

- These leveraged funds have resulted in the widespread deployment and operational use of advanced technologies and systems across the nation.
- Increased deployment has led to exponential growth in benefits delivered to state, local, and regional agencies; travelers; and commercial entities.

Intelligent Transportation Systems (ITS)

Definition: ITS is the application of integrated information and communications technologies to infrastructure and vehicles in order to improve safety and better manage travel and travel choices.

Over the past 20 years, ITS has transformed transportation safety, infrastructure, operational performance, and service delivery. ITS facilitates a connected, integrated transportation system that is information-intensive in order to better serve the interests of users, be responsive to the needs of travelers and system operators, and improve safety. ⁶⁵

This booklet presents examples of and results from the public investment in ITS since its initial funding in 1991. All data compiled has been gathered from documented reports and on-line websites, the majority funded by the USDOT. These examples present the diversity of ITS impacts on the travelling public and the movement of goods. This booklet is organized in three parts:

- The Federal ITS Program history and examples of:
 - Technologies deployed across the nation
 - Benefits derived for the nation

- Case studies on specific ITS benefits.
- Major ITS research initiatives that summarize the current ITS Program.

USDOT Initiates ITS Research and Deployment, 1991–1998

The creation of the ITS Program allowed USDOT to focus on and accelerate the use of advanced transportation technologies through a set of focused activities:

1. Applied research and development (R&D) efforts that investigated the technical, institutional, and societal challenges to ITS deployment.
2. Operational tests and evaluations of real-world deployments that produced results, lessons learned, and evidence as the basis for state and local decision-making with regard to deployment, as well as federal decision-making with regard to regulations and new policies. These tests and evaluations also helped to target where additional research was needed.
3. Deployment-support activities designed to facilitate integration of the various ITS technologies, provide for a well-trained workforce, advance technology transfers, and generate assorted guidance on ITS deployment.

Early Research and Deployment Efforts

In the early-to-mid-1990s, under ISTEA funding, the ITS Program provided the initial research and “laboratory” adaptation of technologies to existing transportation facilities and vehicles. Federal ITS funds were used to conduct field demonstrations and evaluations of new technology applications to determine their appropriateness and suitability for addressing specific transportation needs and problems. As a result of the early demonstrations, proactive public agencies embraced ITS as practical, nontraditional tools that provided opportunities to gain efficiencies in transportation networks, and they began to deploy infrastructure-based ITS.

Most early ITS deployments were stand-alone and included dynamic message signs, electronic fare and toll collection, adaptive traffic-signal timing, automated safety clearance for commercial trucking, public traveler information websites and other information systems, automatic vehicle location (AVL) systems, and incident-response management, the latter of which comprised a number of safety-enhancement and communications technologies. A separate effort focused on the development and testing of advanced vehicle technologies. This research resulted in a field demonstration of the Automated Highway System (AHS) in 1997.

Integration Generates Greater Benefits

Early field-demonstration results pointed to an important conclusion: integrated technologies deliver greater benefits than do stand-alone installations. Integration allows for the sharing of data and the ability to cross jurisdictional boundaries and operate separate transportation assets as a system. For example, regional advanced traffic-signal control systems or transportation-management-center (TMC) information utilize integrated

4700 Dynamic Message Signs (DMS) in U.S. in 2006

Source: 63



communication and control components. Therefore, TEA-21 funding, which began in 1998, focused on facilitating integration of stand-alone ITS technologies with multi-application and regional, cross-jurisdictional systems. In TEA-21, Congress directed significant funds directly to state and local ITS integration

Metra Parking

Available Spaces

➔ **FULL**

⬆ **1234**

Mokena/
Hickory Ck

80th Ave

Advanced Parking Management Systems Benefits:

- Up to 50% drop in parking facility vacancy rate
- Travelers: easier access, reduced time spent looking for parking, reduced frustration
- Commercial venue operators: increased accessibility by patrons, increased customer satisfaction
- Parking garage operators: increased space occupancy, increased revenues
- Nearby neighborhoods and jurisdiction: reduced vehicle circulation seeking available parking, fewer illegally parked vehicles

Source: 1

projects. This program, entitled the ITS Integration Program, provided meaningful, practical insight into the technology deployment projects, as well as supporting the national goal of ITS integration.

To facilitate integration, the ITS Program developed the National ITS Architecture, a common framework to guide agencies in sharing and applying technologies, systems, and the data and information generated from the equipment. As of 2008, no fewer than 274 regional and statewide ITS architectures had been tailored to meet local ITS needs.⁸⁹ To further enable integration of the multitude of varied ITS components that come from a wide array of manufacturers and vendors, the ITS Program has worked with standards development organizations (SDOs) to establish critical ITS standards and

commercial protocols that are essential to the interoperability of different technologies, enabling system components to link and exchange data.

As part of ITS integration efforts, from 1998 to 2004, the Model Deployment Initiative (MDI) demonstrated the powerful effects of integrated systems as opposed to stand-alone technology deployments in four large metropolitan areas. The Federal ITS Program further



U.S. Transit Agency Safety and Security Audio or Video Surveillance Technologies in 2006 in Largest 108 Metropolitan Areas

Transit buses with audio or video: 43%

Transit facilities with audio or video: 31%

Source: 15

41 U.S. States with a Traveler Information Website in 2006

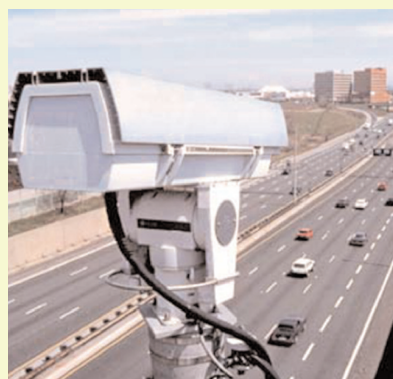


Source: 63

contributed to the widespread transfer of knowledge gained from the evaluations of MDI endeavors and other ITS technologies and systems in real-world settings.

Focus on Intelligent Vehicles

While progress was being made on ITS infrastructure technologies and their integration with operational systems, ITS research also addressed intelligent vehicles. From 1997 to 2004, the Intelligent Vehicle Initiative (IVI) combined federal-government and private-industry funds and efforts to cooperatively conduct research into driver distraction, activities, and workload. The results led to the development



Closed Circuit TV (CCTV) Cameras in U.S. in 2006

- Over 6,000 in use
- Approximately 1,000 provide transit security and surveillance
- 32% of freeway miles are visible for incident detection
- 5% of arterial miles are visible for incident detection

Source: 63

of crash-avoidance systems, designed to prevent road departures as well as rear-end, lane-and-merge, and intersection collisions and to provide vehicle stability. Their primary function was to collect and process data on surrounding-roadway conditions and to generate warnings for drivers on impending threats and hazards. Many of the systems are now in

production and are, or will soon be, available on new-model cars and trucks.

Similar to ITS infrastructure components, many vehicle systems are installed as stand-alone. Integration of the vehicle with any "smart" roadside infrastructure can exponentially increase the productivity of any system. On the basis of this recognition, research on vehicle-to-infrastructure communications was initiated. The findings form the basis of the current Vehicle-Infrastructure Integration (VII) and Cooperative Intersection Collision Avoidance System (CICAS) Initiatives, which seek to combine many of these stand-alone safety systems into one vehicular system with the ability to warn drivers of dangerous situations, communicate with the transportation network, send data on vehicle status and incident or crash conditions, and receive information on traffic conditions and travel choices.

Next-Generation Transportation Technologies

By 2004, it was clear that nationwide ITS deployment was underway. State and local agencies were finding value in ITS technologies and systems.

30 States Included in the Commercial Vehicle Information System Network (CVISN) in 2005



CVISN facilitates safety inspections at weigh stations

Source: 46 / 47

Recognizing that the nation would soon require the next generation of transportation technologies, the ITS Program identified nine major initiatives for high-risk/high-payoff research. In 2006, two more research initiatives, the Congestion Initiative and the Rural Safety Initiative, were introduced (see box for list of eleven research initiatives). Since 2006, the ITS Program has focused on ensuring that its research initiatives are moving toward completion and are delivering maximum value. With increased emphasis on project management, the ITS Program is able to ensure greater delivery of measurable impacts and achievements.

Moving ITS Research into the Marketplace

The ITS Program continuously seeks to identify innovative research on a wide range of advanced technologies that may be utilized to meet current and future transportation needs. In recent years, the program has initiated a focus on technology transfer and commercialization, in order to leverage the processes developed by universities and the private sector in developing new transportation markets and making technologies more rapidly available for commercial sale and consumer use. The recent explosion in the market availability and use of navigational devices and other mobile information technologies by consumers is an example of where the ITS Program can



Emergency Management Technologies in the 108 Largest Metropolitan Areas (2006):

Emergency Vehicle Traffic Signal Preemption:

- Installed at 31,000 signals
- Includes more than 20% of the intersections in metropolitan areas
- Installed in 375 separate jurisdictions

Automatic Vehicle Location (AVL) and Computer-Aided Dispatch (CAD):

- Emergency response agencies in 63 metropolitan areas use both
- Law enforcement agencies in 94 metropolitan areas use both

Regional Multi-agency Communication Networks Used to Coordinate Evacuations:

- Used by law enforcement, emergency management, and other public agencies in 37 areas

Source: [63 / 80](#)

Benefits of Incident Management Programs:

- Time delays due to traffic incidents are reduced up to 65% (a 2-hour delay may now be reduced to 42 minutes)

Source: [6](#)

Major ITS Research Initiatives (by USDOT Goal)

Safety

- Integrated Vehicle-Based Safety Systems (IVBSS)
- Cooperative Intersection Collision Avoidance Systems (CICAS)
- Next Generation 9-1-1 (NG9-1-1)
- Rural Safety Initiative

Mobility

- Congestion Initiative
- Integrated Corridor Management Systems (ICM)
- Mobility Services for All Americans (MSAA)
- Clarus - National Surface Transportation Weather Observing and Forecasting System
- Emergency Transportation Operations (ETO)

Productivity/Global Connectivity

- Electronic Freight Management (EFM)

Crosscutting

- Vehicle Infrastructure Integration (VII)

Source: [108](#)

stimulate the marketplace to expand traveler information, financial transactions, and other communications opportunities. The expanded effort to link ITS research with end users should result in faster attainment of the ITS goals of saving lives, reducing congestion, and lessening environmental impacts.

While further research is still needed, ITS technologies are now being incorporated into solution sets for the national long-range issues of safety enhancements, congestion relief, economic viability, emergency response, energy savings, and environmental improvements.

