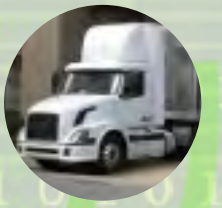
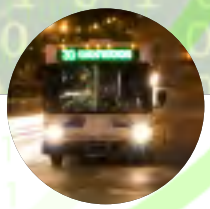
RITA Intelligent Transportation Systems Joint Program Office

ITS Strategic Research Plan, 2010–2014

Executive Summary





Transforming Transportation Through Connectivity

U.S. Department of Transportation
Research and Innovative Technology Administration

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Connectivity~

It's a concept that is rapidly changing our daily habits: real-time information gives us the power to make decisions and act on opportunities, provides us with details needed to understand our fast-paced world, and brings us an awareness of how our systems work. The start of the 21st century introduced advanced wireless technologies to our lives, and already they are having a dramatic impact on our connections to family, friends, and the social and entertainment worlds. These technologies are proliferating throughout the business, political, and educational arenas, changing our relationship to information and creating an awareness of situations that previously would have gone unnoticed. These technologies are redefining how we access knowledge; for the realm of transportation, this means unprecedented awareness about what is happening to and throughout our transportation system at all times.

Transportation Connectivity~

The U.S. Department of Transportation's (U.S. DOT) Intelligent Transportation Systems (ITS) Program aims to bring connectivity to transportation through the application of advanced wireless technologies—powerful technologies that enable transformative change. Envision:

- *A system in which highway crashes and their tragic consequences are rare because vehicles of all types can sense and communicate the events and hazards happening around them.*
- *A fully-connected, information-rich environment within which travelers, transit riders, freight managers, system operators, and other users are aware of all aspects of the system's performance.*
- *Travelers who have comprehensive and accurate information on travel options—transit travel times, schedules, cost, and real-time locations; driving travel times, routes, and travel costs; parking costs, availability, and ability to reserve a space; and the environmental footprint of each trip.*
- *System operators who have full knowledge on the status of every transportation asset.*
- *Vehicles of all types that can communicate with traffic signals to eliminate unnecessary stops and help people drive in a more fuel efficient manner.*
- *Vehicles that can communicate the status of on-board systems and provide information that can be used by travelers and system operators to mitigate the vehicle's impact on the environment or make more informed choices about travel modes.*

Enabling the Vision~

The vision of the ITS Program for the next five years is to provide the Nation with a national, multi-modal transportation system that features a connected transportation environment among vehicles of all types, the infrastructure, and portable devices which will serve the public good by leveraging technology to maximize safety, mobility, and environmental performance.

To make this vision a reality, researchers; vehicle manufacturers (automotive, commercial vehicle, and bus); consumer electronics and telecommunications firms; and Federal, State, and local transportation officials are coming together to define a working relationship that will further research and develop new markets. By enabling wireless connectivity with and between vehicles, between vehicles and the roadway, and with portable devices, the ITS Program has the potential to transform surface transportation safety, mobility, and environmental impacts in our lifetimes.

This document is the *Executive Summary* of the **ITS Strategic Research Plan, 2010-2014**[1]. It describes a focused research agenda for delivering transportation connectivity to the Nation. Building on the last set of recently completed research initiatives[2], this new research portfolio will continue efforts necessary for researching, prototyping, testing and evaluating, and

transferring the next generation of ITS technology into the marketplace. Ultimately, this research portfolio will result in providing a fully-connected, information-rich transportation system for the Nation.

Why?

Highway safety is one of our Nation's major public health challenges, responsible for 37,261 fatalities in 2008[3] and the leading cause of death for people between the ages of 4 and 34.[4] The economic impact of motor vehicle crashes on U.S. roadways is estimated by National Highway Traffic Safety Administration (NHTSA) at $230.6 billion a year, nearly 2.3 percent of the Nation's gross domestic product, or an average of $820 for every person living in the country. NHTSA has reported that the average roadway fatality has economic costs of $977,000, while the costs associated with a critically injured crash survivor surpasses $1 million.[5] Although these statistics reflect a recent decrease in the number of fatalities, it remains an unacceptably high loss of lives.

Traffic congestion is an $87.2 billion annual drain on the U.S. economy—more than $750 for every U.S. traveler. Americans waste 4.2 billion hours in traffic every year or nearly one full work (or vacation) week for every traveler.[6]

Vehicle fuel utilization and its tailpipe emissions are the single largest human-made source of carbon dioxide, nitrous oxide, and methane. These fumes cause pulmonary diseases and premature deaths. Children are particularly vulnerable, as poor air quality triggers asthma which is the number one cause of hospitalization among children and is having a major impact on our schools, emergency rooms, and healthcare system.[7] Additionally, vehicles that are stationary, idling, or traveling at reduced speeds due to congestion emit more than those that are in free flow conditions. Therefore, technologies that reduce fuel consumption, idling, and vehicle miles traveled while reducing acute congestion could play a significant role in reducing greenhouse gas emissions, particularly in major cities, around ports and freight hubs, and on major roads and corridors.

Why Now?

In 2010, a timely opportunity presents itself to the Department—to plan for the delivery of the next generation of ITS research. The planning process began in early 2008 with outreach to stakeholders and the public, input from modal decision makers and technical staff, and a trend analysis (see textbox on next page).

Wireless connectivity emerged as a significant research need driven by the new, powerful, and dynamic technologies that are available on the market now, or are just on the horizon. The predominant research question for industry is *how to **safely** harness their potential for transportation*. It is a timely research question—existing ITS research initiatives are ending, and the previous Vehicle-Infrastructure Integration (VII) Program's proof-of-concept test results both proved the capability for transportation connectivity and identified the remaining research questions and required efforts. The confluence of these events has significantly influenced the direction of this **ITS Strategic Research Plan**.

Noteworthy Trends in Transportation

Trends in Transportation

- Safety focus
- Continued high fatality rates
- Growing congestion
- Growing interest in transit
- Growing environmental awarenes
- Emphasis on performance measurement and management
- Troubled transportation financing
- Road pricing and financing alternatives
- Transportation impacts on livability

Trends in Technology

- Wireless technology boom
- Strong consumer market
- Fast pace of innovation
- Expectation for information
- Ubiquitous connectivity
- Person-to-person networking

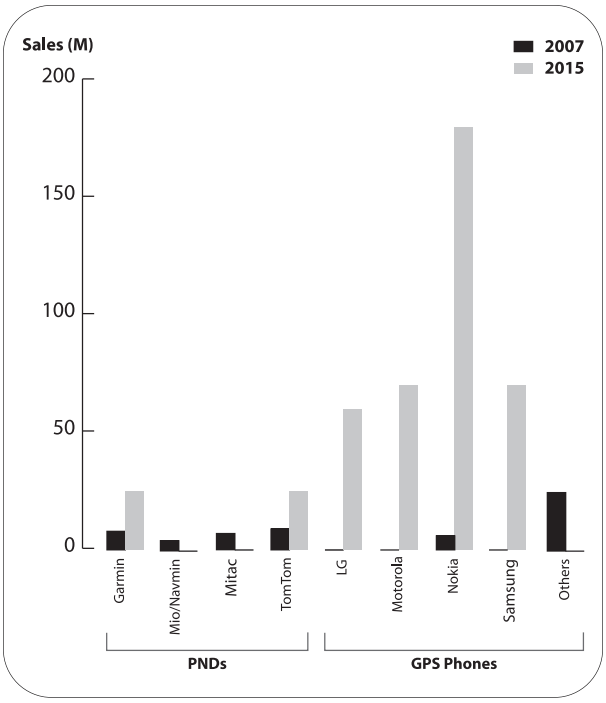


Figure 1: Trends in wireless connectivity.

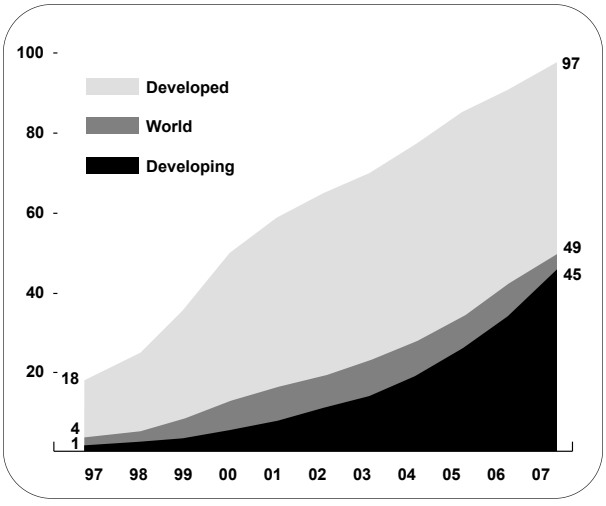


Figure 2: Growth in mobile wireless devices, 1997-2007 (subscribers per 100 inhabitants).

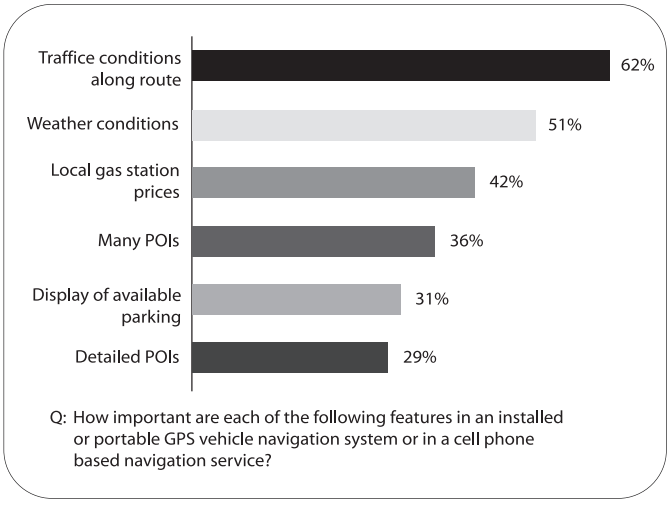


Figure 3: Consumer interest in transportation information.

Enacting the Vision

Collectively, these partners have set the guiding vision for the next five years:

> ***To research and facilitate a national, multi-modal surface transportation system that features a connected transportation environment around vehicles of all types, the infrastructure, and portable devices to serve the public good by leveraging technology to maximize safety, mobility, and environmental performance.***

The **ITS Program's Strategic Research Plan** has been defined through a multi-modal Departmental effort and informed through stakeholder input. The resulting research program is administered as a collaborative partnership between the ITS Joint Program Office (JPO), part of the Research and Innovative Technology Administration (RITA), and modal administrations that include:

- Federal Highway Administration (FHWA)
- Federal Motor Carrier Safety Administration (FMCSA)
- Federal Railroad Administration (FRA)
- Federal Transit Administration (FTA)
- Maritime Administration (MARAD)
- National Highway Traffic Safety Administration (NHTSA)

To explore the potentially transformative capabilities of wireless technologies to make transportation safer, smarter, greener and, ultimately, enhance livability for Americans, the ***centerpiece of the ITS Program's research plan is a program called IntelliDrive℠***—a cross-modal, research initiative that aims to create safe, interoperable connectivity between vehicles (automobiles, trucks, motor coaches, transit vehicles, rail, and other fleets), infrastructure, and mobile devices.

The IntelliDrive℠ research is designed to achieve a deployable system. To do so, critical success factors were identified, each of which must be addressed and resolved for IntelliDrive℠ to be implementable. These critical success factors define three distinct areas for research:

- **Applications:** *Applications in safety, mobility, and environment are effective and validated.*
- **Technology:** *Technology is secure and interoperable.*
- **Policy:** *The system as a whole is sustainable. The system is publicly acceptable.*

From these critical success factors, programmatic research questions were derived (summarized below). Using these questions, research programs were formed that are organized and focused

Critical Success Factors

Applications	✔ Are applications available and benefits validated? ✔ What is the minimum infrastructure needed to create the maximum benefit? How much, where, when, and what type? ✔ What is the degree of market penetration required for effectiveness?
Technology	✔ Is the technology stable, reliable, secure, and interoperable? ✔ Are international standards available to ensure interoperability?
Policy	✔ What policies, governance, and funding are required for sustainability? ✔ How to address public concerns for privacy and ensure that applications do not cause driver distraction?

All must be answered to be deployable

specifically on resolving these questions and other technical issues, as a means for achieving the goal of deployment.

This *Executive Summary* describes four major components of the **ITS Strategic Research Plan, 2010–2014**:

- **The IntelliDrive℠ Program:** The applications, technology, and policy research programs that are structured to address the research questions are described. While the above questions apply to the program overall, they also apply in a more specific manner within the multiple areas of research. As a result, these questions will again appear under the research program descriptions.
- **New Mode-Specific ITS Research:** As noted earlier, ITS is more than IntelliDrive℠. In close cooperation with modal partners, new ITS technologies, strategies, and systems have also been defined as part of the next five-year research agenda.
- **ITS Exploratory Research:** The ITS Program intends to provide an avenue to solicit creative ideas for new technology options that deserve further attention. This section describes this new program element.
- **ITS Cross-Cutting Support:** In addition to the research programs, the ITS Program hosts critical functions that provide support across the research programs. These cross-cutting functions are described and include: architecture, standards, technology transfer, professional capacity building, evaluation, and outreach and communications.

Finally, this *Executive Summary* concludes by describing the expected benefits of delivering the next generation of ITS to the Nation.

Use of Dedicated Short Range Communications (DSRC) Technology

With this five-year strategic research plan, the Department is committing to the use of the DSRC technologies for active safety for both vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) applications. The Department is also reaffirming its intention to explore all wireless technologies for their applicability to safety, mobility, and environmental applications.

In 2008, the ITS Program framed the definition of connectivity to include both DSRC and non-DSRC technologies as a means of providing an open IntelliDrive℠ platform. Such a framework has multiple benefits:

- It will allow for the integration of a wider array of technologies, and thus enable private industry to develop innovative technologies that may offer new or additional features.
- It will allow the IntelliDrive℠ architecture to adapt as technologies evolve over time, ensuring that the IntelliDrive℠ network incorporates innovative approaches and applications as they become available.
- It will ensure that benefits are not limited only to drivers of IntelliDrive℠–equipped vehicles.

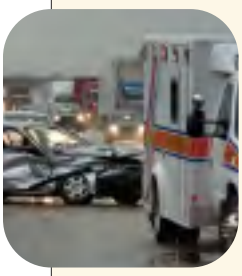
The Department's commitment to DSRC highlights two critical points:

- That safety is the highest priority for the Department and will form the central focus for the IntelliDrive℠ Program.
- That analysis illustrates that DSRC is the only available technology in the near-term that offers the latency, accuracy, and reliability needed for active safety (for further discussion, see: http://www.intellidriveusa.org/about/dsrc-faqs.php.

With the commitment to an open environment, the ITS Program partners have developed a taxonomy of levels for describing IntelliDrive℠ connectivity and applications. The levels can be found at: http://www.intellidriveusa.org/about/overview.php and will be monitored and updated as IntelliDrive℠ evolves.

The IntelliDrive℠ Applications

IntelliDrive℠ applications are being developed to address real-world problems. The table on this and the following page depicts significant transportation challenges and identifies how the IntelliDrive℠ vision and applications are intended to address them.



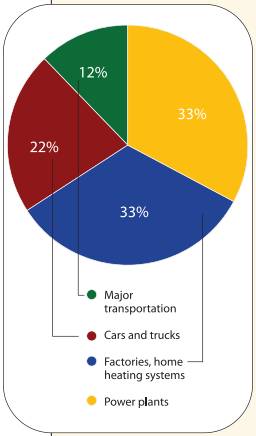
Problem	Vision
Safety Problem • ***37,261 deaths/year (US)*** • ***5.8 million crashes/year (US)*** • ***Direct economic cost of $230.6 billion*** • ***Leading cause of death for ages 4 to 34***	**Imagine:** • ***Your vehicle can "see" vehicles you can't see*** • ***Your vehicle informs you of roadway conditions and hazards that you can't see*** • ***Your vehicle knows the speed and location of approaching vehicles***

IntelliDrive℠ safety applications are designed to increase situational awareness and reduce or eliminate crashes through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) data transmission that supports: driver advisories; driver warnings; and vehicle and/or infrastructure controls. With these applications, IntelliDrive℠ may potentially address up to 82% of crash scenarios[8] with unimpaired drivers, preventing tens of thousands of automobile crashes every year (further research will incorporate heavy vehicle crashes including buses, motor carriers, and rail).

Mobility Problem	Imagine:

• ***Traffic congestion $87.2 billion annual drain on the U.S. economy…***
  • ***4.2 billion lost hours***
  • ***2.8 billion gallons of wasted fuel.***
	• ***Managing the transportation system as if you knew where every vehicle (automobiles, trucks, motor coaches, and transit vehicles) was in real time***
	• ***Planning for growth patterns as if you could see complete traffic patterns around development***
	• ***Planning travel as if you knew real-time options on all roads, transit, and parking along your route***

IntelliDrive℠ mobility applications provide a connected, data-rich travel environment. The network captures **real-time data** from equipment located on-board vehicles (automobiles, trucks, and buses) and within the infrastructure. The data are transmitted wirelessly, and are used by transportation managers in a wide range of ***dynamic, multi-modal applications*** to manage the transportation system for optimum performance.



Problem	Vision
Environment Problem	**Imagine:**
• ***2.8 billion gallons of fuel wasted each year***	• ***Managing your system for environmental and weather events as if you knew specific information about the road and vehicle***
• ***22% CO_2 emissions from vehicles***	

IntelliDrive℠ environmental applications both generate and capture environmentally-relevant real-time transportation data, and use this data to create actionable information to support and facilitate "green" transportation choices. They also assist system users and operators with "green" transportation alternatives or options, thus **reducing the environmental impacts of each trip**. For instance, informed travelers may decide to avoid congested routes, take alternate routes, public transit, or reschedule their trip — all of which can make their trip more **fuel-efficient and eco-friendly**. Data generated from IntelliDrive℠ systems can also provide operators with detailed, real-time information on vehicle location, speed, and other operating conditions. This information can be used to **improve system operation**. On-board equipment may also advise vehicle owners on how to **optimize the vehicle's operation and maintenance** for maximum fuel efficiency.

As described on pages 18–25, IntelliDrive℠ technology and policy underpin the successful development and deployment of these applications by:

- Providing a platform for interoperability, security, and access that is based on a logical, systems approach.
- Distinguishing the appropriate boundaries that effectively leverage public-sector funding versus private sector financing and market opportunities.
- Defining minimum governance requirements that use regulatory actions only when fact-based evidence (based on field testing and evaluation) points to its effectiveness.
- Identifying options for resolving institutional issues that enable successful deployment and sustainable market development and growth.
- Providing a platform for effective technology and knowledge transfer.

The following pages describe the specific IntelliDrive℠ applications research areas:

- **Safety:** **Vehicle to Vehicle Communications for Safety**
  Vehicle to Infrastructure Communications for Safety
- **Mobility:** **Real-Time Data Capture and Management**
  Dynamic Mobility Applications
- **Environment:** **Applications for the Environment: Real-Time Information Synthesis (AERIS)**

Vehicle to Vehicle (V2V) Communications for Safety….

…is the dynamic wireless exchange of data between nearby vehicles that offers the opportunity for significant safety improvements.

The vision for V2V research is that each vehicle on the roadway (inclusive of automobiles, trucks, transit vehicles, and motorcycles) will be able to communicate with other vehicles, and that this rich set of data and communications will support a new generation of active safety applications and systems.

Research Plan

The objective of the V2V safety research program is four-fold:

(1) Develop *V2V active safety applications* that address the most critical crash scenarios (listed below in Track 4)

(2) Develop a *rigorous estimation of safety benefits* and an *assessment of potential regulatory action by NHTSA* by 2013.

(3) Work with industry and enable market factors that will *accelerate V2V benefits through in-vehicle V2V technologies and through the use of aftermarket and/or retrofit options* to ensure that the first V2V-equipped vehicle owners find value in their investment.

(4) Building from the results of the VII program's proof-of-concept tests, *complete the development and testing of the V2V communications technologies and standards.*

Success will be measured by progress on:

- Development of practical, DSRC-based, V2V *active safety applications and supporting equipment* and demonstration of their effectiveness.
- Completion of the *DSRC standards and other standards* that are needed for deployment of V2V, and development of solutions to *security, scalability, positioning, and other technical issues* (refer to the Technology section on page 18).
- Research on *human factors* for the driver-vehicle interface to find effective approaches that can *minimize distraction and driver workload* (refer to Human Factors research program description on page 20).
- *Acceleration of V2V technology implementation into vehicles* through aftermarket or retrofit approaches for basic V2V technologies that generate *"Here I Am"* messages.
- *Definition of infrastructure requirements* for V2V and its supporting systems (such as certification, security, or access procedures).

The ITS Program has defined a collaborative research process that will engage the appropriate parties in a multi-track program to address the breadth of technical and non-technical V2V research needs:

- **Track 1 – Identify critical crash scenarios for V2V.** By connecting pre-crash scenarios to crash avoidance safety applications, initial benchmarks for safety application function, performance, and effectiveness will be developed.
- **Track 2 – Ensure interoperability and determine supporting infrastructure needs** for V2V deployment. Safety applications must work across equipped vehicles and adhere to a level of communication standards to ensure security and message integrity.

Research Goals:

- To employ advanced V2V wireless technologies to reduce, mitigate, or prevent 82 percent of crashes by unimpaired drivers.
- To establish robust DSRC standards for safety-critical applications.
- To accelerate in-vehicle technology to ensure value to the first V2V vehicles.