ITS Deployment Success Stories Cited In This Document

US-Canada

- Streamlined truck border crossing

East Coast

- E-ZPass electronic toll collection

NY-NJ-CT

- TRANSCOM partnership regional operations

Arizona

- Phoenix AZTech partnership regional operations-REACT
- Phoenix Metropolitan Model Deployment

Arizona, Minnesota, Montana

- Animal-vehicle collision avoidance systems

California

- Automated snow plows
- Ventura County Transit electronic fare payment
- Los Angeles County MTA 2nd train warning
- Los Angeles bus rapid transit and vehicle location information

Colorado

- Truck safety improvements and downhill speed warning

Florida

- Road Ranger freeway service patrol
- SunPass electronic toll collection
- iFlorida Surface Transportation Security and Reliability Information System Model Deployment

Georgia

- NaviGator Transportation Management Center and incident management

Illinois

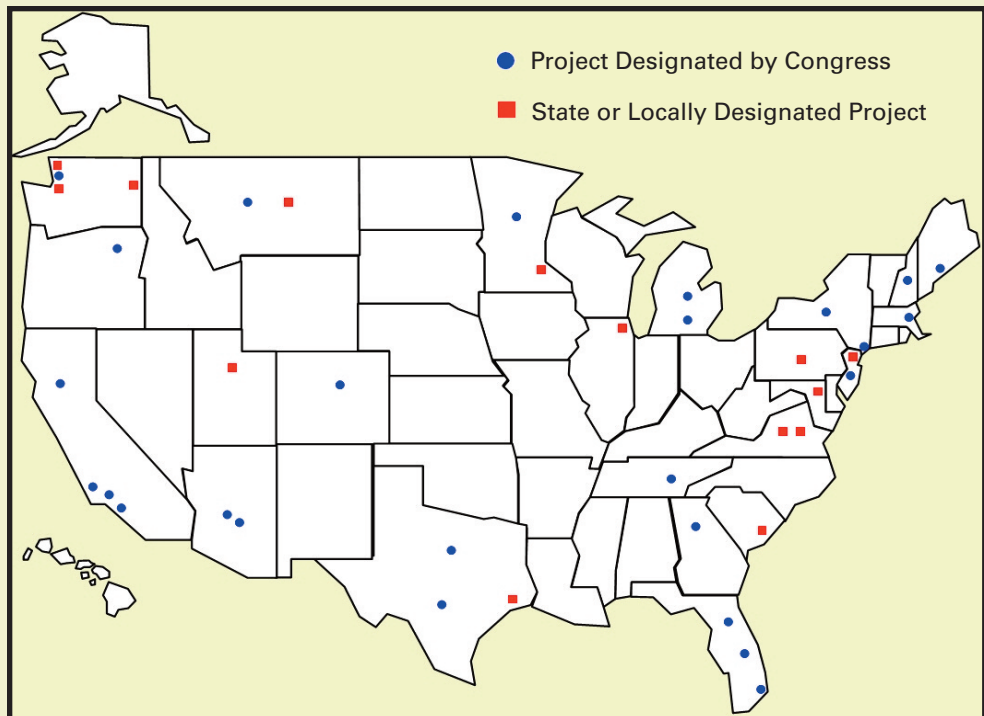
- Chicago signal optimization

Maine

- Acadia National Park traveler information

Maryland

- CHART incident management



Massachusetts

- Boston MBTA electronic fare CharlieCard

Michigan

- University of Michigan IVBSS
- Michigan VII-enabled vehicles

Minnesota

- Minneapolis-St. Paul ramp meters

Montana

- Rural emergency response

New Hampshire

- Maintenance Decision Support System (MDSS)

New York

- New York City I-95 emergency travel information
- Syracuse signal optimization

Oregon

- Emigrant Pass downhill speed information system

Pennsylvania

- Turnpike truck rollover warning

South Carolina

- Hurricane evacuation decision support information system

Tennessee

- I-75 weather alerts and safety devices

Texas

- Plano emergency vehicle signal preemption
- Harris County flood warning system
- San Antonio Metropolitan Model Deployment

Utah

- Salt Lake Valley Advanced Transportation Management System

Virginia

- 511 services
- Reston signal optimization

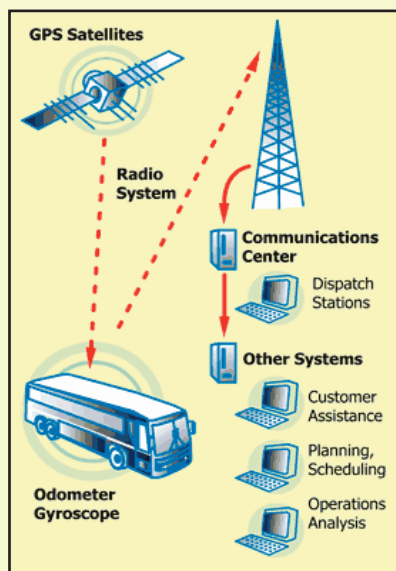
Washington

- Seattle signal optimization
- Spokane weather information
- Seattle Metropolitan Model Deployment

Transit GPS

Approximately 1500 public transit agencies use Global Positioning Systems (GPS) technology for various purposes, including bus or transit vehicle location

Source: 2 / 63



Leveraging the Federal ITS Funds

The Federal ITS Program can only facilitate ITS deployments in state and local agencies and into private sector products and services. Decisions to invest in and deploy ITS technologies and systems rest with state and local agencies and depend on their priorities for allocating a portion of the federal funding that they receive for surface

Electronic Toll Collection

80% of all toll facilities in the U.S. have electronic collection capabilities (over 160 facilities)

Source: 63 / 93 / 94



transportation. Spurred by results from the ITS Program's demonstrations and evaluations, state and local governments have taken the ITS deployment challenge to improve their transportation networks through the application of a variety of advanced technologies. To date, the \$3.45 billion in federal ITS funds has been leveraged by state, regional, and local agencies to yield tremendous increases in the number of transportation technologies and systems deployed, which have resulted in greater traveler safety and mobility and other direct and indirect benefits.

The State of New York received an estimated \$47.6 million in federal ITS funds, but total public investment in ITS technologies surpassed \$890 million—over 18 times the amount of federal ITS funds received—throughout the state.⁷⁴ Many other states have similarly invested substantially more state and local funds in ITS than the amount provided through the Federal ITS Program. The Government Accounting Office (GAO) and USDOT have estimated that states

and localities invest from \$500 million to \$1 billion per year in ITS projects. On the basis of this annual rate, over \$10 billion in nonfederal funds has been invested in ITS deployments and operations since 1991, almost three times the amount of federal funds allocated to ITS.⁴⁸

Federal ITS resources have enabled extensive ITS deployments and benefits on a national scale (displayed in the deployments and benefits boxes). The dotted areas on the ITS deployment success stories map highlight an array of just some of the successful deployments and applications that have occurred at state and local levels. The following case studies illustrate beneficial effects that advanced technologies, originally deployed through the Federal ITS Program, have produced both locally and statewide. (For other ITS success stories, deployments, and benefits, see the ITS Benefits, Costs, Deployments, and Lessons Learned: 2008 Update.⁵⁹)

ITS Saves Lives

Warning Systems Reduce Train/Pedestrian Collisions

Los Angeles County's light rail transit system intersects with a number of major streets. At the Vernon Avenue highway-rail intersection, 17 train-pedestrian collisions have occurred, resulting in five fatalities. One factor contributing to these accidents is the "second-train-coming" phenomenon. This issue arises on double-track rail systems when a second train activates a grade crossing within seconds after a first train has passed through the crossing. Even though the gates are still activated, pedestrians may attempt to cross the tracks after the first train has passed without realizing that a second train is approaching from the opposite direction.

To address this safety concern, a second-train-coming warning system was installed at the Vernon Avenue intersection to alert pedestrians and direct their attention to the approaching second train. The warning system has helped to reduce the number of pedestrians crossing the tracks four seconds or less in front of an approaching train by 73 percent.⁸⁶

Motor-vehicle crashes are the leading cause of death among Americans aged one through 34. Transportation statistics paint a stark and compelling reality of the high cost of vehicle crashes and the resulting effects on mobility and the environment.

Collectively, rear-end, road departure, and lane-change crashes accounted for 60 percent of all police-reported light-vehicle and heavy-truck crashes. In addition, intersection-related crashes take a heavy toll on lives, productivity, and the economy each year. In 2003 alone, 8,569 people died and more than 1.4 million suffered injuries in intersection-related crashes;²⁵ road departures accounted for an additional 25,000 fatalities.⁸⁵

The use of ITS can help to reduce the number of fatalities and injuries

The High Cost of Vehicle Crashes (Annual Average):

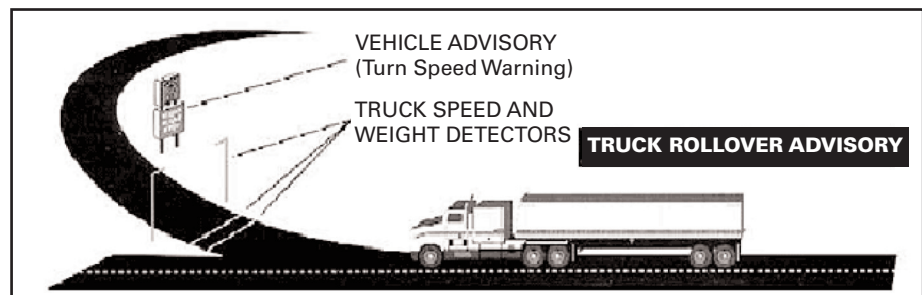
- 6 million crashes
- 42,000 fatalities
- \$230.6 billion in direct economic costs

Source: ⁹⁷

sustained on the roadways and to improve the response time to people involved in accidents. The goal of the Integrated Vehicle-Based Safety System (IVBSS), a joint research project

conducted by USDOT and the University of Michigan Transportation Research Institute (UMTRI), is to develop a system that will help to reduce the number of crashes through the use of onboard technology to warn drivers of possible dangerous maneuvers. Preliminary analyses by USDOT indicate that a substantial number of police-reported crashes (1.8 million, or 48 percent) can be reduced through the widespread deployment of integrated crash-warning systems that address rear-end, lateral drift, and lane-change/merge crashes.⁵⁴ IVBSS is currently conducting a field-operations test to evaluate the suitability of a state-of-the-art integrated crash-warning system for extensive deployment in both passenger cars and trucks.

Emerging technology advances, such as the incorporation of GPS into vehicles and increasingly accurate sensors, are



Schematic of an Interactive Truck Rollover Advisory System⁹⁰



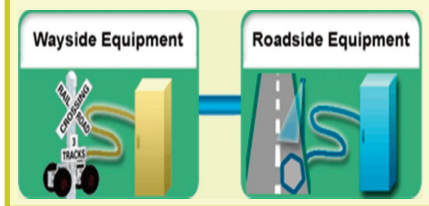
Fire trucks safely traverse an intersection equipped with emergency vehicle preemption and visual warning system.⁸⁷

opening up the possibility of a wide-range of technological applications that can better aid motorists and help them to avoid potential accidents. One such system is the road geometry warning system, which uses detectors and electronic signs to warn drivers, typically those in commercial trucks and other heavy vehicles, of potentially dangerous conditions that may cause rollovers or run-off-the-road crashes. A truck rollover-warning system installed on the Pennsylvania Turnpike was designed to alert truck drivers of a dangerous curve at the Breezewood Interchange. During 21

Highway-Rail Crossing Safety Systems in U.S. in 2006:

554 automated detection and driver warnings in 34 metropolitan areas and 16 states

Source: 63



months of data collection prior to system deployment, five rollover crashes occurred compared with only one after deployment.⁷⁷

Vehicle Infrastructure Integration (VII) is a concept for integrating transporta-

tion systems with communications systems, creating a system that allows a dynamic exchange of data from vehicle-to-vehicle and from vehicle-to-infrastructure. The State of Michigan has partnered with automotive manufacturers to carry out a proof-of-concept test for VII-enabled vehicles. As part of the project, a network of communications devices was installed along 43 miles of I-96 and I-275. The VII test fleet includes 35 vehicles from 10 different manufacturers and a network of 57 Dedicated Short-Range Communications (DSRC) roadside units. Early results show that active safety can be achieved with use of VII technology and that DSRC allows a wide variety of applications to integrate, generate, and transmit data.⁹⁸

ITS technologies also enhance the safety of emergency vehicles, which are at higher risk for involvement in crashes and are subject to unpredictable delays in reaching the scene of a fire or crash. One method to reduce the risk of an accident is the installation of emergency vehicle preemption (EVP) equipment at signalized intersections. This ITS technology provides a special green interval to the EV approach while providing a special red interval on conflicting approaches. The use of signal preemption has allowed the city of Plano, Texas, to dramatically reduce the number of emergency vehicle crashes from an average of 2.3 intersection crashes per year to less than one crash every five years.⁹⁵

ITS Reduces Congestion

Traffic Congestion Impacts: (Average annual totals for 437 of the largest urban areas)

- \$78 billion in direct costs from congestion
- 2.9 billion gallons of fuel wasted due to traffic congestion
- 4.2 billion hours of travel delay
- Increased fuel consumption and carbon emissions from idling vehicles during congestion
- 25% of congestion and \$20 billion in cost attributed to vehicle crashes
- 2.6 million crashes in large urban areas

Source: 105

Roadway congestion is a familiar experience for people on the roads today. Americans spend 4.2 billion hours in traffic, using an extra 2.9 billion gallons of fuel, for a total cost of \$78.2 annually.¹⁰⁵ The impacts of congestion

are felt in lost time and increased gas usage, the latter of which has environmental, economic, and security effects. The congestion resulting from crashes often leads to further accidents and creates delays in getting emergency services to those who need them.

ITS features prominently in many congestion-reduction techniques. Highways and roads can improve traffic flow and increase safety through the introduction of measures such as ramp metering, aggressive incident management, improved toll collection, and signal timing.