Research Questions:

- *Are applications effective and are benefits validated?*
- *What infrastructure is needed? How much, where, when, and what type?*
- *What is the degree of market penetration needed and what is the required timing for effectiveness?*
- *What existing technologies can be leveraged to accelerate in-vehicle equipment?*
- *What are the special needs and applications for trucks, motor coaches, and transit vehicles?*

Research Outcomes:

The outcome of this research is to validate sufficiently the potential benefits of V2V technologies and to develop the factual evidence needed to support a decision for potential NHTSA rulemaking.

- **Track 3 – Develop rigorous estimates of safety benefits.** The development of performance measures, objective test procedures, and an adaptation of Advanced Crash Avoidance Technologies (ACAT) will assist in validating safety benefits.
- **Track 4 – Develop prototype active safety applications and evaluate through objective tests and field trials.** Currently under development are applications for: *Emergency Brake Light Warning, Forward Collision Warning, Intersection Movement Assist, Blind Spot and Lane Change Warning, Do Not Pass Warning, and Control Loss Warning*. The development of these applications is dependent upon and assists in the analysis of the functional and performance requirements for the underlying technologies such as positioning and communications. However, additional work needs to be done to address more complex crash scenarios for *head-on collision avoidance, intersection collision avoidance, pedestrian crash warning* and extending the capabilities to prevent *motorcycle crashes*. An additional effort under this track will be the cooperative research and development of one safety appliation with partners in the European Union (see page 19 for additional details on a Cooperative Agreement with the European Union).
- **Track 5 – Develop effective driver vehicle interfaces.** Collision warning system effectiveness relies on the quality of its interface, which can affect the driver's performance.
- **Track 6 – Investigate policy issues and formulate regulatory decisions** within the context of the broader IntelliDrive[SM] program (refer to policy research program description on page 26).
- **Track 7 – Develop Commercial Vehicle Safety Applications.** Develop and evaluate V2V safety applications that incorporate the unique needs and vehicle dynamics of large trucks and motor coaches, since a collision with a vehicle in transport was the first harmful event in 75% of all fatal crashes involving large trucks. Other applications for commercial vehicle operators will also be evaluated.[9]
- **Track 8 – Develop Transit Safety Applications.** The ability to transition automobile safety applications to transit vehicles have the potential to provide positive impacts to the transit industry.

The results achieved through the V2V safety research program will be indicators of an environment in which V2V can flourish. The Department and its modal partners will engage the automotive, truck, and bus manufacturers and suppliers, along with other partner groups, through IntelliDrive[SM] working group participation. In addition, the Department will work with stakeholder groups to define effective technology transfer opportunities. Ultimately, this research will support a decision with NHTSA in 2013 on whether a regulatory decision for deployment is warranted.

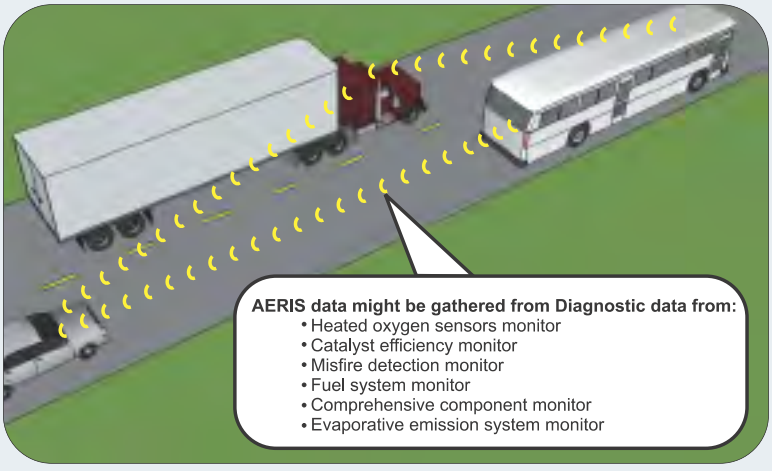


Figure 4: V2V connectivity.

Figure 5: *Here I AM* broadcast data message.

Vehicle to Infrastructure (V2I) Communications for Safety….

…. is the wireless exchange of critical safety and operational data between vehicles and highway infrastructure, intended primarily to avoid motor vehicle crashes and enable a wide range of other safety, mobility, and environmental benefits.

The vision for the V2I research is to enable safety applications that are designed to avoid or mitigate vehicle crashes (inclusive of automobiles, trucks, motor coaches, and transit vehicles), particularly for those crash scenarios not addressed by V2V. It is also focused on creating national interoperability to support infrastructure and vehicle deployments.

Research Goals:

- To employ advanced V2I wireless technologies to reduce, mitigate, or prevent an additional 12 percent of crashes.
- To develop signal warnings that support active safety.

Research Questions:

- *Are applications effective and are benefits validated?*
- *What is the minimum infrastructure needed for maximum benefit at the point of initial deployment?*
- *What is the degree of market penetration required for effectiveness?*
- *Are there unique applications for specialty vehicles (transit bus, light rail, trams, trucks, etc)?*

Research Outcomes:

- Understand and plan for the minimum level of infrastructure needed to support V2V and V2I safety and operational efficiency applications.
- Based on test results and stakeholder inputs, research the needs and impacts associated with developing policy guidance or a possible regulatory decision in support of deployment.
- Enable additional safety and mobility applications through the use of SPaT data exchange.
- Enable and facilitate interoperable, cost-effective infrastructure deployment.

Research Plan

The objective of the technical V2I safety research program is three-fold:

(1) Develop *V2I active safety applications* that address some of the most critical crash scenarios, particularly using the signal phase and timing (SPaT) capability.

(2) Develop a *rigorous estimation of safety benefits* that will contribute to the assessment of possible safety regulations and/or guidelines.

(3) Provide *objective data and information that will support decision making* regarding nationwide infrastructure deployment.

The program research will involve multiple transportation agencies and modes. It will concentrate on key FHWA, FTA, and FMCSA application areas of interest including intersection safety, run-off-road prevention, speed management, transit communications and operations, and commercial vehicle enforcement and operations. In addition, exploratory research on V2I safety for commuter, freight, and heavy rail will investigate data interoperability and communication to support a variety of applications, including grade crossing operations, track surveillance, and Right-of-Way detection.

Due to the great variety of vehicle and infrastructure safety systems currently installed and forthcoming, the program will also emphasize the need for consistent, widely applicable standards and protocols.

The key to success in this research area is the definition of minimum infrastructure needed to ensure maximum benefit from the applications. Success will be further measured by progress on:

- Development of practical, *high-value V2I applications and supporting tools and guidance* (including applications for specialty vehicles such as transit bus, rail, trams, and trucks)
- Development and assessment of a *traffic signal system application* to communicate SPaT information to the vehicle in support of delivering active safety advisories and warnings.
- Testing and demonstrations of *application effectiveness*:
  - Identification of all *critical interfaces* and analysis of where *standards* are needed.
  - Research on the *driver-vehicle interface* to ensure effective approaches that enhance overall safety while minimizing

distraction and driver workload (refer to Human Factors research on page 20.)

Through collaborative research, the ITS Program will engage the appropriate parties in a multi-track approach that addresses the breadth of technical and non-technical V2I research needs:

- **Track 1 – Identify and analyze critical crash scenarios for V2I applications.** Preliminary studies show that 12 percent of crash scenarios could be addressed by V2I safety applications. The focus on these scenarios is in addition to the crash scenarios addressed by V2V safety applications.
- **Track 2 – Develop prototype applications**, which include the identification and refinement of requirements and countermeasures. An additional effort under this track will be the cooperative research and development of one safety appliation with partners in the European Union (see page 19 for additional details on a Cooperative Agreement with the European Union).
- **Track 3 – Address interoperability** that enables multiple systems or components to exchange (across jurisdictional boundaries) useful information including mapping, positioning, standards, security, and wireless communication, among other areas.
- **Track 4 –** Through controlled demonstrations and field operational testing, **conduct benefits assessments** by collecting and analyzing real world data, while assessing engineering architecture and design. This supports analysis resulting in more detailed understandings of the market potential, infrastructure requirements, and level of market penetration needed to enable future systems.
- **Track 5—Conduct deployment planning** by developing tools and guidelines that give practitioners the information required to make sound decisions on how eventually to deploy and maintain V2I systems.

Ultimately, the results of the V2I safety research program will develop a foundation for developing safety applications supporting infrastructure and vehicle communication.

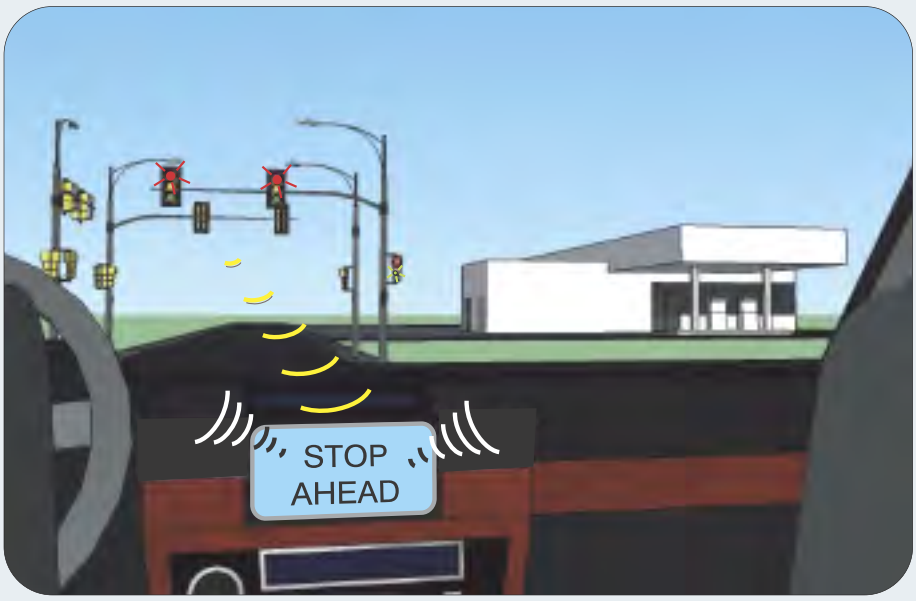


Figure 6: Signal Phase and Timing (SPaT) broadcast message.

Real-Time Data Capture and Management….

… is the creation and expansion of access to high-quality, real-time, multi-modal transportation data that is captured from connected vehicles (automobiles, transit vehicles, trucks, rail, and other fleets), mobile devices, and infrastructure.

The vision for the Real-Time Data Capture and Management research is the active acquisition and systematic provision of integrated, multi-source data to enhance current operational practices and transform future surface transportation systems management.