- Ramp Meters: These small stoplights at highway entrances help to keep traffic flowing at high speeds and to reduce the possibility of crashes as cars enter the highway. In 2001, Minneapolis-St. Paul conducted a trial of ramp meters; subsequently, the meters were turned off to gauge the public's reaction. Without ramp metering there was a 22 percent increase in



Ramp meter in Arizona⁶

freeway travel times, a 7 percent reduction in freeway speeds, and a 26 percent increase in crashes on previously metered freeways and ramps. Over 85 percent of people supported reactivation of the meters.⁹⁶

- Traffic Incident Management: Aggressive traffic incident management, where a traffic management center quickly deploys on-call emergency vehicles to crash scenes, reduces the duration of incidents and helps save lives. Quick response also helps to prevent secondary crashes and the resulting congestion. In 2002,

Utah's Advanced Transportation Management System (ATMS)

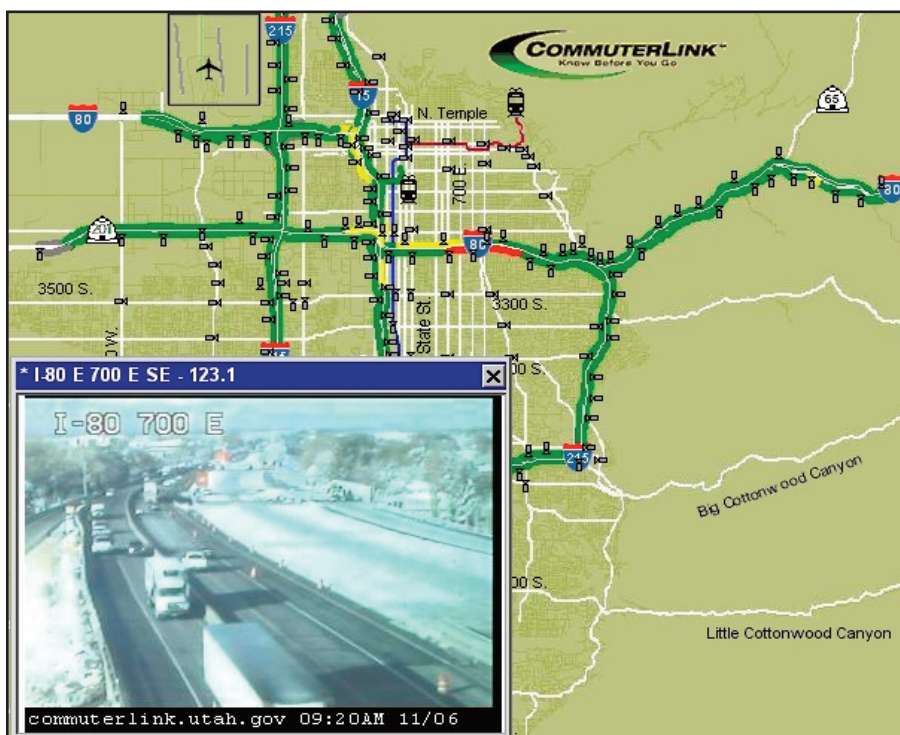
The ATMS in Utah's Salt Lake Valley consists of numerous ITS technologies that work in concert to manage traffic effectively. Initially developed with use of over \$25 million in federal ITS funding as well as state funds, the system includes over 230 cameras, along with traffic monitoring stations located every half mile, to observe speeds, flow, and occupancy. Variable Message Signs (VMS) convey information to road users, and ramp meters are utilized to reduce freeway congestion. Traffic incident-management teams patrol the freeway and respond to incidents. The new '511' telephone service and the Utah Commuterlink website provide real-time traveler information.

Annually, Utah's ATMS provides \$116.1 million in benefits related to the reduction in travel-time delays. The system has helped to increase peak-hour freeway speeds by 20% and decrease freeway and intersection delays and traffic-signal stops by 36%, 27%, and 15%, respectively.¹¹⁰

Maryland's Coordinated Highways Action Response Team (CHART) program responded to 32,814 traffic incidents, saved 30 million hours for travelers, reduced fuel consumption by 5 million gallons, and reduced incident time by 28 percent.⁷⁸

- Electronic Toll Collection: In the past, tollbooths often contributed to

congestion as cars queued up to pay their cash tolls. This began to change with electronic toll collection, whereby drivers with a toll tag (E-ZPass, Sunpass, Fast Lane, etc.) only need to slow down while their toll is paid electronically, substantially reducing wait times. Thirteen states began utilizing this technology to create a



Utah DOT Freeway Traffic Camera Image¹¹¹

Ramp Meters

Ramp Meters in U.S. in 2006:

- Over 4000 ramp meters
- Ramp meters used in more than 30 metropolitan areas

Benefits:

- Freeway speeds improved up to 26%
- Freeway capacity increased up to 30%
- Freeway crashes reduced up to 50%

Source: 63 / 105



regionally compatible system. The resulting E-ZPass system provides travelers with a seamless travel-payment option from Illinois to Maine. Today, open-road tolling allows vehicles to use tags at full highway speeds. Orlando's deployment of an open-road tolling system (EPass) reduced crashes by 25 percent and decreased delays by over 50 percent.³⁸

- Signal Timing: On city streets, the use of signal timing and adaptive signal controls optimizes traffic lights to move the most traffic as quickly as possible, creating a "green wave" that reduces the need for many cars to stop. A signal timing trial in Chicago improved travel times by up to 53 percent; Reston, Virginia, and Seattle also produced positive results. Optimizing traffic signal timing can produce benefit-to-cost ratios as high as 40-to-1.⁶⁰

ITS Enables Travelers to Make Informed Decisions

Congestion and traffic delays cause Americans to lose valuable time and money. In 2005, the average annual delay for peak-period travelers was 38 hours, the equivalent of almost one week of vacation time. The value of the time lost and the associated wasted fuel amounted to \$710 per traveler.¹⁰⁵ Recurring congestion and unexpected delays also affect travel-time reliability. A trip that, under normal circumstances, takes 30 minutes, often takes longer due to disturbances such as vehicle crashes, inclement weather conditions, and roadwork. Due to unreliable travel times, travelers and commercial freight operators must allow extra time for travel—as much as twice the normal travel time in some metropolitan regions—to ensure that they will arrive at their destination on time.¹⁰⁵

Real-time traveler information enables the public to be more in control of their transportation options and can lead to improved on-time reliability, better trip planning, and reduced early and late arrivals. ITS technologies are used to collect detailed information on a variety of roadway and transit conditions, and these data are then broadcast to the public.

Travelers who are able to access reliable, up-to-the-minute information on traffic and transit conditions prior to departing



VMS on evening of September 11³⁰

Active 5-1-1 Traveler Information Systems in the U.S. in 2008: 41

- Average monthly calls to each system: 73,370 calls to each system
- Calls per day per system: 2,370



- Total calls since nationwide 511 inception in 2001: 112 million

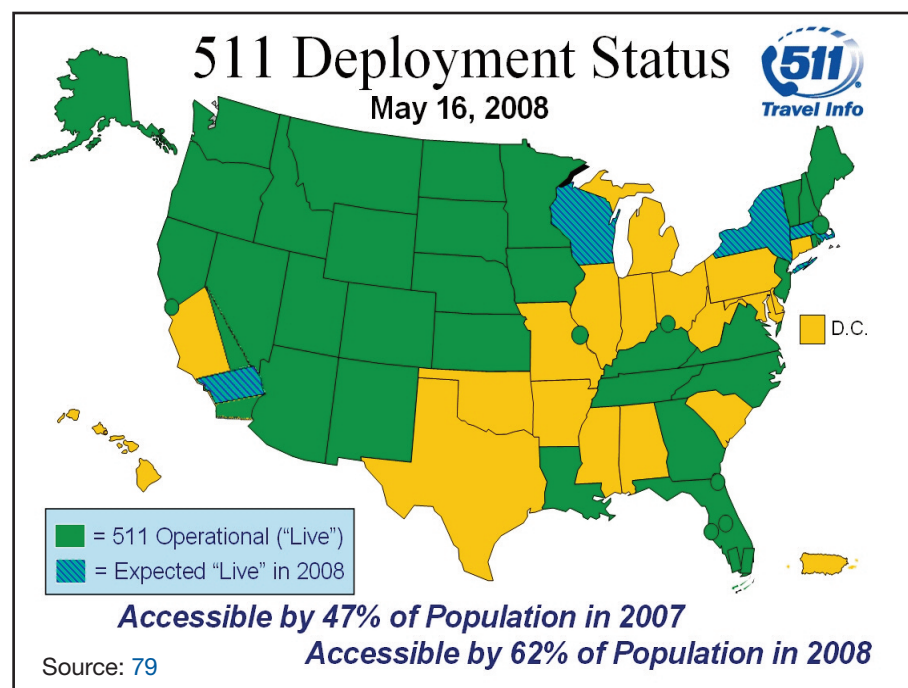
Source: 42 / 79

on a trip may decide to alter their departure time, take a different route than the one originally planned, or choose an alternative mode of transportation. Even when traffic congestion and delays are unavoidable, information regarding the source of the problem and the duration of the delay can help to minimize stress associated with unex-

Traveler Information Assists During Times of Emergency

Within minutes of the terrorist attacks on New York City on September 11, 2001, there was an extraordinary demand for accurate, timely information. Through the use of ITS, officials were able to alert motorists of problems long before they reached the Manhattan area. Using highway advisory radio (HAR) and variable message signs (VMS) along the I-95 corridor—from Delaware to New Haven—travelers were alerted to avoid the New York City region.

Within two minutes of the decision to close the George Washington Bridge, VMS was used to alert motorists 10 miles away of the closing of the bridge.³⁰



pected delays. In addition to assisting in better trip planning and helping avoid congestion-related delays, traveler information plays a critical role in informing travelers about evacuation routes during emergency situations.

Nationwide, nearly every metropolitan area provides some form of traveler information. Examples of traveler information and the associated benefits include:

- The ITS Integration Program provided the Washington DOT with \$447K in funding to install various ITS technologies, including road-weather information-system sensor stations and mobile highway-advisory radio systems, to enhance the collection and dissemination of critical road and weather information in a mountainous area of Spokane. Following deployment, 94 percent of

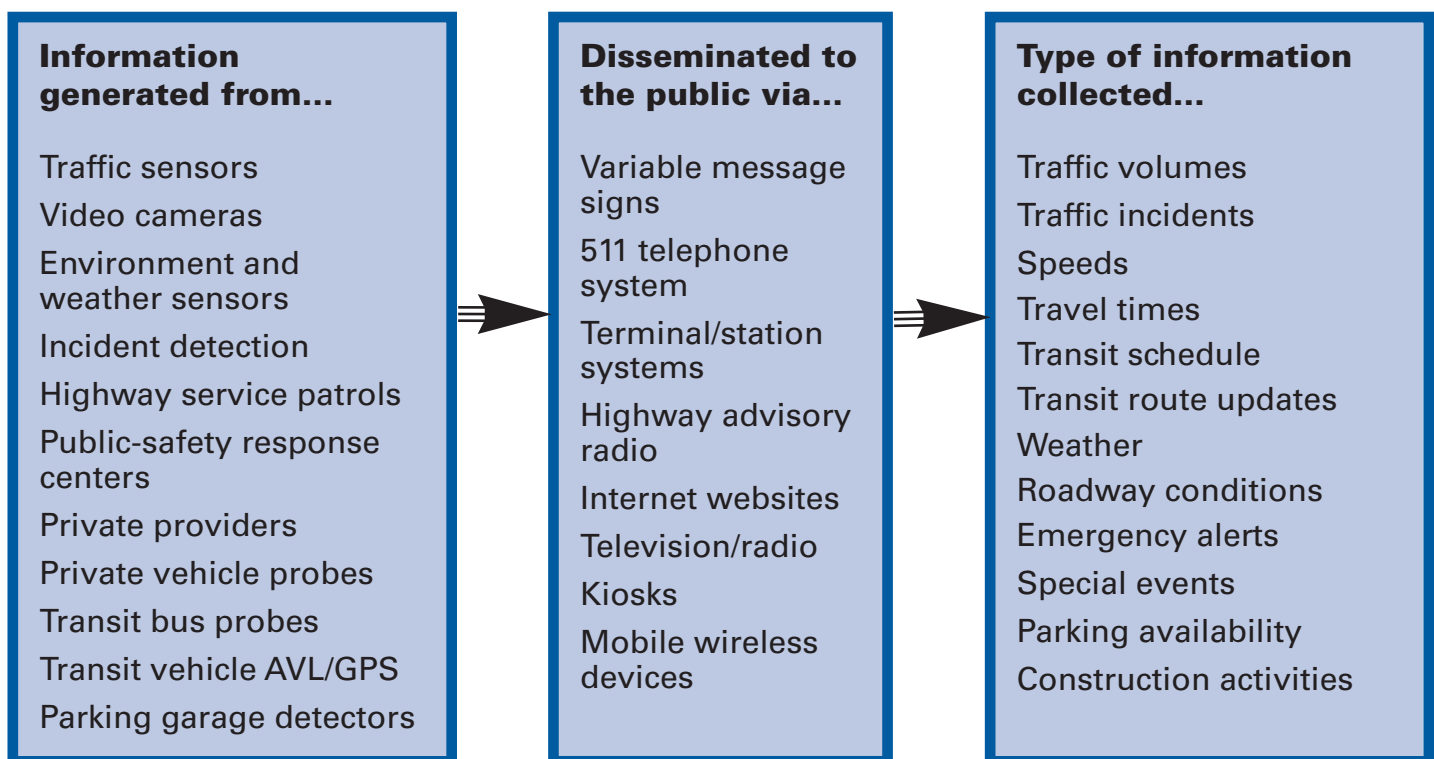
travelers who were surveyed indicated that the road-weather information website better prepared them for travel, and 56 percent said that it helped them to avoid travel delays.³⁹