Research Goals:

- To systematically capture real-time, multi-modal data from connected vehicles, devices, and infrastructure.
- To develop data environments that enable integration of high-quality data from multiple sources for transportation management and performance measurement.

Research Questions:

- What data is available today from both traditional and non-traditional sources? What is the quality?
- How can probe data be integrated with traditional data sources to support traffic/transit/freight applications?

Research Outcomes:

The outcomes of this research are to develop data environments and demonstrations that show the value of ubiquitous real-time multi-modal information.

Research Plan

The objective of the Real-Time Data Capture and Management research program is to *enable the development of environments that support the collection, management, integration, and application of real-time transportation data*.

Real-time data applications offer an ability to increase highway safety and operational efficiency nationwide. Not only will this data allow travelers to make better-informed travel decisions, but public and private sector data on all modes and roads can be used to transform transportation management. Real-time data sets also have the potential to support a range of multi-modal mobility applications. Real-time information on parking availability and transit schedules can enable smarter mode choice decisions and efficiencies for travelers. Updated freight movement data assists commercial freight operators with optimizing operations. Overall, the information developed from the Real-Time Data Capture and Management research program will reveal opportunities for achieving greater efficiencies within our transportation systems.

Some types of data that can be captured and managed include: situational safety, environmental conditions, congestion data, and cost information derived from both traditional (traffic management centers, Automated Vehicle Location systems) and non-traditional (mobile devices, IntelliDrive℠ equipment) sources. Data can also be collected from sources that are generating data on elements of the transportation system such as toll facilities, parking facilities, and transit stations.

Results that are key to success in this research area include:

- *Establishment of one or more multi-source data environments* for the development and testing of safety, mobility, and environment applications.
- Engagement of stakeholders to assist in *defining the requirements for test data environments and to encourage active use of prototypes and test beds*.
- Identification of *data management processes, operational practices, standards, integration, and rules for data exchange and sharing*, particularly across jurisdictions.
- Successful testing that *validates assumptions* about:
  - The data (availability and accessibility of sources, quality, reliability, consistency, timing, etc.)
  - The management and operational practices (how real-time data capture and use is managed)
  - The benefits, as they are demonstrated through testing of the applications.

Success will be further measured by progress on:

- Synthesis of foundational research to assess the state of the industry.
- Development of a variety of large-scale data sets (utilizing connected vehicles, mobile devices, and infrastructure) for testing transportation management and performance measurement applications.
- Demonstrations of multi-modal and multi-state, real-time data capture and management to show the value of ubiquitous transportation information. Some smaller-scale, real-time data sets may be available for research purposes before 2011.

The ITS Program will use a collaborative, multi-track approach to comprehensively address the Real-Time Data research needs:

- **Track 1: Engage stakeholders** for input across all phases from foundational analysis to pilot deployment.
- **Track 2: Develop data environments and address technical, institutional, and standards issues** surrounding the collection and dissemination of data.
- **Track 3: Conduct proof-of-concept tests and test standards, procedures, tools, and protocols** to produce implementation guidance for a real-world environment.
- **Track 4: Conduct pilot deployments and demonstrate the data capture and data management techniques in an operational setting**, while giving stakeholders the opportunities to develop systems beyond the life of the program.
- **Track 5: Develop evaluation and performance measures**.
- **Track 6: Coordinate outreach and technology transfer.** Test data sets, data collection, and analysis methodologies will be shared with stakeholders, with information available to the broader transportation community.

This research program will build on the existing Real-Time Information Market Assessment and the recent Real-Time System Management Information Program. Collaboration is expected from a wide range of stakeholders to help guide the research program. Related U.S. DOT research programs, such as Dynamic Mobility Applications and the AERIS Program (see descriptions on the following pages), are anticipated to both define data requirements (and identify information gaps) as well as use real-time data sets that are developed under this program.

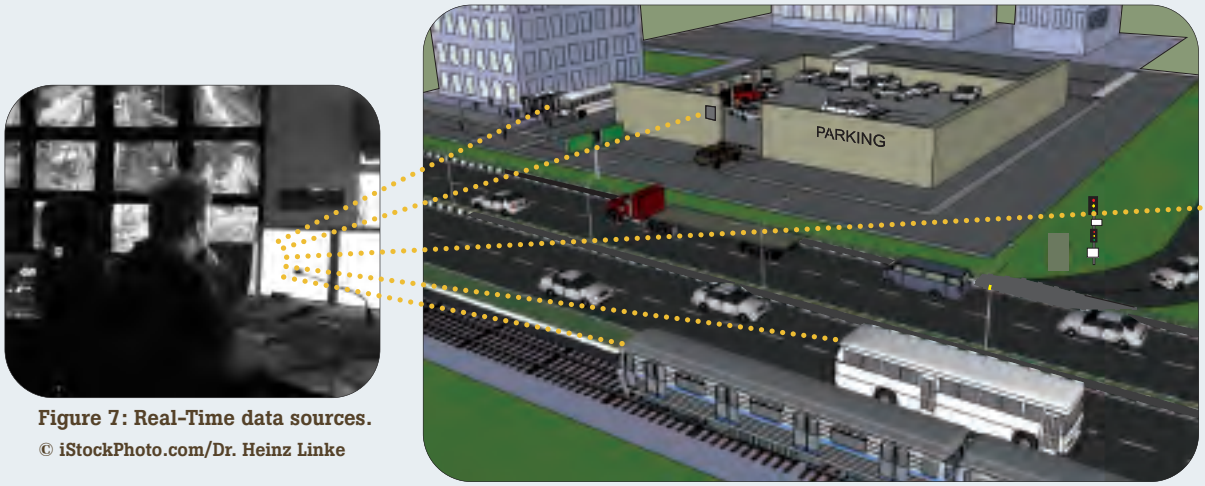


Figure 7: Real-Time data sources.
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Dynamic Mobility Applications….

…are the next generation of applications that transform mobility by providing transportation managers and systems operators with real-time monitoring and management tools to manage mobility between and across modes more effectively, and travelers the ability for dynamic decision making. These applications capitalize on vehicle-infrastructure connectivity, e.g., data from vehicle probes and other real-time DSRC and non-DSRC data sources.

The vision for dynamic mobility applications research is to provide significant improvements to mobility by: (1) introducing innovative methods for operating existing transportation systems based on the availability of new data sources and communications methods and (2) creating opportunities for greater multi-modal integration.

Research Plan

The objective of the Dynamic Mobility Applications Research Program is to *identify high-value applications for research and develop the tools, metrics, and concepts that form the foundation for applications development*. The applications that will be evaluated are those that enable public sector, multi-modal system management and:

- Use available vehicle and infrastructure connectivity and data to enable dynamic decision making.
- Allow managers to anticipate problems, be proactive in addressing issues, and rapidly monitor impacts on and across the transportation networks.
- Support emerging work in decision support systems—systems that can assimilate and analyze large volumes of detailed real-time and historic data to provide recommendations in a manner that is most valuable to the user.

Examples of multi-modal dynamic applications may include: measurement and prediction of system performance using probe data generated through DSRC and non-DSRC technologies; increasing intersection safety and efficiency through SPaT and geospatial information map (GID) technology; road weather management; transit management; freight operations; dynamic, real-time route planning and adjustment to emerging incidents; advanced parking management systems; or Integrated Corridor Management.

The first steps in this reseach program are to:

- *Define multi-modal performance metrics* that form the basis for decision support systems, tools, and models.
- *Collect real-time data for assessment* (to include collaboration with the Real-Time Data Capture and Management program).
- Assess data from historical and real-time traffic and travel behavior perspectives to *understand what data enables dynamic, proactive decision-making*.
- Identify which public-sector, multi-modal dynamic applications might be of *highest value and use demonstrations to test the validity of those assumptions with stakeholders*.

Success will be measured by progress on the development of a foundational platform (concept of operations, performance specifications, test results, etc.) that could encourage other entities (e.g., private sector entrepreneurs) to develop viable mobility applications. This program will coordinate with a range of stakeholder groups to foster software and application development.

Research Goals:

- To identify transformative applications and innovative methods to manage and operate transportation systems based on the availability of new data sources and communications methods.
- To build the foundation for development of applications that can provide travelers and system operators greater access to real-time information about the transportation system to enable better decision making.

Research Questions:

- *What are the data needs for dynamic mobility monitoring and management?*
- *What public-sector dynamic mobility applications are enabled by the availability of real-time data? Are they effective?*
- *What technical guidance and support is needed for deployment?*
- *What minimum infrastructure is needed for maximum benefit?*

Research Outcomes:

The outcome of this research is the development of the foundation (the concepts, requirements, specifications, analyses, tests, and metrics) needed for development of dynamic mobility applications.

The ITS Program will use a multi-track approach that addresses the breadth of research needs and include:

- **Track 1: Engage stakeholders** for input across all phases from foundational analysis to focused demonstrations.
- **Track 2: Develop tools** that will ultimately enable public and private sector applications development and support application impact assessment while utilizing communications across interoperable platforms.
- **Track 3: Conduct proof-of-concept tests** for the standards, algorithms, tools, and protocols that will be needed for implementation of the applications.
- **Track 4: Conduct focused demonstration and analysis** based on a partnership with the Real-Time Data Capture and Management initiative and the AERIS program to demonstrate applications in a market-based environment and assess quantifiable benefits. This track includes conducting a near-term demonstration of market-ready technologies and applications.
- **Track 5: Develop evaluation and performance measures.**
- **Track 6: Coordinate outreach and technology transfer.** Well-documented applications, demonstration and proof-of-concept test findings will be shared with stakeholders, with information available to the broader transportation community.

Applications for the Environment: Real-Time Information Synthesis (AERIS)….

…are the capture, synthesis, and delivery of real-time, vehicle- and infrastructure-based, environmentally relevant information to support system management that advances environmental improvements within the transportation system.

The vision for AERIS research is to generate, capture, and analyze data to create actionable information that allows systems users and operators to make "green" transportation choices.

Research Goals:

- To capture real-time environmental data from vehicles and integrate it with other sources for use in transportation management and performance improvement.
- Create applications that use real-time data on environmental impact for use by transportation managers and travelers.

Research Questions:

- *What vehicle-based data is available? How can we collect environmentally-relevant data from the transportation system? Is it valid? Of good quality? Reliable? Is it the right data?*
- *How will access to information impact transportation system user choices, system management choices, and overall transportation system performance with respect to the environment?*
- *How can this program leverage the IntelliDrive℠ data sets and test beds? With probe vehicle data or weather data?*
- *What applications would make the most positive overall impact on the environment?*

Research Outcomes:

Real-time, environmental data from all sources will be integrated and available for use in multi-modal transportation management and performance improvement and will contribute to better environmental practices.

Research Plan

The objective of the AERIS research program is four-fold:

(1) To enable the public sector to *manage transportation for environmental purposes*.

(2) To establish *definitive results on the potential of ITS data* to positively affect the environment.