- Acadia National Park in Maine served as a demonstration site for a joint research effort by the Department of Interior and USDOT to determine how technology could be used to address transportation problems in national parks. As part of the demonstration project, a suite of ITS components was deployed in the Park to support the region's need for public transportation management, traffic management, and traveler information. One component, real-time parking information, was posted on signs and the Park's website, making it easier for visitors to get around and to avoid parking problems and traffic congestion. A survey of bus riders

within the Park revealed that 44 percent who experienced real-time parking information found it helped them decide whether to ride the bus.³⁶

- 511 serves as the nation's dedicated travel information telephone number. As part of the ITS Integration Program, FHWA offers states grants of up to \$100,000 to develop 511 implementation plans. As of 2008, 44 states have received grants, and 511 services are operating in 33 states (see 511 Deployment Status map on page 10). The 511 systems allow travelers to access up-to-the-minute information on travel conditions via landline and wireless phones. An evaluation of Virginia's 511 services indicated that 90 percent of callers found the service useful, and nearly half adjusted their travel plans based on the information provided.⁴⁵

Dissemination of Traveler Information



ITS Minimizes Environmental Impacts

Freeway Service Patrols Generate Environmental Benefits

In 2004, the Florida Road Ranger Service Patrol Program saved over 1.7 million gallons of fuel per month by eliminating over one million vehicle-hours of delay. The program, designed to assist disabled vehicles along congested freeways and to relieve peak-period nonrecurring congestion, was initially used for the management of traffic incidents in construction zones. The Road Ranger program has since expanded to respond to all types of incidents and has become one of the most effective elements of Florida DOT's (FDOT) incident management program.

Motorists can request Road Ranger service from their cellular phones. The call is connected directly to a TMC operator, who uses closed-circuit television cameras (CCTV) to verify the location of motorists along the highway.

The Road Ranger Program benefits Floridians through reduced traffic delays and congestion, which in turn decreases fuel consumption and air pollution. The benefit-cost ratio for the Road Ranger program is estimated to be in excess of 25-to-1.⁸²

The transportation sector is responsible for a significant amount of the nation's air pollution. Mobile sources, including passenger cars, motorcycles and light-duty trucks, emit significant amounts of

carbon monoxide, hydrocarbons, nitrogen oxides (NO_x), particulate matter (PM), and air toxins. These pollutants can lead to a variety of health issues, including respiratory and cardio-

vascular problems, as well as to detrimental ecological and ecosystem impacts. Although considerable progress has been made in improving air quality in recent years, in 2006 more than 100 million people in the United States lived in counties that exceeded national air quality standards for ozone or fine PM.⁶⁶ In addition, in 2006, the transportation sector accounted for 33 percent of all US carbon dioxide (CO₂) emissions from fossil fuel combustion, the largest share of any end-use economic sector. More than 60 percent of CO₂ emissions resulted from gasoline consumption by personal vehicles.⁵⁸

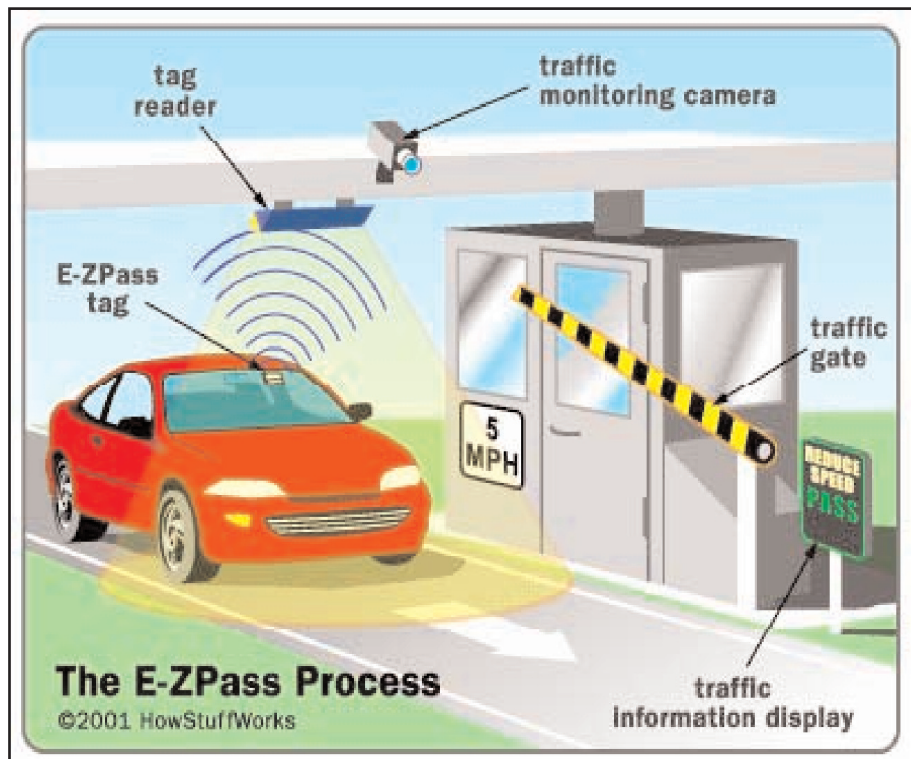
By maximizing transportation-system efficiency, ITS applications can help the transportation sector to decrease its negative impacts on the environment. ITS technologies are particularly effective at reducing congestion, which is directly related to air quality. Vehicles that are stationary, idling, or traveling at reduced speeds due to congestion emit more than those that are in free-flow



Traffic Signal Timing and Operation

- Traffic delays reduced up to 40%
- Travel time improved up to 25%
- Number of stops reduced up to 40%
- Fuel consumption reduced up to 10%
- Harmful emissions reduced up to 22%

Source: 72



The E-ZPass Process ⁴⁹

conditions. ITS applications that help to reduce congestion and minimize vehicle emissions include:

- **Traffic Incident Management:** In Georgia, the NaviGator traffic incident management program was shown to have reduced annual fuel consumption by 6.83 million gallons and prevented 2,457 tons of carbon monoxide, 186 tons of hydrocarbons, and 262 tons of nitrous oxides from entering the air between May 2003 and April 2004.⁸
- **Traffic Signal Priority:** In Syracuse, New York, \$8.3 million in federal ITS funds and non-federal funds was used to implement a Signal Interconnect Project, which optimized and inter-connected signals at 145 intersections in the central business district and key arterials. After three years of operation, the project had resulted in a



Florida Road Ranger Service Patrol Program⁸²

13.8 percent decrease in fuel consumption and a 13 percent reduction in vehicle emissions and noise pollution.⁸¹

- **Electronic Toll Collection:** By reducing queue lengths and minimizing stop-and-go traffic, electronic toll collection systems reduce fuel consumption and associated emissions. An evaluation of the E-ZPass system on the New Jersey Turnpike found a savings of 1.2 million gallons of fuel per year. In addition, VOC and NOx emissions were reduced by 0.35 and 0.056 ton per day, respectively.⁷⁵

ITS Creates Seamless Transportation

In the nation's metropolitan regions, numerous jurisdictions, agencies, and service providers are responsible for operating various aspects of the

transportation system. When traffic managers, transit operators, and public safety officials work independently of each other, the public suffers from

decreased response times and mobility.

ITS technologies provide the means for agencies to share information and coordinate activities in order to improve the efficiency and safety of the transportation network. Many regions have created Transportation Management Centers (TMCs), which serve as the nerve center of the area's transportation system. Through TMCs, transportation

Regional Coordination Enhances Public Safety

AZTech is a partnership of over 75 federal, state, and local public and private entities, formed to address a variety of regional operations issues in the Phoenix metropolitan area. Initially formed in 1996 to manage and coordinate one of four Metropolitan Model Deployment Initiative grants from the ITS Program (\$7.5 million), AZTech has grown into an integrated regional ITS system that provides real-time information and on-time services to enable safe, efficient travel.

One of AZTech partnership's numerous success stories is the development of a Regional Emergency Response Team (REACT), which assists local law-enforcement agencies in addressing traffic control during roadway incidents. REACT's incident management activities improve safety conditions both for emergency responders and the public. When REACT is deployed, roadways are able to reopen more quickly, thereby minimizing traffic delays due to incidents.⁷



AZTech REACT vehicle⁷










Transportation Management Centers Benefits

There are over 150TMCs operating in the United States and can yield:

- Rush hour speed increase up to 35%
- Reduction in accident rates up to 25%
- Significant decrease in emergency response time
- Freeway capacity increase up to 22%

Source: 60 / 63

information is collected from multiple locations and a variety of sources. With a more complete picture of the issues across the network, officials are able to make more informed traffic management decisions and to share pertinent information with the public.

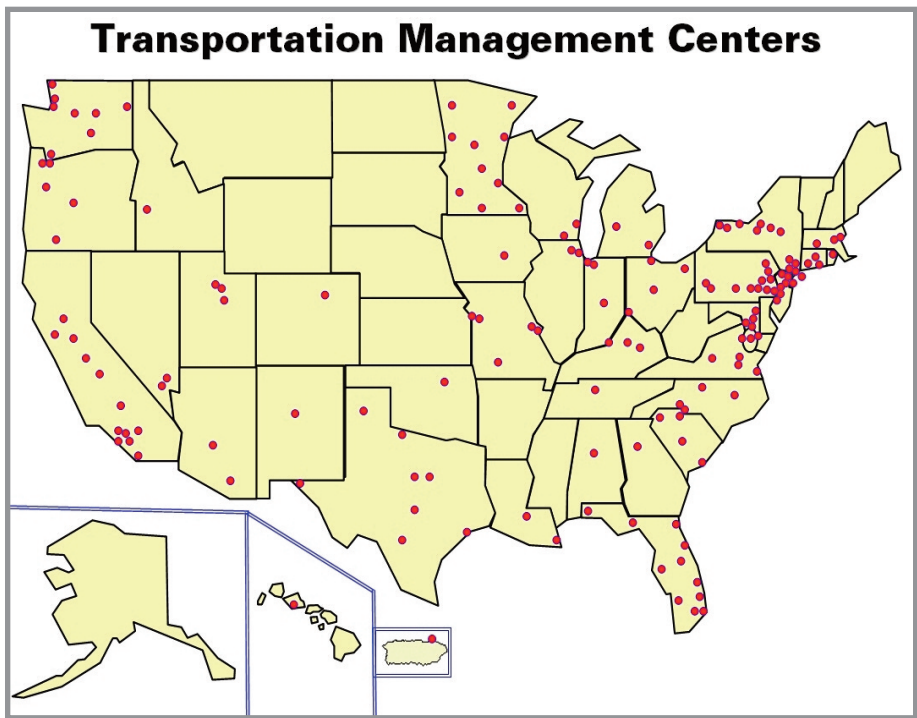
In the New York/New Jersey/Connecticut region, the Transportation Operations Coordinating Committee (TRANSCOM), a coalition of 16 transportation and public safety agencies, operates an Operations Information Center, which collects and disseminates real-time regional incident and construction information, 24 hours a day, to over 100 member and affiliated agencies. Coordinating the dissemination of information through the center allows for a much wider segment of the public to be reached.

ITS also plays a critical role in creating a seamless connection between transit services. Transfer Connection Protection (TCP) systems strive to improve the reliability of transfers between transit



Utah’s TCP system issues a “hold” message on a transit vehicle’s MDT. ¹¹¹

vehicles to optimize the travel time of passengers as they move from mode to mode. TCP involves holding a transit vehicle (a train or a bus) at a station in order to wait for another transit vehicle that has been planned to provide a timed transfer but has been delayed. The Utah Transit Authority implemented a TCP system to improve the reliability of transfers from the light rail system, TRAX, to connecting buses on selected routes. Using data on a train’s estimated arrival time and train and bus schedules, the system automatically generates a “HOLD” message when a potential missed connection is identified. The information is then sent to the vehicle’s onboard Mobile Data Terminal (MDT). Utah’s CP system has been found to significantly increase the percentage of successful train-to-train connections, and riders report a high level of satisfaction with their connection experience.⁴⁰



Source: ITS Statistics Database⁶³ - <http://www.itsdeployment.its.dot.gov/> and FHWA TMC Pooled-Fund Study: TMC Clearinghouse - <http://tmc-clearinghousedev.tamu.edu/facilities.php>



An operator at the Regional TMC in Florida ⁴⁴

ITS Improves Travel in Rural Areas

Rural America contains approximately 20 percent of the U.S. population but comprises 74 percent of public road miles. Rural communities and travelers face numerous transportation challenges, including dispersed networks and long distances between population centers, operation and maintenance of remote roads and equipment, adverse weather conditions, and steep grades and mountain passes. Although most crashes occur in urban areas, 54 percent of motor-vehicle fatalities occur on rural roads.

Deployment of ITS applications in rural areas has helped to address some of these

transportation challenges. ITS technologies improve traveler safety by alerting drivers to hazardous conditions and dangers. At Oregon's Emigrant Pass, a nine-mile stretch on I-84 that experienced 65 truck-related accidents from 1997 to 2004, Federal ITS Program and state funds have been used for the installation of a Downhill Speed Information System that has led to a significant reduction in crashes.⁶⁴ In Colorado, a similar system decreased truck accidents by 13 percent and reduced runaway ramp usage by 24 percent over a two-year period.^{26 / 60}

Each year, there are over 1 million wildlife-vehicle crashes, resulting in 200 deaths, 26,000 injuries, and \$8 billion in property damage.¹⁰² To address safety issues associated with wildlife-vehicle collisions, many states, including



Animal detection system on U.S. Highway 191 in Yellowstone National Park¹⁰²



Downhill speed information system displays safe speeds at Emigrant Pass⁷⁶



Variable speed limit sign under low visibility conditions on I-75¹³

Weather Alerts Improve Rural Safety

On December 11, 1990, a 99-car pileup occurred along a section of I-75 in southeastern Tennessee, injuring 42 people and killing 12. The cause was heavy fog with a visibility distance of less than 10 feet.

To prevent future fog-related incidents, a low-visibility warning system was deployed on 19 miles of I-75. When sensor data indicate low visibility, travelers are alerted to conditions through radio and dynamic message signs (DMS). Highway officials vary speed limits on the basis of visibility distance and display current speed limits on variable signs. When visibility is less than 240 feet, the Tennessee Highway Patrol closes the interstate remotely by activating automatic ramp gates.

This technology has improved safety significantly. Since the system was deployed in 1994, only one crash has occurred in fog.¹⁴



Tennessee ramp gate¹⁴

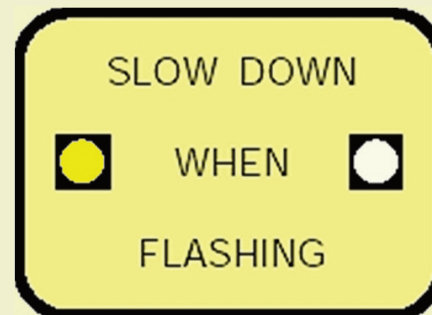
Arizona, Minnesota, and Montana, have implemented animal-vehicle collision avoidance systems. Using federal funding, Minnesota has installed a series of animal warning systems to alert motorists to possible animal crashes. This program has reduced the number of deer-vehicle crashes in troublesome locations by over 50 percent.⁶⁷

ITS has also improved rapid emergency response rates, which, in rural areas, can be a matter of life or death after vehicle crashes. A 911 caller reporting a crash on a remote or unmarked road may find it difficult to give specifics of the location, and emergency responders may have trouble finding it. The Montana Association of Counties and Montana DOT are collecting roadway GPS coordinate data on nearly 70,000 miles of roads in 12 counties, enabling emergency vehicles to better locate and reach these remote areas following an incident or emergency.⁶⁸

Truck Speed Monitoring and Excess Speed Automated Warning Benefits:

- Truck speeds reduced up to 8.3 miles per hour
- Truck crashes decreased up to 13%

Source: 12



ITS Keeps Travelers Safe and in Motion During Adverse Weather

Both predictable and unpredictable adverse weather conditions impact travel on an almost daily basis nationwide. Travel can be affected by seasonal occurrences such as wind, snow, heavy rains, and fog, as well as by catastrophic events such as hurricanes, tornadoes, floods, and fires. Motorists endure more than 500 million hours of delay each year as a result of fog, snow, and ice. Weather also impacts safety; each year between 1995 and 2005 more than 673,000 people were injured and nearly 7,400 were killed in roadway crashes under adverse weather conditions.^{16 / 59}

Many localities already employ ITS during bad weather, allowing important information to be relayed to emergency personnel, system managers, and the public so that informed decisions about transportation options, road closures, and staying off the roads can be made if necessary.

The Harris County, Texas, Office of Emergency Management's Automated Local Evaluation in Real Time (ALERT) flood warning system and Texas DOT's environmental monitoring

system provide advanced warning of severe weather conditions to travelers. The systems include 164 sensors deployed in a number of locations that monitor roadway water depth, rainfall, humidity, wind speed and direction, pavement moisture, stream velocity, and other weather-related information in real time and then relay the information to a central location. If an alarm threshold is met, the public is notified. In the last decade about 2,000 occurrences of flooding or "near flooding" have been identified by the ALERT system.^{11 / 35}

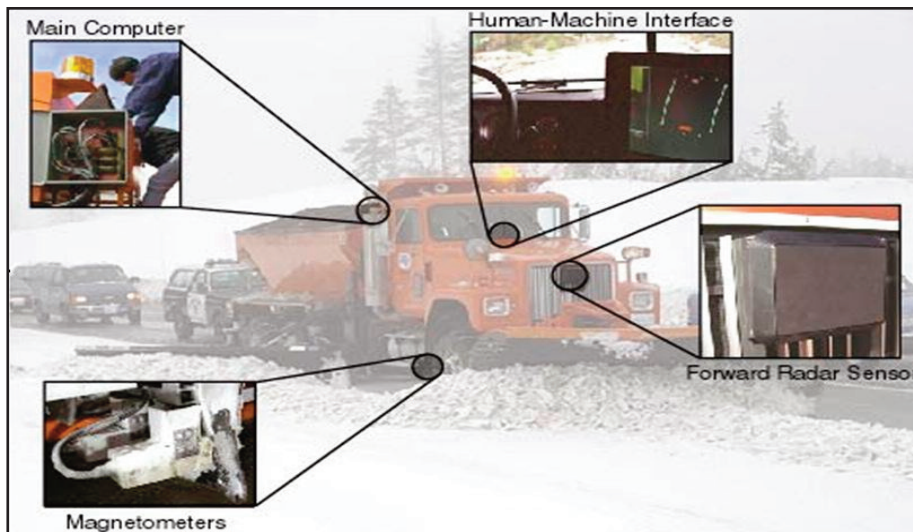
Information is also a key component in managing winter weather conditions. The Maintenance Decision Support System (MDSS) prototype is a decision support tool that integrates relevant road weather forecasts, coded maintenance rules of practice, and maintenance resource data to provide transportation and public works managers with recommendations as to the most efficient winter road treatment strategies. MDSS, which was developed with ITS Program funds, is now being incorporated into private sector product lines for state DOT clients. By 2007, 21 state



ITS is used to track thousands of public works vehicles during dangerous conditions.⁸²

transportation agencies were using or developing MDSS tools.⁸³

MDSS application can reduce environmental concerns and save agencies money. Overall benefits include reduced use of materials, labor, equipment, and fuel, and decreased fleet-replacement costs and infrastructure damage. MDSS also helps to reduce traveler delay, the time needed to clear snow and ice, and vehicle corrosion from chemicals. An MDSS case study conducted in New Hampshire showed a savings of \$2.9 million in terms of resources, delay, and safety compared with a system cost of \$333,000, resulting in a benefit-cost ratio of about eight to one.⁹



Automated snowplow and vehicle-roadway position display⁸²

Managing mass evacuations, such as those that occur prior to a hurricane, also requires a vast array of information. The South Carolina Hurricane Evacuation Decision Support Solution provided near-real-time information on traffic

conditions and enabled successful management of the mandatory evacuation of residents along the 150-mile South Carolina coast during Hurricane Charley in 2004. Application of the decision support software enabled

California's Automated Snow Plows

Caltrans leveraged research that began under ISTEA as the Automated Highway System (AHS) in 1991 to develop an automated snow plow. When federal funding for AHS ended, Caltrans continued to apply research from lessons learned. The automated snow plow uses magnetic sensors in the roadway to help plow drivers remain aware of the roadway centerline when whiteout conditions would normally prevent them from operating and would force the road to be closed. Combined with onboard radar, the automated snow plows help Caltrans to keep roadways open and cleared in heavy snow while reducing the likelihood of snowplow crashes with guardrails, parked vehicles, and other objects on the side of the road.⁸²



Roadside technology is used to warn of dangerous driving conditions.⁸³

South Carolina DOT and South Carolina Department of Public Safety to deploy a highway contraflow return plan that increased lane volumes by 44 percent over the evacuation volumes three days earlier (1,445 vehicles per lane per hour was increased to 2,082 vehicles per lane per hour).¹²



In-vehicle technology is used to warn of dangerous driving conditions.⁸³

ITS Reduces Costs in the Movement of Goods and Speeds Delivery to Markets

Truck transport is the main method for the movement of freight across America, constituting approximately two-thirds of total freight movement. Reliability is of upmost importance to American businesses and consumers, as late or unpredictable deliveries increase costs to consumers and represent lost business for firms. ITS can assist in moving goods more quickly across the country by improving communication between trucks and government officials, by reducing the number of stops that trucks must make along their routes, and by providing safety information that applies to the unique characteristics of large trucks.