(3) To *identify potential future regulatory needs* for applying information technologies to environmental sustainability.

(4) To *research the feasibility of integrating numerous, existing environmental data sources* with IntelliDrive℠ technologies and leverage the capability of ubiquitous connectivity to provide real-time, environmentally-relevant actionable information.

At the core of this program is the idea of "facilitating green transportation choices." It is the intent of the program to:

- Support research into the generation, capture, standardization, and use of real-time data present in the transportation system (i.e., connected travelers and infrastructure) to enable environmentally-beneficial choices by system users and system operators.
- Leverage existing research and stakeholder activities to create a unique body of knowledge and experience that demonstrates the most effective uses of ITS to reduce the negative impacts of transportation on the environment.
- Form the foundation for addressing future, long-range efforts to conserve energy, address air and water quality issues, address weather issues, mitigate other environmental impacts of the transportation system, and support likely environmental goals in the new transportation authorization.

Success will be measured by progress on:

- Development of an extensive foundational research program that will inform application and strategy development by both the public and private sectors.
- Identification of the most effective technological solutions.

The ITS Program will use a multi-track, collaborative approach that supports a rigorous research program. The AERIS program will leverage data from vehicles via IntelliDrive℠ research and data sets to:

- Assess what environmentally-relevant data can currently be acquired.
- Assess if this is the "right" data and if there are data gaps.
- Undertake research that will create the most useful data sets and information to support "green choices."

This foundational research will identify opportunities for further research to develop specific strategies for improving environmental decisions and outcomes by public agencies and consumers through ITS.

The research will be comprised of five major tracks:

- **Track 1: Survey and build knowledge** by comprehensively reviewing the state-of-the-practice to:
  - Determine the limits of current technology and available data sets.
  - Identify the limits and challenges of monitoring and analysis, including a review of existing models and algorithms.
  - Examine and evaluate where ITS technologies and data can be more effective and contribute maximum value to addressing environmental impacts.
  - Use existing travel models to explore traveler behavior and existing traffic simulation models to explore the effectiveness of improvement strategies.
- **Track 2: Identify candidate strategies and applications** that appear to improve environmental decisions by public agencies and travelers (including an assessment of the technology and data needs and cost-benefit analysis).
- **Track 3: Analyze and evaluate candidate strategies and applications** that make sense for further development and evaluation based on the expectations of their potential contributions.
- **Track 4: Demonstrate and test strategies and applications** within an IntelliDrive℠ test bed.
- **Track 5: Develop the facts and evidence needed to inform any future policy and regulatory decisions**. This analysis will include an exploration of the relationships between traveler behavior and incentives; progress in private sector application development, commercialization, and development of sustainable markets; the evolution of alternative energy vehicles and their role in mitigating environmental impact; and the ongoing analysis of carbon cap policies, trade policies, and worldwide environmental agreements.

The AERIS program will closely coordinate research with other ITS research programs such as: U.S. DOT's Road-Weather Research Program, the Dynamic Mobility Applications research program, and Real Time Data Management and Capture research program.

The IntelliDrive℠ Technology

The development and deployment of a fully connected transportation system that makes the most of multi-modal, transformational applications requires a robust, underlying technological platform. The platform is a combination of well-defined technologies, interfaces, and processes that, combined, ensure safe, stable, interoperable, reliable system operations that minimize risk and maximize opportunities.

A successful platform will be developed through a process of thorough and considered research while meeting a set of rigorous criteria:

- The platform will allow for growth, expandability, and incorporation of newly evolving technologies.
- In knowing the architectural configuration and definition of interfaces, creative private sector firms will be able to develop new applications that are not yet envisioned but remain for future imagination.
- And finally, the platform will be developed based on the complexity and range of human behaviors that will interact with and impact upon the system.

For the ITS Program and its partners to deliver such a platform, further research is needed in the creation of standards for interoperability; security of the system; strategies that address the complexity of human behavior and risks associated with the driver's workload; and processes that define how travelers and equipment become a certified part of the system. Other technical research will also be pursued to identify and resolve technological limitations with positioning, scalability, and other technical issues.

The following represent some, but not all, of the critical research efforts over the next five years that will address the underlying technological platform and are described on the following pages:

- Harmonization of International Standards around the Vehicle Platform
- IntelliDrive℠ Human Factors Research
- IntelliDrive℠ Systems Engineering
- IntelliDrive℠ Certification
- IntelliDrive℠ Test Environment(s)

Harmonization of International Standards and Architecture around the Vehicle Platform….

….is a process through which various stakeholders, vehicle and equipment manufacturers, standards organizations, and governments work together to agree on common standards.

The vision is for the Intelligent Transportation Systems (ITS) Joint Program Office (JPO), in partnership with NHTSA, to participate in international standards harmonization activities focusing on standards "around the vehicle platform," that is, any standards needed to provide connectivity between vehicles and between vehicles and infrastructure.

Research Goal:

- To globally harmonize IntelliDrive℠ technologies by taking an active role in developing and harmonizing standards and architecture around the vehicle platform.
- To provide the standardization necessary for vehicles and infrastructure to communicate using widely available, affordable, and interoperable technologies that maximize safety and efficiency.

Research Outcomes:

Vehicle connectivity through harmonization of standards and architecture will reduce costs to industry and consumers in that hardware and/or software development costs will be spread over a larger user base, resulting in reduced unit costs. Differences between vehicles manufactured for different markets will also be minimized, allowing private sector markets to have a greater set of global opportunities.

Research Plan

The objective of the Standards Harmonization research program is to *work with the international standards community to harmonize standards and architecture* in order to increase vehicle connectivity. Harmonization facilitates interoperability between products and systems, which can benefit transportation management agencies, vehicle manufacturers, equipment vendors, and others. By overcoming institutional and financial barriers to technology harmonization, stakeholders could realize lower life-cycle costs for the acquisition and maintenance of systems.

Efforts under this research program include collaboration with standards development organizations (SDOs), original equipment manufacturers (OEMs) and other stakeholders to seek agreement and provide appropriate incentives.

The program uses a multi-track approach to address the range of activities required for research:

- **Track 1: Establish a U.S. DOT working group**, including NHTSA, ITS-JPO, and other appropriate representatives.
- **Track 2: Develop a program of work identifying specific harmonization efforts** that require negotiation with relevant global authorities.
- **Track 3: Engage global authorities** to seek agreement on the selection of standards requiring harmonization and provide appropriate Federal government support (possibly funding) for these efforts.
- **Track 4: Provide appropriate Federal government support** to ensure maintenance of standards.
- **Track 5: Monitor ongoing and future global activities** to identify harmonization/standardization opportunities.

As a global industry, it is critical to reduce barriers to standardization and achieve a broad agreement on harmonization that can benefit both the public and the motor vehicle industries. To that end, the Department has established a *Joint Declaration of Intent on Research Cooperation in Cooperative Systems* with the European Union (EU). The purpose of the agreement is to advance cooperation on research for information and communication technologies, as applied to transportaion. The U.S. DOT/RITA and the European Commission Information Society and Media Directorate intend to identify the research areas which would benefit from a harmonized approach and which should be addressed by coordinated or joint research. In particular, the parties intend to make efforts to preclude the development and adoption of redundant standards and to support and accelerate the deployment and adoption of Cooperative Systems.

IntelliDrive℠ Human Factors Research….

…is research that is focused on understanding, assessing, planning for, and counteracting the effects of signals or system-generated messages that take the driver's eyes off the road (visual distraction), the driver's mind off the driving task (cognitive distraction), and the driver's hands off the steering wheel (manual distraction).

The vision for the Human Factors research is to address the number of new, competing visual and audible stimuli that create increasing demands for the driver's attention and comparatively greater driver workload in order to ensure that IntelliDrive℠ applications and technologies are not distracting.

Research Plan

Operating the radio, eating, passenger noise, and fatigue are among a variety of distractions that drivers have always encountered. With the recent growth in technologies and portable devices used in vehicles, drivers now face an increasing number of distractions, further highlighting the need for human factors research.

The objective of the research program in Human Factors for IntelliDrive℠ is to *assess, counteract, and ultimately eliminate possible driver distraction from IntelliDrive℠ technologies*. The program aims to research and implement technology-based solutions that could deter drivers from multi-tasking and reduce vehicular sources of distraction.

Using a cooperative and cost-sharing approach, the program will work with NHTSA and other DOT agencies and vehicle manufacturers, operators, and equipment suppliers. This collaborative effort will raise public awareness about the distracted driving problem and encourage vehicle and equipment manufacturers to design interfaces with minimal demands on driver workload. The program goals outlined below will guide the overall research. Success factors include the ability to:

- Lower the frequency with which drivers multitask, to reduce their exposure to risk.
- Reduce the complexity of distracting tasks and reduce demands on driver attention.
- Manage the multitasking options that drivers can make, to avoid overloading them.
- Assist distracted drivers through in-vehicle technologies that monitor their attention status and provide feedback on unsafe behaviors and potential crashes.

Similar to the other research programs, Human Factors Research program will use a multi-track approach for this research:

- **Track 1: Define the problem by identifying the types of distractions that contribute to crashes**. Distraction is anything that diverts the driver's attention from navigating the vehicle and it often fits into more than one category. For example, eating is visual and manual, while using a navigation system is visual, manual, and cognitive.
- **Track 2: Develop and evaluate performance metrics for distraction mitigation.** By monitoring new technology interfaces and developing best practices, objective test procedures can be developed to assess distraction and usability of production vehicles and nomadic technologies.

Research Goals:

- To provide drivers with safe advisories, alerts, and warnings through advanced vehicle technologies – both built into the original equipment and brought into the vehicle (portable or nomadic technologies) – that increase highway safety and offer drivers and passengers the promise of enhanced safety, comfort, security, and convenience.
- To control and mitigate the ever-present and growing threat to safety represented by driver distraction, which is a factor in many crashes.
- To evaluate driver distractions and other human factors related to ITS, leveraging the convergent findings of epidemiological and experimental studies, as well as analyses of crash data.

Research Outcomes:

The outcomes are intended to eliminate distractions related to IntelliDrive℠ devices as a contributing factor to crashes.

- **Track 3: Produce an integration strategy** that allows nomadic systems to be functionally integrated with vehicle-based systems to optimize the driver-vehicle interface. Integration reduces interface complexity and multitasking. In addition, real-time distraction monitoring systems that provide distraction alerts or messages are potential areas of integration research.
- **Track 4: Develop longer-term exposure testing** through field operational experiments to determine safety impacts of crash warning technologies and their effects on long-term driver behavior that could affect the safety of distracted drivers.
- **Track 5: Perform strategic outreach with stakeholders** to identify requirements, information needs, and usability issues, so that the program and its results are publicly acceptable.

The Human Factors Research program is a highly collaborative effort that addresses the effectiveness of safety applications by evaluating potential issues around driver distraction. The program will develop technology-based solutions and will work toward eliminating distraction from IntelliDrive℠ technologies.

Figure 8: Driving simulator. © Texas Transportation Institute, 2004

IntelliDrive℠ Systems Engineering….

…is a structured process by which a system is logically, physically, and functionally defined. The outcome of implementing a systems engineering process is a set of documents that describe a system's architecture, interfaces, and requirements.

The vision for the systems engineering research is to update the IntelliDrive℠ Concept of Operations to include the broadening of the scope of the concept, update the System Architecture to accommodate the new definition of the system, and provide recommendations for updates to standards that define system elements. A contractor will execute the process that will convert stakeholder requirements into the new system definition. From this process will emerge the first set of security requirements for IntelliDrive℠.

Research Plan

The existing documents that describe the technology platform for IntelliDrive℠—the concept of operations, the architecture, the standards interfaces, and the system requirements—are based on the work done to establish the VII system and the requirements of the DSRC technologies. In 2008, the VII architecture was opened up to include both DSRC and non-DSRC based technologies, and the program became the IntelliDrive℠ Program.

To complete the research needed for the IntelliDrive℠ technology, *a systems engineering process will be used to update the critical foundational documents*. In using the systems engineering approach, the ITS Program looks to ensure that the final products are comprehensive and thorough.

A critical first task will be the solicitation of requirements from IntelliDrive℠ stakeholders. Representatives from the following ITS industries will be invited to participate in requirements gathering workshops: the automotive industry, the transportation management industry, the traffic signal controller industry, the telecommunications industry, the commercial vehicle operators (CVO), the vehicle aftermarket and retrofit providers, transit operators, and rail operators. These workshops will occur in 2010 and form the basis for the iterative development of updated and new documents that will include:

- **A revised Concept of Operations (ConOps)** that is based on a set of User Needs workshops that include public sector transportation managers, the automobile industry, traffic signal controller industry, telecommunications industry, commercial vehicle operators, transit operators, rail operators, and vehicle and aftermarket providers. The ConOps will be prepared in accordance with standard systems engineering practices. Additionally, the ConOps will consider ongoing efforts in Europe and Asia.
- Analysis and development of **a set of revised, refined requirements for the core system** of IntelliDrive℠. These requirements are not for the IntelliDrive℠ applications, but instead define the key interface requirements that govern how applications will gain access to IntelliDrive℠ capabilities and services.
- A set of alternative **system architectures for IntelliDrive℠** that will allow for further analysis and stakeholder review. The architecture documents will describe:
  - The physical architecture that identifies all system components.
  - The security architecture that describes how security and privacy will be handled, as well as the consideration of alternative implementations of the *anonymity by design* approach.

Research Goal:

- To describe and define the elements of IntelliDrive℠ system.
- To update the existing documentation such that it reflects changes that occurred in the transition from the VII concept to IntelliDrive℠ and reflects input from key stakeholder groups.

Research Outcomes:

This research will result in a set of critical products that define IntelliDrive℠ as a comprehensive and interoperable system:

- A revised ConOps for IntelliDrive℠.
- An updated IntelliDrive℠ System Architecture showing all components and interfaces, and identifying how security processes will ensure the integrity of the system and protect the privacy of its users.
- A refined System Requirements Specification (SRS) that will result in inputs to standards updates.
- Analysis, Modeling, and Simulation (AMS) tools for use in evaluation.

- A functional architecture that identifies all major functions performed within IntelliDrive[SM] and allocates those functions to system components.

- **Development of Analysis, Modeling, and Simulation (AMS) tools** to assess the feasibility and trade-offs of the system architectures proposed for IntelliDrive[SM] and examine performance issues related to the different technical solutions.

The workshops will be the first attempt at defining security requirements for IntelliDrive[SM]. Security requirements occur at a number of levels:

- **Physical security** associated with the IntelliDrive[SM] infrastructure, hardware, facilities, and staff. This type of security is typically governed by laws and procedures in place with public and private sector organizations responsible for existing infrastructure. Under the policy research plan, these laws and procedures will be reviewed to understand their relevance to IntelliDrive[SM].

- **Data, software, and communications** security that focuses on the credentials that determine who can communicate with and in the IntelliDrive[SM] environment. From a technical perspective, the ITS Program will develop processes that establish the trust relationship between communicating partners. For instance, this may be accomplished by adding a signature to each transmitted message or by establishing a certification process that determines what equipment is allowed to interact with the IntelliDrive[SM] system. From a policy perspective, this security is based on certifying who (travelers, drivers, system operators) can interact with the IntelliDrive[SM] and how credentials are managed; options for certification will be a part of the policy research (see section on Certification on page 24 and Policy on page 26).

IntelliDrive℠ Certification….

…is the process of ensuring that system components meet the necessary requirements to perform as intended. Certification ensures that components that are manufactured according to IntelliDrive℠ requirements will be trusted by the system and by users.

The vision for the Certification research is to work in close cooperation with public and private partners to establish appropriate certification requirements for equipment.

Research Goals:

- To work with industry to define certification needs and develop supporting test methods and tools.
- To develop a plan so that in the future, certification activities will become self-sustaining through fees for testing; development of new requirements and test methods will be shaped by the organizations seeking those requirements.

Research Outcomes:

The outcomes are intended to deliver:

- Nationwide interoperability of system components.
- Elimination of inherent risks to consumer safety, security and privacy in the event of a whole or partial system breakdown.
- Establishment of an oversight structure (governance structure) that will provide the processes and procedures for system access as well as system enforcement.
- An open, well-defined process that allows manufacturers to know the system requirements in order to provide trustworthy components.

Research Plan

A successful IntelliDrive℠ deployment must address the inherent risks to consumer safety, security, and privacy associated with a system breakdown. With national interoperability comes the opportunity to establish national standards and criteria for certification of individual products that will have access to the system, system processes, and operational procedures. Because this is a new high-risk industry without an established consumer base, the Federal Government finds that an appropriate role is to work with industry to develop certification processes and procedures independently. The ultimate form that a certifying entity would take, and the role of Government in oversight and enforcement of requirements, is yet to be determined and will be investigated as part of both the technical research program as well as the IntelliDrive℠ Policy research program (see page 26).

Certification research will be primarily focused on understanding the needs for device compliance, system security, and privacy requirements. The ITS Program will conduct the following research activities in support of certification:

- **Policy Research Related to Certification** – Establish a forum for solving policy-related issues, including determining what is to be certified, what entity is responsible for certification, and what parties need to obtain certification. This research is included within the IntelliDrive℠ policy research program, and it is envisioned that government (U.S. DOT and State/local) will have the lead role in this research area.
- **Technical Requirements for Certification** – Define what level of items within a device or what interfaces need to be certified and how to accomplish the certification. It is envisioned that government and industry will share responsibility for this area of work. However, Government will have a primary role in funding developments prior to a consumer market emerging for certified products. Government will serve as an enabler and coordinator of this function.
- **Implementation Support and Oversight** – Executing the planned certification scheme will likely be done by a third party entity. This includes development of test tools and methods. However, Government may have a role in assisting with start-up, and in overseeing operation and adherence to standards. This implies an ongoing operational role for Government beyond the scope of research.

Milestones for certification activities must match related milestones in the other program roadmaps. For instance, a 2013 milestone for potential rulemaking on equipment requirements in vehicles must be matched by a similar milestone to have certification requirements and processes established in time for implementation of the rule. More specific milestones will be established in conjunction with the development of the individual program roadmaps.

IntelliDrive℠ Test Environment(s)….

…are real-world, operational test beds that offer the supporting vehicles, infrastructure, and equipment to serve the needs of public and private sector IntelliDrive℠ testing and certification activities.

The vision for the test environment research is to establish a minimum of one test bed that can support continued research, testing, and demonstration of IntelliDrive℠ concepts, standards, applications, and innovative products. Test environments will also serve as a precursor or foundation for State and local IntelliDrive℠ deployments. They are expected to generate sustainable markets for the private sector, as the test environment will enable products and applications that will deliver benefits to State and local consumers who purchase them.

Research Plan

A key element in the culmination of the VII research was a set of proof-of-concept tests that were conducted in 2008 using field (roadside) installations in Michigan and California, with a network control center located in a Herndon, Virginia facility. The findings from this testing form the foundation of this **ITS Strategic Research Plan,** and its recommendations are reflected in the structure of the IntelliDrive℠ technology, applications, and policy research programs.

In early 2009, with the re-branding of the VII initiative as "IntelliDrive℠", the Department has been assessing its options with regard to the test bed in Michigan. Although there are known limitations with the current facility, it represents a major investment on the part of the Department and has great potential value in carrying out the anticipated tests and demonstrations described within this next five-year research plan.

To realize and maximize that value, the Department is conducting two concurrent activities pertaining to the Michigan test bed:

- One activity is to stabilize the test bed operating environment and open it up to industry for supporting continued research and demonstration.
- Another activity is to procure a Systems Engineering Contractor that will review, revise, and upgrade the existing VII documentation to make it consistent with the new vision of IntelliDrive℠ (see Systems Engineering on page 22).

An additional focus of this effort is to develop and prototype a set of generic management processes, equipment, and back-end services that are needed in support of test bed operations and, eventually, IntelliDrive℠ deployment. These processes, equipment, and services will be the mechanism that enables the management, oversight, and general operations of the IntelliDrive℠system at all levels (State, local, regional, national, as appropriate). They will be developed and prototyped at the Michigan test bed but will be extensible to all early test beds and early deployments.

Research Goals:

- To operate, manage, and maintain the existing Michigan test bed for use by organizations and researchers in both the public and the private sectors, inclusive of the ITS Program's testing of IntelliDrive℠ standards and safety-, mobility-, and environment-related IntelliDrive℠ applications.
- To enhance and/or modify the existing test bed and establish it as a model for other test beds.
- To research, develop, and prototype a set of generic management processes, equipment, and back-end services.

Research Outcomes:

The outcome of this research will result in the establishment of an accessible IntelliDrive℠ test bed in Michigan for the public and private sectors to pursue research, testing, and demonstrations on innovative, next generation ITS technologies. The test bed will help establish requirements for future test beds that will provide the State and local foundation for IntelliDrive℠ deployment.

IntelliDrive℠ Policy and Institutional Issues

IntelliDrive℠ Policy and Institutional Issues Research is the research and analysis that will:

- Address policy and institutional issues that limit or challenge successful IntelliDrive℠ deployment.
- Formulate recommendations and options.
- Identify how key partners and industry will contribute to the development of actions that will move the IntelliDrive℠ research and deployment forward.

The vision for the Policy research is one of a collaborative effort among the Department, key industry stakeholders, vehicle manufacturers, state and local governments, and representative associations. Collectively, this group will structure and conduct a research agenda that results in successful deployment of IntelliDrive℠ for the Nation.