The primary accomplishment in this area is the Commercial Vehicle Information System and Networks (CVISN) Program, which allows state agencies, trucking companies, and the federal



Freight Technology Benefits

- Electronic intrusion detection and asset tracking technologies - theft reduction savings up to 4-5% of the cargo value
- Gateway facilitation combines commercial vehicle tracking transponder programs and electronic toll payment at ports, highways, and border crossings
- Gateway facilitation provides annual savings to public inspection and security agencies up to \$25M

Source: 46 / 47



Weigh-in-motion sensor 29 / 101

government to communicate electronically with use of common standards. CVISN streamlines permit approvals, facilitates the transmission of safety information, and helps inspectors to identify trucks needing extra attention on the highways. Through the ITS Program, the USDOT has contributed over \$95 million to CVISN, which in turn has leveraged an additional \$106 million from states. In the 45 states that have implemented CVISN, costs for

credentialing have been reduced by up to 75% and emissions at inspection stations have decreased.³⁷

Weigh-in-motion (WIM) technology further streamlines freight operations by capturing and recording the weight of trucks as they drive over a sensor. In the State of Washington, CVISN uses WIM scales and transponder readers to screen trucks electronically as they approach a weigh station. If trucks satisfactorily

Colorado's Automated Screening Saves Time and Fuel

The Colorado Department of Transportation is seeking to expand and enhance ITS capabilities statewide. A key element in this endeavor is the state's I-25 Truck Safety Improvement Project, which has been allocated \$9 million in federal funding. As part of the overall project, computer automated clearance systems were installed to streamline clearance of the state's Ports of Entry (POE). Automation of the POE systems involved deployment of weigh-in-motion, automatic vehicle locators, and communications equipment to enable electronic credential checking. Federal funding was used to automate an initial three POE locations, and the state subsequently funded the automation of four additional POEs.²⁰

By allowing drivers to bypass inspection stations, Colorado's trucking POE automation has led to enhanced throughput of goods, savings in the private sector, and reduced vehicle emissions. An evaluation of the system found that it saves 8,000 hours of vehicle delay and 48,200 gallons of fuel every month.⁵⁰

meet weight and safety compliance, a green light is displayed on the transponder and the driver is cleared to bypass the weigh station. In 2007, transponder-equipped trucks were precleared and received over 896,000 green lights at Washington weigh stations. The savings to the industry was approximately 79,000 hours of travel time and \$5 million.²¹

ITS also plays an important role in streamlining border crossings for trucks that carry cargo between the United States and Canada. At crossings between Vancouver and the United States and from Seattle-Tacoma into Canada, transponders are affixed to trucks in order to record the cargo that they pick up at the port. This information is then

transmitted to the border patrol and crosschecked as trucks drive through WIM stations on the way to the border. Because the documentation has already been checked, customs and the border patrol can let trucks drive through with no or minimal stopping, keeping goods moving quickly and efficiently.⁵⁷

ITS Improves the Transit Customer's Experience

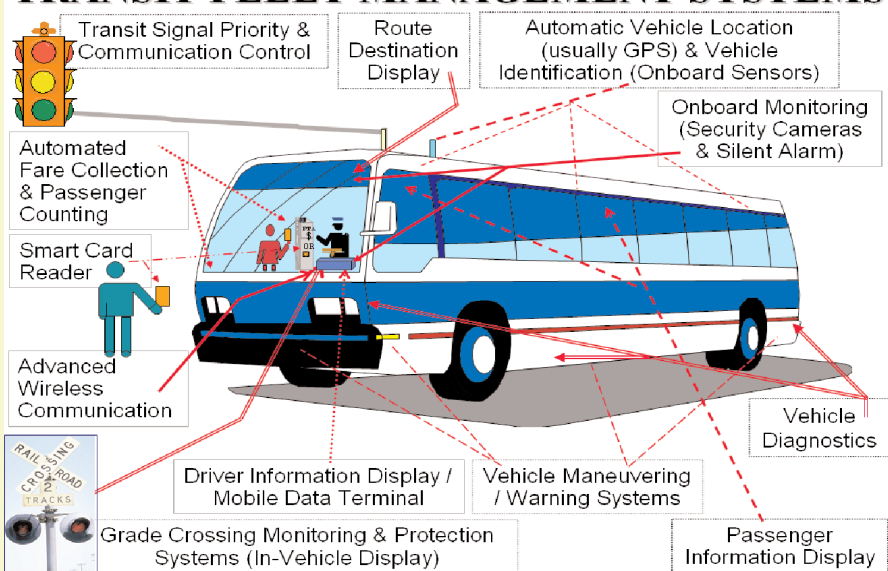
In order for transit systems to compete for riders, they must be able to provide reliable, on-time service. The integration of ITS with transit operations enables transit systems across the nation to provide better customer information, move through congested roadways more quickly, and enhance the riding experience. ITS technologies involved in improving transit customers' experience include:



The MBTA uses a reusable, rechargeable electronic fare card called the CharlieCard.⁶⁸

- **Electronic Fare Cards:** Electronic fare cards allow transit systems to provide customers with a variety of payment options, such as monthly passes, special fares, and single rides. The electronic cards allow the transit system to better understand its ridership and adapt its services to better align with customer demand. In Boston, the Massachusetts Bay Transportation Authority (MBTA) has introduced the CharlieCard, which allows transit riders to store both monthly passes and value. This has resulted in a quicker boarding process on rapid transit and has enabled the MBTA to

TRANSIT FLEET MANAGEMENT SYSTEMS



Transit Management Systems with AVL-GPS and Transit Signal Priority Benefits:

- Travel times reduced up to 50%
- Schedule reliability increased up to 35%

Source: 10

reduce labor costs associated with staffing for fare collection. After implementation of the MetroCard, New York City Transit reported a 50 percent reduction in fare evasion, while Ventura, California's transit agency saw an annual savings of \$9.5 million in reduced fare evasion and almost \$6 million in reduced collection costs.⁵¹

- **Automatic Vehicle Location Systems (AVL):** Using data gathered from AVL, a transit agency is able to provide customers with up-to-the-minute information at bus stops and rail

stations as well as on its website.

Electronic transit-status-information signs at stations provide passengers with estimated arrival times, helping them to manage their time. Denver's Regional Transportation District was able to decrease the number of late bus arrivals by 21 percent after it implemented AVL on its bus fleet. Atlanta's Transit Authority, MARTA, estimates that the agency saves about \$1.5 million a year by using AVL data to adjust schedules.⁵¹



Real-time traveler information signage at Metro Rapid Station ⁶⁷



Electronic Fare Payment:

- 1991, Phoenix Transit System was 1st U.S. transit agency to use magnetic card readers on buses
- 1995, Phoenix Transit was 1st U.S. transit agency to accept commercial credit cards on buses
- 20 contactless smart card, stored value, fare payment systems are used in the U.S.
- Over 30 cities with smart-card parking systems

Source: ⁸⁸

Benefits of Electronic Fare Payment:

- Multiple applications for a smart card
- Almost 90% user satisfaction of multi-application smart cards.
- Ability to deploy innovative fare structures
- Reduced fare collection costs by agencies
- Faster boarding time
- Simplifies partnerships with businesses, schools, or other institutions

Source: ⁸⁸

BRT Improves Transit Experience at a Low Cost

Bus Rapid Transit (BRT) systems offer higher-quality service than traditional bus lines by utilizing technology to improve travel times and provide customers with up-to-date travel information. The Los Angeles County Metropolitan Transportation Authority (MTA) and the City of Los Angeles Department of Transportation (LADOT) have collaborated to design, build, and operate the Metro Rapid Program system of BRT routes. The program has proved successful, with passenger travel times reduced by as much as 29 percent and ridership increased by nearly 40 percent. ⁶⁷

By utilizing technology, BRT is able to provide customers with service comparable with that of rapid transit systems, at dramatically lower capital costs.

- Transit Signal Priority (TSP): In collaboration with local municipalities, many transit systems are able to take advantage of vehicle prioritization systems that give transit vehicles priority when they are traveling through signalized intersections. After King County Metro in Seattle implemented a TSP system, prioritized buses experienced a 57 percent reduction in average delay time at intersections. ⁵¹



Electronic transit-status-information sign at a Los Angeles bus station ⁶⁷

Major Research Initiatives

The Federal ITS Program's ITS Research Initiatives

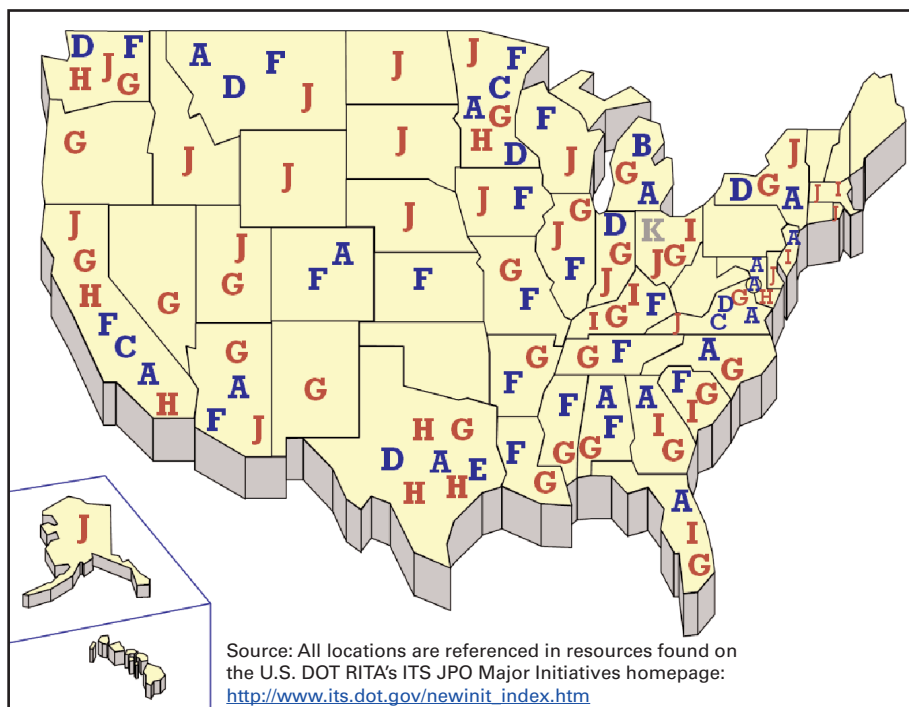
Although previous ITS research and deployment efforts have been successful, the ITS Program recognizes that critical transportation challenges still exist, and it will continue to seek new and evolving technological solutions to meet these challenges. A number of federally funded research initiatives that target safety, mobility, and productivity are already actively being pursued.

The map shows the national distribution of proof-of-concept test sites, demonstration sites, and system networks associated with the eleven major ITS research initiatives identified earlier. These test sites allow the ITS Program to evaluate system and technology prototypes, models, and strategies under real-world conditions before finalizing research and initiating commercialization and technology-transfer activities. Importantly, the systems and technologies tested at these sites frequently remain in use by state and local agencies, which integrate them into existing systems to provide local travelers and shippers with state-of-the-art transportation services.

Data Collection and Distribution through VII

- Dynamic routing
- Weather and driving conditions
- Vehicle diagnostics
- Parking information
- Transit arrival times, delays, etc.
- Traffic signal timing and phases
- Assorted advisories / enroute alerts
- Dangerous driving warnings
- Wireless financial transactions (fares, tolls, parking, etc.)

Source: 97



ITS Research Test and Demonstration Sites:

Proof-of-Concept Test Sites, demonstrations sites, and system network site locations by program goal

Program Goal: **Safety**

- A** Vehicle Infrastructure Integration (VII)
- B** Integrated Vehicle-Based Safety Systems (IVBSS)
- C** Cooperative Intersection Collision Avoidance Systems (CICAS)
- D** Next Generation 9-1-1 (NG9-1-1)
- E** Emergency Transportation Operations (ETO)
- F** Rural Safety Initiative

Program Goal: **Mobility/Congestion**

- G** Congestion Initiative
- H** Integrated Corridor Management Systems (ICM)
- I** Mobility Services for All Americans (MSAA)
- J** Clarus—National Surface Transportation Weather Observing and Forecasting System

Program Goal: **Productivity**

- K** Electronic Freight Management (EFM)

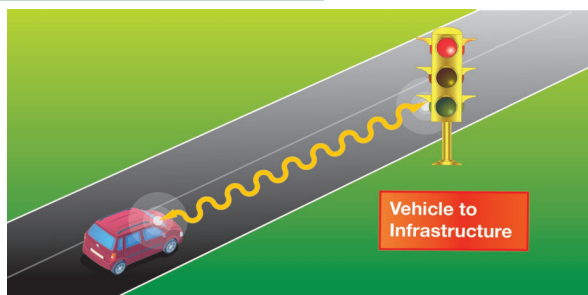
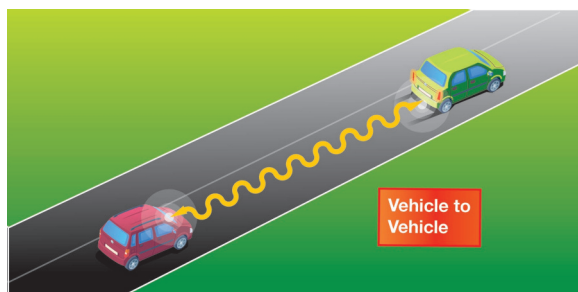
Safety Initiatives

1. Vehicle Infrastructure Integration (VII)

VII will 1) develop the capacity for vehicles to communicate with each other and with the roadway and 2) develop an information infrastructure on the roadways and in all production vehicles that will support critical safety applications, improve the safety

and mobility of the roadway environment, broaden travel options, and assist in reducing the environmental impact of transportation. In 2007, the SafeTrip-21 field test allowed the incorporation and assessment of mobile devices and commercially available communications (such as cellular and WiFi).

VII technologies include wireless dedicated short range communica-



VII Scenarios⁹⁹

tions (DSRC) and other appropriate communication networks for (1) vehicle-to-vehicle (2) vehicle-to-infrastructure, (3) vehicle-to-enterprise, (4) vehicle-to-Internet, and (5) vehicle probe for mobility and environment applications.

2. Integrated Vehicle-Based Safety System (IVBSS)

IVBSS will field test an integrated driver-assistance/ crash-alert system that helps drivers to avoid the three most common types of crashes (rear-end, run-off-road, and lane-change

crashes). All systems will use software that monitors vehicle speed, braking, and throttle output and will provide messages to the driver if necessary.

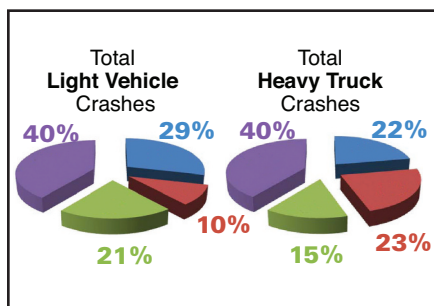
The IVBSS test will experiment with a range of options for delivering information to drivers. The IVBSS Program has already conducted a

Rear-End, Road-Departure, and Lane-Change Crashes

- 21,000 of 43,000 annual traffic deaths result from vehicles departing roadway or traveling unsafely through intersections
- About 3.6 million of these three types occur each year, representing:
 - 60% of reported light-vehicle and heavy truck crashes
 - 27,500 (75%) of fatal crashes

Source: ⁵⁴

series of controlled, on road, and test track tests. A more comprehensive test will enable better evaluation of the system's effectiveness and benefits. These test procedures and results will be provided to decision-makers to facilitate industry adoption.



Crash types in the U.S.⁵⁶

- Rear-End
- Lane Change
- Road Departure
- Other

Awareness Provided

These illustrations show three types of prevalent crashes and the awareness provided to the driver by each safety system.



Forward-Looking Collision



Lane-Departure Warning

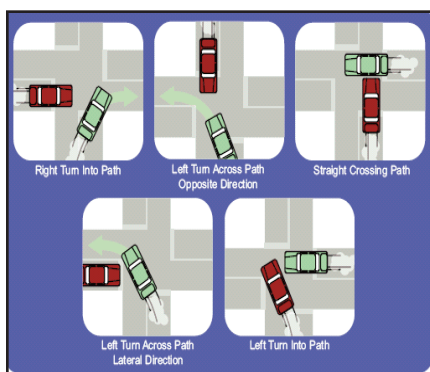


Lane-Change Collision Warning

Integrated Vehicle-Based Safety Systems⁵⁵

3. Cooperative Intersection Collision Avoidance System (CICAS)

CICAS research will result in the development of driver decision-making/crash avoidance systems that save lives and prevent injuries at the most hazardous intersections throughout the United States. The CICAS system will be designed to notify drivers of the potential for unsafe actions at traffic signals, at stop signs, when entering main roads from minor roads, and when making left turns at signals.



Intersection problems being addressed through CICAS⁶²

CICAS combines vehicle-based technologies, infrastructure-based technologies, and communications systems. The CICAS Initiative is researching and developing four intersection collision avoidance

Intersection Safety Problems (Annual Average):

- 9,100 fatalities at intersections
- 1.5 million injuries
- 3 million crashes
- 21% of all traffic crash fatalities occur at intersections
- Almost 50% of all pedestrian injuries and fatalities occur at or near intersections
- \$124 billion in costs attributed to intersection crashes

Source: 24

systems. CICAS research and testing are being closely coordinated with the VII Initiative. As deployment of CICAS will ultimately depend upon others (for instance, state and local governments, automotive manufacturers, the traffic signal industry, and other manufacturers), the CICAS Initiative engages a wide group of stakeholders to facilitate their decisions and generate input regarding implementation and deployment.

4. Next Generation 9-1-1 (NG9-1-1)

NG9-1-1 will enable updating of the nation's antiquated 9-1-1 emergency calling system through the development of a next-generation platform that will enable emergency 9-1-1 voice, video, text, and data transmissions from any networked communications device, including wired, wireless, or Voice-over-Internet-Protocol (VoIP) telephony. The NG9-1-1 system design will be able to handle emergency "calls" such as automatic crash notification (ACN) and camera phone 9-1-1.

5. Emergency Transportation Operations (ETO)

ETO research resulted in tools, guidance, and standards used to improve safety, speed, and effectiveness of response and management of major incidents. Tools and processes developed under



ITS technologies are applied to coordinate the transportation flows during major emergencies.³⁴

9-1-1 Emergency-Response System

- February 16, 1968: First 9-1-1 phone call placed in Haleyville, Alabama
- March 1973: White House calls for national 9-1-1 system
- 200 million calls are made to 9-1-1 annually
- 6,166 primary and secondary Public Safety Answering Points (PSAP) in the U.S.
- 96% of the U.S. covered by 9-1-1 system
- 99% of the U.S. population is covered by 9-1-1 system
- 5% of PSAPs have basic 9-1-1 that receives voice only calls
- 95% of PSAPs have enhanced 9-1-1 enabling calls to go to the nearest PSAP and identifying the caller's wireline phone number and address
- 73% of PSAPs have some form of Wireless Phase I capabilities, which identifies wireless call-back number
- 41% of PSAPs have some form of Wireless Phase II capabilities, which identifies wireless call-back number and location of caller through cell-tower triangulation
- National Fire Protection Association (NFPA) standard of 90 seconds from answering the call to dispatch the appropriate responders

Source: 28 / 73

Annual Emergency Challenges in the United States

- 400+ tropical storms, hurricanes, tornadoes, and highway hazmat incidents, requiring evacuations
- An extensive number of localized incidents in the form of winter weather, wildfires, multi-vehicle crashes, and security activities
- 72-hour warning for hurricane evacuations

Source: 34

the ETO initiative included improvements for information sharing, evacuation management and operations, and transportation operations during biohazard events.

6. Rural Safety Initiative

The USDOT's Rural Safety Initiative Program will help states and communities develop ways to eliminate the risks drivers face on America's rural roads and highlight available solutions and resources. The new endeavor addresses five key goals: safer drivers, better roads, smarter roads, better-trained emergency responders, and improved outreach and partnerships. Rural safety research will result in the identification and implementation of both proven technologies and high-impact, leading-edge technologies and solutions that prevent accidents, reduce fatalities and injuries, and ease congestion in rural transportation environments.

Rural Safety Challenges

- Over 70% of all lane-miles of roads in the U.S. are rural (6 million of 8.4 million lane-miles)
- 55% or more of all traffic fatalities occur on rural roads
- Longer emergency response to a crash:
 - 66% of rural drivers killed in crashes died at the scene versus 51% of urban drivers
 - 72% of drivers who died en route to a hospital were in rural areas
- Fatality rate for rural crashes is more than two times that of urban crashes

Fatality rate per 100 million vehicle miles traveled:

Rural = approximately 2.30 deaths

Urban = approximately 0.95 deaths

Source: 3 / 84



Colorado Downhill Truck Speed Advisory System integrates weigh-in motion (WIM) and dynamic message signs (DMS).¹⁹

Safety enhancements that are or will soon be available as a result of ITS technologies include:

- Intersection and vehicle-based collision avoidance systems, such as sensors and obstruction-detection devices, DMS/warning signs, and automatic braking systems.
- Variable speed limits and roadway indicators that adjust on the basis of weather and roadway conditions.
- Dynamic curve-warning systems that warn drivers through DMS or direct communication with the vehicle.
- Road weather-information systems that help officials know when deicing materials are needed.
- Stop-sign-controlled intersection technology that provides drivers with real-time information about gaps in oncoming traffic to help them make safer turns.
- Real-time traveler information



Winter driving in rural Pennsylvania¹⁰³

pertaining to traffic, weather, and navigation.

- Traffic and criminal software and database for better rural law enforcement planning.

Congestion Reduction Toolbox

1. Service on Existing Roads
 - Traffic-incident management
 - Traffic-signal timing (including emergency pre-emption and transit signal priority)
 - Arterial management
 - Access management
 - Freeway management and traffic operations
2. Pricing
 - Value pricing
 - Regional toll and fare payment and collection system
3. Capacity
 - Adding capacity / easing bottlenecks
 - Public-private partnerships
 - Increase transit routes and vehicles available
 - Increase coordination among transportation providers
4. Better Work Zones
 - Work-zone management
5. Travel Options
 - Planned-special-events traffic management
 - Travel-demand management
6. Traveler Information
 - 511 traveler information telephone service
 - Travel-time message signs
 - National traffic and road-closure information
 - Real-time travel-time and transit information
 - Freight-shipper congestion information

Source: 23

Mobility and Congestion Initiatives

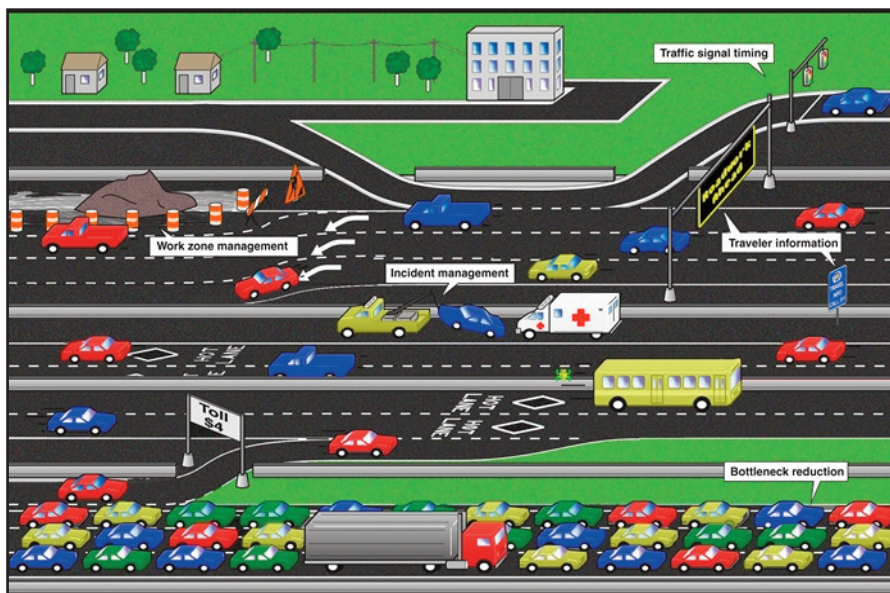
7. Congestion Initiative

Transportation system congestion is one of the greatest threats to our Nation's economic prosperity and way of life. Whether it takes the form of trucks stalled in traffic, cargo stuck at overwhelmed seaports, or airplanes stuck on the tarmac, congestion costs the Nation an estimated \$200 billion a year. The problem of traffic congestion in our major metropolitan areas in particular is severe and worsening. In 2003, traffic jams in the Nation's largest 85 urban areas cost Americans 3.7 billion hours and 2.3 billion gallons of fuel. Congestion is also affecting the quality of life in America by robbing us of time that could be spent with families and friends and in participation in civic life.

In May 2006, the Department announced a major initiative to reduce transportation system congestion. This plan, the National Strategy to Reduce Congestion on America's Transportation Network (the "Congestion Initiative"), provides a blueprint for federal, state, and local officials to consider as they work together to reverse the alarming trends of congestion. One major component of the Congestion Initiative is the Urban Partnership Agreement (or "UPA"). Urban Partners are adopting the "Four Ts:" tolling (congestion pricing), transit, telecommuting and technology – strategies believed to be effective on a combined basis in reducing traffic congestion.

8. Integrated Corridor Management (ICM)

ICM will improve mobility through integrated management of a multitude of transportation assets (freeways, arterials, and transit) in the nation's most critical metropolitan transportation corridors.