RESEARCH PLAN

The **first track of the research is focused on developing a set of systems definitions** of IntelliDrive℠ *or deployment scenarios* that describe alternative visions for how IntelliDrive℠ might result in deployment for the Nation. The deployment scenarios will enable stakeholders to identify infrastructure requirements and the minimum level of infrastructure needed to gain the maximum benefit.

Alternative deployment scenarios also form the basis for the Department, stakeholders, and experts to further research and analyze IntelliDrive℠ opportunities and options. Additional tracks will build from these deployment scenarios to research:

- **Track 2: Financing and Investment Models:**
  - *How will IntelliDrive℠ be funded and/or financed and by whom?*
- **Track 3: Governance Models:**
  - *What elements of the IntelliDrive℠ system need to be governed?*
  - *What are options for doing so?*
- **Track 4: Institutional Issues:**
  - *What are the major institutional, legal, and policy issues that limit or challenge successful IntelliDrive℠ deployment? How can they be resolved?*
  - *How do we address public concerns for privacy and ensure that applications do not cause distracted driving?*

Answers to these critical questions are at the core of whether IntelliDrive℠ will be deployed. While research may result in convergence around one viable deployment scenario, it is possible that it may also result in multiple, feasible scenarios. A fifth track of research has been defined to compare the alternative scenarios for strengths, weaknesses, opportunities, and risks; analyze the trade-offs; and develop recommendations for a robust policy and institutional foundation for IntelliDrive℠ deployment.

Research Goal:

To structure a comprehensive research agenda that enables a successful and sustainable deployment of IntelliDrive℠; addresses institutional issues; and provides options for a policy foundation.

Research Questions:

- *What policy or legislation is required to successfully launch and sustain IntelliDrive℠?*
- *Do these address the institutional issues?*
- *Are the options publicly acceptable?*
- *What entities will potentially fund, own, and govern IntelliDrive℠ systems, components, and data?*

Research Outcomes:

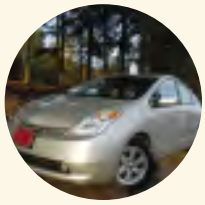
The outcomes of the research incorporate the following:

- Research and analysis that produces a *range of viable options* for policies, legislative/regulatory options, governance structures, investment models, market forces, and resolutions to institutional issues related to IntelliDrive℠.
- The combination of the options with *basic deployment scenarios* to illustrate a set of alternative, viable, more richly detailed deployment scenarios for IntelliDrive℠.
- The development of *concepts and recommendations* that will be presented for discussion.

Mode-Specific ITS Research

Although IntelliDrive℠ research is a central part of the ITS Program, additional ITS research will be conducted that reinforces the overall vision of ITS. Specifically, a set of mode-specific research programs are expected to further the Department's goal of *leveraging technology to maximize safety, mobility, and environmental performance*. The mode-specific ITS research programs include:

- Active Traffic Management
- Smart Roadside
- Commercial Vehicle Information Systems and Networks (CVISN) Core and Expanded Program
- Intelligent and Efficient Border Crossings
- Multi-Modal Integrated Payment Systems
- ITS Maritime Applications
- ITS Rail Exploratory Initiative



Photos, top to bottom: © iStockphoto.com/jfmdesign; thad; dlewis33; globo; Jon Patton; nashvilledino2.

Active Traffic Management….

…are the market-ready technologies and innovative operational approaches for managing traffic congestion within the existing infrastructure.

The vision for Active Traffic Management research is to allow transportation agencies to increase traffic flow, improve travel time reliability, and optimize available capacity throughout the transportation network.

Research Goal:

- To identify the state-of-the-art/state-of-the-practice and provide recommendations that bridge gaps through research.

Research Questions:

- *What are the performance targets, operational constraints, and business rules required to support active traffic management?*
- *When should ATM strategies be enabled and disabled?*
- *What are the impacts on the transportation facility and system?*
- *What modifications to existing simulation models are needed to accurately model the ATM at different levels of control?*
- *How do we improve the planning models to include ATM?*

Research Outcomes:

By deploying market-ready technologies and strategies an agency can evolve from monitoring and responding to congestion problems to an operational strategy that manipulates flow rates, capacity, and demand throughout the network.

Research Plan

Active Traffic Management (ATM) offers significant potential for reducing freeway congestion without the need for building additional lanes or infrastructure. By using real-time information and technologies, transportation managers can optimize available capacity, increase traffic flow, improve travel time reliability, decrease primary/secondary incidents, and improve the uniformity of driver behavior.

The program builds upon existing research to establish an operational concept and analyze enabling technologies. Due to the deployment of innovative ATM practices in countries outside the U.S., the program will incoporate an assessment of existing international efforts and realized benefits.

Although there are several efforts underway, there is no cohesive effort to bring the results from these projects together to provide actionable guidance, algorithms, models, or requirements. A need exists to develop a research test environment that would include a simulation test bed, data test bed, and model deployment evaluation to bring the existing research efforts together.

An existing effort to develop the ATM Concept will provide basic foundational research and directly contribute to furthering Active Traffic Management. Preliminary results indicate that current technological research in algorithms, decision support systems, real-time modeling, data needs, and system impact from ATM is still limited. As a result, the initial program efforts will focus on addressing system engineering issues and basic technology and data gaps. The program will pursue research along several tracks:

- **Track 1: Finalize the development of an Active Traffic Management (ATM) Concept of Operations.**
- **Track 2: Identify the requirements** necessary to support the Concept of Operations.
- **Track 3: Develop algorithms, rules, and processing software** based on requirements.
- **Track 4: Produce real-time data** needed for ATM application, which will include identifying the necessary fidelity and granularity. Examine data from various sources, for example, from fixed and mobile sensing technologies.

- **Track 5: Create and evaluate a simulation** test bed that can reveal potential ATM benefits.
- **Track 6: Fully scope an operational test and evaluation of the benefits** of combining variable speed limits (VSL) and automated speed enforcement (ASE) technology, which are two promising ATM strategies.

The Active Traffic Management research program will assist transportation agencies in moving from monitoring and responding to congestion problems to an operational strategy that influences traffic flow rates, capacity, and demand throughout the transportation network. The Concept of Operations this program establishes leads to the development of performance criteria and traffic management techniques that safely optimizes the flow of traffic.

Smart Roadside….

…is the development of roadside infrastructure for commercial vehicle operations that employs technologies for information sharing.

The vision for Smart Roadside research is to demonstrate, evaluate, and deploy interoperable technology and improved data sharing to improve safety, security, operational efficiency, and mobility on the Nation's freight transportation system.

Research Goals:

- To enhance roadside enforcement operations through improved screening and automation of inspection/compliance checks.
- To identify key entities (e.g., motor carrier, commercial vehicle, commercial driver, cargo) and communicate with commercial vehicles in real-time at highway speeds.
- To ensure that the necessary standards and architecture are in place to support interoperable operations across the country.
- To provide enhanced road condition and traffic information to support commercial vehicle route planning and improved access to intermodal ports, urban pick-up, and delivery locations.

Research Outcomes:

Stakeholders will have clear evidence of how technologies and information sharing really help to improve commercial vehicle operations on the road.

Research Plan

The Smart Roadside program is a joint modal initiative between FHWA and FMCSA. The Smart Roadside program encompasses technology and information sharing research efforts with commercial vehicle roadside elements that are crucial to the missions of the Department. The objectives of the program are to:

- Manage the flow of commercial vehicle traffic.
- Prevent and respond to crashes and other incidents in a timely manner.
- Focus enforcement resources on high-risk carriers, vehicles, and drivers.
- Ensure timely transport of goods to the marketplace.
- Reduce unnecessary delays for commercial vehicles, leading to reduced energy consumption and emissions.
- Preserve the roadway infrastructure.

In support of the Smart Roadside Initiative, FMCSA and FHWA will:

- Fund selected tests, demonstrations, and deployments.
- Coordinate with State and industry representatives to identify promising applications of Smart Roadside infrastructure.
- Coordinate the development of the necessary architecture and standards.
- Develop appropriate guiding principles.
- Document the business case for the Smart Roadside.
- Develop/implement a deployment strategy.
- Maintain a Smart Roadside roadmap and projects database to coordinate FMCSA, FHWA, and other related programs/projects.
- Facilitate stakeholder collaboration.
- Seek collaboration with the Department of Homeland Security and the Environmental Protection Agency.

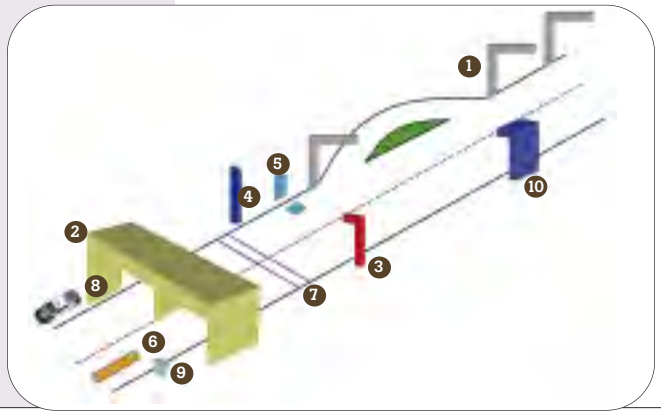


Figure 9: Smart Roadside Vision

1. E-Screening Site
2. E-Tolling
3. Over-Height Detector
4. Weather Monitoring Station
5. Transponder Reader (probes)
6. Weigh-in-Motion
7. Loop Detector
8. In-Vehicle Monitoring (In Motion)
9. E-Permitting Verification
10. Radiation Detection Systems

Commercial Vehicle Information Systems and Networks (CVISN) Core and Expanded Program….

…is a collection of information systems and communications networks that are owned and operated by governments, motor carriers, and other stakeholders that support commercial vehicle operations (CVO).

The vision for this program is to implement core CVISN and Expanded CVISN to improve the safety and productivity of motor carriers and their drivers, and reduce regulatory and administrative costs for public- and private-sector stakeholders through improved data sharing, electronic credentialing, and targeted automated screenings and enforcement of high-risk carriers at the roadside.

Research Plan

CVISN is a framework or "architecture" that assists transportation agencies, motor carrier organizations, and other stakeholders in planning and deploying integrated networks and systems. Use of the CVISN Architecture for planning and deployment enables agencies and the motor carrier industry to integrate systems to share data. Working together in this manner greatly leverages the capability of the individual systems, allowing agencies and firms to accomplish more than they could independently, in a more cost-effective and timely manner.

As a flexible framework, CVISN allows FMCSA the ability to ensure that technological advances, updates to the National ITS Architecture, and other research that might impact motor carriers are considered and incorporated. There are two levels of CVISN functionality for States and motor carrier firms:

- Core CVISN functionality provides specific capabilities in three areas:
  - Safety information exchange
  - Electronic credentialing
  - Electronic screening
- Expanded CVISN leverages the functionality of the Core CVISN systems to provide further capabilities for:
  - Driver information sharing
  - Enhanced safety information sharing and data quality
  - Smart roadside
  - Expanded electronic credentialing.