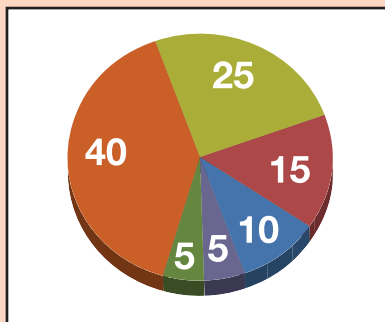


Operational and technological improvements that relieve congestion ¹⁰⁶

Congestion Costs and Issues

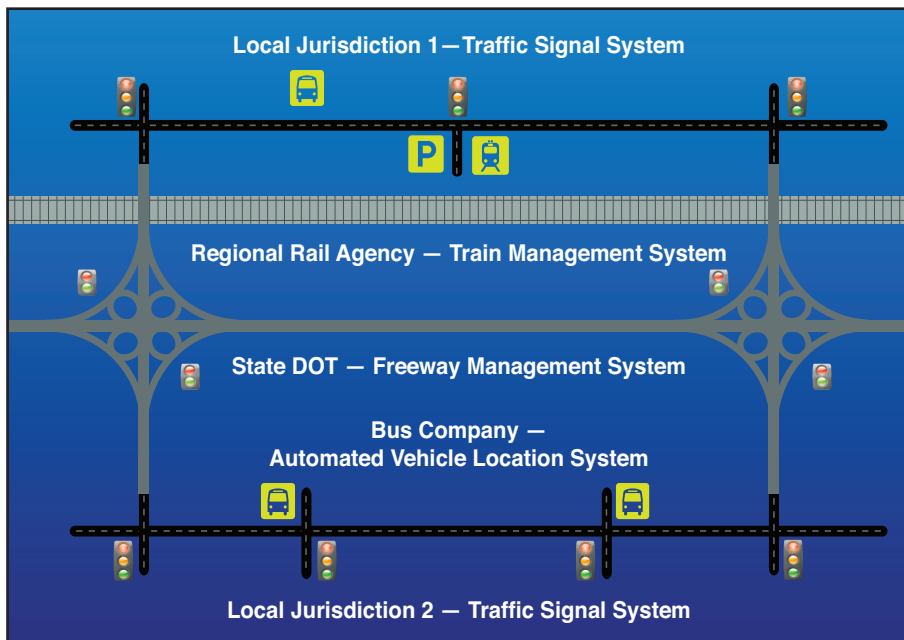
- About \$200 billion in freight bottlenecks
- Depending on the product carried, congestion adds between \$25 and \$200 per hour to freight costs
- Average annual cost of congestion per traveler: \$794
- 4 billion hours wasted waiting in traffic jams
- 2 billion gallons of fuel wasted in traffic jams
- Greatest concentration of congestion is along critical urban transportation corridors that link residential and commercial/business nodes
- Between 1980 and 1999, highway-route miles in the US increased 1.5% while vehicle miles traveled increased 76%
- Incident lane blockage:
 - Each minute of lane blockage creates 4 minutes of congestion
 - Blockage of one of three freeway lanes reduces capacity by 50%
 - Blockage of two of three freeway lanes reduces capacity by 80%
- Work Zones:
 - Average of one work zone every 100 highway miles
 - Average of one work zone lane closure every 200 highway miles
 - Average of 1,000+ fatalities and 40,000 injuries in work zone crashes

Source: 22 / 53



The Sources of Congestion: ^{91 / 104}

40% Bottlenecks
 25% Traffic Incidents
 15% Bad Weather
 10% Work Zones
 5% Poor Signal Timing
 5% Special Events/Other



An example of an urban corridor with ICM strategies ⁵²

The ICM Initiative selected eight Pioneer sites located around the country to demonstrate the ICM concept. The ICM Initiative approach also includes an adaptation of commercial-off-the-shelf modeling software packages to create the capabilities to model the complex combinations of multimodal and integrated system strategies, known as the analysis, modeling, and simulation (AMS) approach.

9. Mobility Services for All Americans (MSAA)

MSAA will result in a replicable and scalable model of Traveler Management Coordination Centers that will increase mobility and access for transportation-disadvantaged communities through transportation service coordination, reducing the transportation cost and increasing the productivity of human service transportation.



MSAA provides one vision of enhanced human service transportation. ⁶⁹

Human Service Transportation Facts

- 62 federal programs fund transportation services for the transportation-disadvantaged
- 29 federal programs spent \$2.4 billion in 2001 to provide transportation assistance to disadvantaged populations
- Lack of coordination among programs results in fragmented, duplicative, unreliable transportation services
- Trip purposes vary widely, ranging from medical to paratransit to elder travel to social-service links
- Over 10,000 agencies provide some form of human service transportation
- Over 75% of agencies rely on small fleets of less than six vehicles

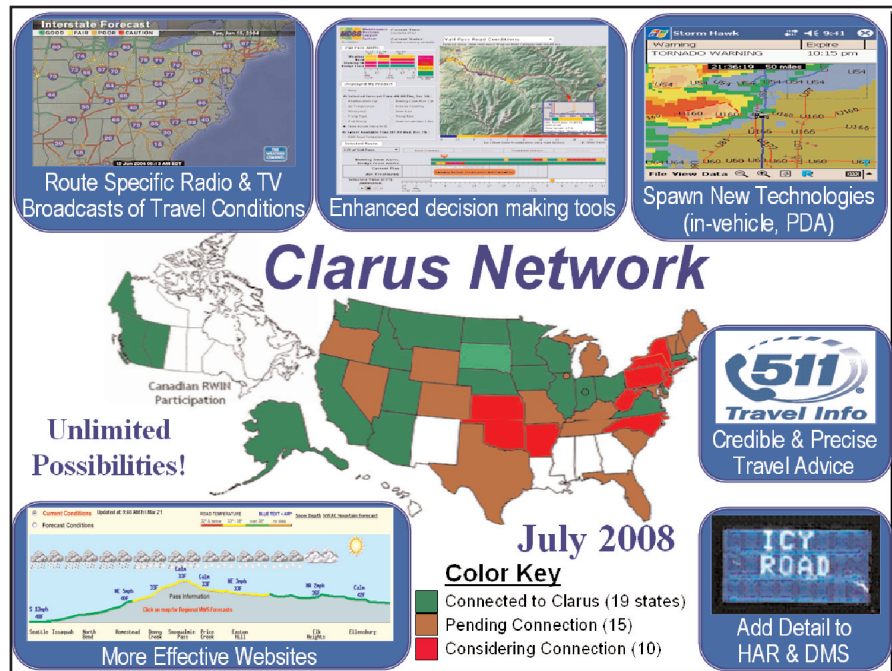
Source: ⁷⁰

The key to enabling such effective and efficient coordination is the integration of ITS technologies that are tested and proven. Such technologies include Geographic Information Systems (GIS); integrated computer-aided vehicle dispatching and scheduling (CADS); automatic vehicle location (AVL) systems, primarily global positioning systems (GPS); communications systems; electronic payment systems; financial tracking and billing systems; and advanced traveler information systems.

Annual Transportation Impacts from Severe Weather

- 1.5 million motor vehicle crashes
- 800,000 injuries
- 7,400 fatalities
- \$42 billion in costs (injuries, loss of life, property damage) from weather-related crashes
- 500 million hours of delay from fog, snow, and ice
- 24% of all crashes occur in adverse weather conditions
- Weather delays add up to \$3.4 billion to freight costs annually

Source: 16



Clarus Network - Unlimited Possibilities!¹⁷

10. Clarus—National Surface Transportation Weather Observing and Forecasting System

Clarus will result in a nationwide coordinated road-weather network. Clarus will integrate a wide variety of weather observing, forecasting, and data management systems to deliver timely, accurate, and reliable weather and road condition information as a means of impacting decisions by both drivers and transportation operators in order to reduce the negative effect of adverse weather on safety and congestion. As of 2008, 19 U.S. states and 3 Canadian provinces connect their sensor networks and provide data to Clarus, with a goal to network 33 states by 2010.



International Trade Facts

- U.S. foreign trade rose from \$1.2 to \$2.6 trillion between 1990 and 2003
- In 2007, over \$3 billion in goods moved into and out of the country via freight transport
- The volume of trade moved on the U.S. transportation system in 2020 is expected to increase up to 70% from 1998 levels

Source: 32

Electronic Freight Management

Based on replication of initial tests, results include:

- 12% reduction in total shipment travel time
- 75% reduction in paper-work-entry labor per shipment
- 12% improvement in data accuracy
- 15% reduction in data-entry errors
- 10% improvement in customs-clearance processing

Source: 31

Productivity Initiative

11. Electronic Freight Management (EFM)

EFM will transform market opportunities for businesses of all sizes, but particularly small businesses, by providing them with the

streamlined, non-proprietary means to track cargo shipments in near-real time, connect with new shipping partners both home and abroad, and expedite the paperwork process required when moving goods through the air-truck supply chain.

EFM involves Internet and advanced communications technologies that enable standardized electronic information-sharing, real-time information, and security monitoring enhanced by freight electronic data.

Continued Investments by the Federal ITS Program

As the many examples detailed in this document have demonstrated, USDOT's ITS Program has provided funding and guidance for investments in technology at all levels of government—local, regional, state, and federal—as well as the private sector. These investments have touched the lives of every citizen in the country, whether by making the roads safer, providing the traveling public with better real-time transit and traffic information, creating greater opportunity

for multimodal travel or improving the efficiency and flow of goods to sustain our economy. All of this has been achieved with an annual investment by the federal government of about 60 cents per person, equivalent to the amount of federal tax collected on $3\frac{1}{2}$ gallons of gas.

ITS has played, and will continue to play, a key role in proactively providing the nation with a 21st-century transportation system. The ITS Program will con-

tinue to provide leadership through the demonstration and evaluation of new advanced technologies to ensure that their applications are appropriate and produce effective results. By doing so, advanced technology applications will continue to enable safer and more secure travel, expanded travel options, and greater movement and productivity for the entire transportation system.



USDOT will continue to support technology investments.⁶⁵

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ITS Benefits

Safety:

Changes in crash rates, vehicle speeds, traffic conflicts, traffic law violations

- Improved safety
- Decrease in accident rate
- Presents warnings to drivers to detect hazards or unsafe conditions
- Presents warnings to drivers to evaluate the severity of the hazard
- Provides travelers with real-time weather conditions and warns about unsafe driving conditions
- Provides transportation agencies with detailed information to address safety and increase operational improvements
- Improved detection of incidents

Economic Productivity:

Cost savings to transportation travelers, providers, or shippers

- Fewer lane closures
- Enhanced communication between bus operators and dispatchers (with information on schedule adherence, delays, traffic incidents, and operating problems)
- More accurate revenue base
- Greater coordination of shipment of goods
- Expanded methods to pay fares

Efficiency (Capacity / Throughput):

Better managed transportation facilities to accommodate additional demand, typically represented through increases in capacity or level of service within existing road networks or transit systems

- Reduced congestion
- Reduced vehicle miles traveled (VMT)
- Improved traffic conditions
- Total stops reduction
- More route diversion to alleviate congestion
- Increased transit mode share
- Improves the ability of operational agencies to more rapidly address road conditions based on real-time information
- Provides agencies with a network for monitoring and information dissemination to support numerous activities such as incident detection and verification, weather and roadway conditions monitoring, dynamic message sign message verification, and event management
- Provides information to drivers on construction areas and work zones, incidents, road surface and weather conditions, congestion, public transit schedules, and tourism
- Alerts drivers to problems on the roadways and provides alternative solutions
- Improved system operations
- Decrease in headway variability
- Provides operating agencies with information for decision support
- Reduces costs through effective use of maintenance resources; maintenance vehicles become a source of system information
- Improved fleet utilization enabling reduction in transit fleet
- Ability for transit agencies to initiate alternative services, such as demand-response service.

Customer Satisfaction:

Perception of deployed ITS technologies by traveling public

- Improved trip quality
- Reliable travel times
- Public/traveler desire to expand ITS service

Energy/Environment:

Fuel savings and reduced pollution

- Average fuel consumption reduction
- Average vehicle emissions reduction
- Improved air quality
- Reduced emissions at tollbooths

Mobility:

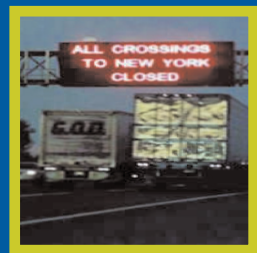
Travel time or reduced delays, travel time budget savings, on-time performance

- Decrease in incident duration
- Decrease in incident response time
- Vehicular delay reduction
- Vehicle speed increases
- Travel-time reduction
- Decrease in commute times
- Better paratransit trip planning
- Improved schedule reliability and on-time performance
- Reduction in boarding times
- Improved coordination with transportation operators to reach incidents more quickly
- Advanced notice of traffic conditions and lane closures

Sources:

ITS Benefits Website (benefits categories)⁶¹

5-Year ITS Program Plan – 2007 (detailed benefits)¹¹⁹



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