The objective of this research program is to support FMCSA in continuing the grant funding and oversight that has facilitated progress in establishing CVISN in fifty States. This partnership between the ITS JPO and FMCSA to fund and coordinate CVISN with the National ITS Architecture was established in previous legislations. Although the program is well on its way to meeting its stated goals, the funding will be continued through the new authorization, when it is anticipated that the authority and funding responsibility for the CVISN Program will be ceded to FMCSA. Until that transition, the key elements of this effort will include:

- Support for deployment of core and expanded CVISN capabilities.
- Support for the ITS/CVO CVISN Program.
- Technical support for ITS/CVO training and CVISN Deployment Workshops.
- Program, research, and policy Support for the ITS/CVO CVISN Program.

Research Goals:

To effectively facilitate the seamless exchange of critical information in support of efficient commercial vehicle operations (for instance, information on safety, credentials, and tax administration).

Research Outcomes:

To ensure deployment of Core and Expanded CVISN in support of the Smart Roadside program and a host of other information exchanges that improve motor carrier safety, identify inspection priorities, and create operational efficiencies that mean that carriers save time and money and can assure more timely delivery of cargo.

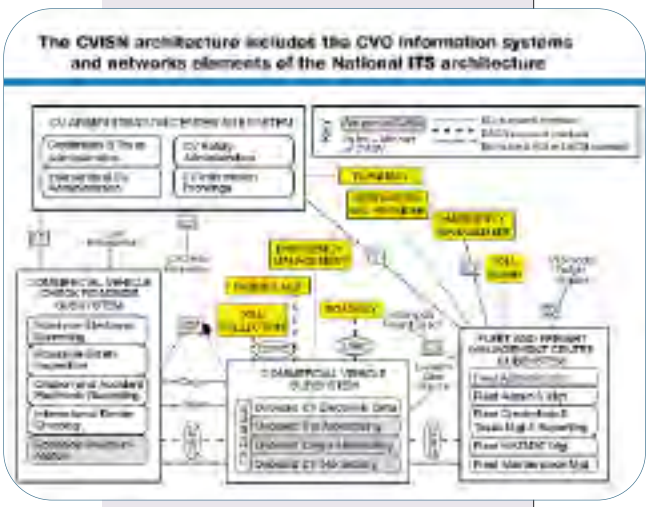


Figure 10: Image of CVISN Architecture.

Intelligent and Efficient Border Crossings….

…are ITS applications that use variable toll pricing, advanced traveler information systems, electronic screening, and other technologies to improve safety and mobility, reduce emissions, and improve security at our Nation's borders.

The vision for the research on Intelligent and Efficient Border Crossings is to enable the implementation of innovative ITS solutions for a bi-national border system that ultimately improve safety and mobility, reduce emissions, and facilitate trade and travel without compromising the vital mission of securing America's borders.

Image 11: Image of a Border Crossing.
© iStockPhoto.com/lillyday

Research Goal:

- To implement and evaluate bi-national systems at border crossings.

Research Outcomes:

The deliverables and results of the research will contribute to the overall ITS-driven model for safer, smarter, and more environmentally-friendly border crossing systems.

Research Plan

The Intelligent and Efficient Border Crossings program is a joint modal initiative between the ITS JPO, FHWA, and FMCSA that is focused on using ITS to create safer, less congested, and more environmentally-sustainable border crossings.

The research under this initiative is two-fold:

- At a U.S.-Mexican border site, the Department will collaborate on and support the development of a plan for a tolling system that can accommodate dynamic pricing at the border. Currently, Caltrans, the San Diego Association of Governemnts (SANDAG), and Mexican agencies are planning a third border crossing to reduce delays caused by traffic congestion, better accommodate projected trade and travel demand, and increase economic growth and job opportunities on both sides of the border without sacrificing border safety and security. This opportunity allows all parties involved to plan a holistic approach to ITS at the new border crossing that enables a "Clean, Green, and Smart Border." The ITS components/areas included in this research are: electronic toll collection systems, border wait-time monitoring systems, variable pricing of tolls to reduce wait times, enhanced border security systems, and advanced traveler information systems. It will be the first North American international land border crossing project that proposes the use of non-traditional transportation project financing to improve capacity and operation of an international land border crossing.

  A key aspect of this research initiative is to examine and develop marketing strategies such as discounting for lower-emission trucks (promoting a green border) and advance toll payment (pre-payment discounting). It will also focus on prioritizing the discounting or pricing for guaranteed usage and on determining what ITS and technology is needed to implement these strategies. If this research is not undertaken, no model will exist to encourage other border crossing regions to consider innovative financing and solutions to border infrastructure and operations issues.
- At a U.S.-Canadian border site, the U.S. DOT will support the development of a detailed plan for implementing the International Border Crossing – Electronic Screening System (IBC E-Screening) for trucks, motor coaches, and buses. IBC E-Screening is an alert-based system expediting the safe and legal flow of freight and passengers across northern and southern U.S. borders while targeting unsafe operations.

The IBC E-Screening component of this project leverages investment in the FMCSA Query Central-to-Customs and Border Protection's Automated Commercial Environment/ International Trade Data System (QC-ACE/ITDS) to provide an automated, data-driven approach to selection of vehicles for inspection at the border. This system enables uniform and consistent application of policies and procedures related to safety and compliance assurance of cross-border commercial traffic. The data will be augmented to include verification of more than 20 additional screening factors, and enable identification and full safety/compliance verification of carriers, trucks, trailers and drivers electronically, within three seconds or less of a truck's presentation at the processing point rather than the current 15 minute manual process.

Additionally, at this second site, research will center on the implementation of IBC E-Screening to assess the feasibility of reducing large truck crashes using an automated tool. This tool has several functions:

- Electronically identifies the carrier, truck, trailer and driver data associated with commercial truck trips entering the U.S. at land ports through the use of radio frequency identification (RFID) which exists on approximately 90 percent of trucks .
- Electronically screens each trip component for factors of interest to State and FMCSA inspectors, providing for full safety and compliance verification of carriers, trucks, trailers, and drivers, each time they enter the U.S.
- Displays screening results to State and FMCSA enforcement officers and inspectors to assist them in making more informed inspection selection decisions in fixed and mobile operations, and mainline and ramp settings, significantly increasing the efficiency and effectiveness of their operations.
- Enables data monitoring/reporting by States and FMCSA to better position each organization to fulfill its mission.

At both sites, FHWA and FMCSA will research the use of DSRC (5.9 GHz) technologies and determine how implementation might maximize opportunities to work with Canada and Mexico on the potential to improve safety and operations in border regions.

Multi-Modal Integrated Payment Systems….

…are integrated, interoperable electronic fare payment systems that can be utilized by all modes at all times.

The vision for the Multi-Modal Integrated Payment Systems research is to deliver to travelers the ease of use and convenience that comes from one payment system that can be used across modes. Transportation agencies will benefit from simplified transactions, streamlined revenue collection, improved efficiency and lower transaction costs.

Research Goal:

- To research the national policy requirements and investigate technological options for an interoperable, multi-modal payment platform.
- To identify target markets of early adopters that demonstrate the greatest sustained value in having integrated electronic payment formats.

Research Outcomes:

The outcome of the research will result in the facilitation and expedition of multi-modal, commercially-available, regionally-integrated, next-generation electronic payment systems that accept multiple payment media and are cost effective.

Image 12: Paying highway toll with creditcard.
© iStockPhoto.com/susib

Research Plan

This research program assesses the impediments to deploying multi-modal, integrated payment systems (MMIPS) and identifies whether there are opportunities for markets and business models that would lead to sustainable markets for these technologies. While the private sector has done much to develop and deploy electronic payment technologies for transit and tolling systems, further research is needed to extend these systems across all modes by addressing interoperability.

The FTA and the FHWA will cooperatively investigate the potential for multi-modal, integrated payment systems. In partnership, they will build upon previous research into electronic fare payment systems, tolling systems, parking reservation and payment systems, standards, and back-end financial transaction models that currently support transit and highway systems. New research will begin with a feasibility assessment of integrated systems, including analysis of new and emerging technologies and models for operations, financial transactions, and consumer electronics capabilities. This first phase will assess the platform of various electronic payment techniques and technologies, such as smart cards, bank-owned cards, cell phones, personal digital devices (e.g., BlackBerry, iPod), and transponders.

Further research will be conducted to determine the ITS standards needed to create an open architecture environment. Research will also be done to evaluate the technological capabilities and flexibility for identifying and assigning fees based on usage of the system. Finally, research will be conducted to identify benefits and costs.

If it is determined that an integrated, multi-modal system is technologically feasible, non-technical research will address institutional issues and customer acceptance, assess market opportunities, analyze back-office clearinghouse operations, and develop one or more business models for consideration in developing policy options.

The research is expected to result in the demonstration and evaluation of an integrated system comprised of transit bus service, parking, and tolls.

Image 13: Electronic tolling.
© iStockPhoto.com/hutchyb

Image 14: Smart Card.
Image courtesey of WMATA

ITS Maritime Applications….

…are transportation technologies applied within intermodal freight transfers between port, Marine highway, truck, and rail. More than 90 percent of the Nation's imported and exported goods move by water and over one billion tons of domestic freight travels annually on America's Marine Highways.

The vision for the ITS Maritime Applications research is to investigate the range of ITS applications that can provide greater operational efficiencies within the maritime environment.

Image 15: Multi-modal Port.
© iStockPhoto.com/javier fontanella

Research Goals:

- To identify effective ITS applications for the maritime transportation environment.
- To pilot and evaluate a range of maritime ITS applications and capture their benefits.

Research Outcomes:

To develop definitive insight into whether ITS applications can provide increased efficiencies and lower costs for waterborne freight arrival and transit.

Research Plan

Using waterborne transportation for moving freight can help mitigate landside congestion, reduce greenhouse gas emissions, and conserve energy. Despite these benefits, inefficiencies within the first and last travel legs of freight delivery can make waterborne transportation cost prohibitive.

Effective application of ITS technologies can lead to greater resource efficiencies and increased system performance. Some examples of ITS applications include:

- Optimized scheduling for waterborne freight arrival and transit, which increases system capacity and reduces fuel consumption by minimizing delays.
- Providing real-time weather information to improve safety operations for vessels.
- Coordinating the scheduling of truck and container moves to reduce wasted trips and unnecessary empty containers moves.

The ITS maritime technology research will be conducted in two phases:

- The first phase will begin with a series of stakeholder workshops that focus on two outcomes: identifying opportunities for increased efficiency and lowering the cost of intermodal maritime services; and determining the most appropriate ITS application(s) to meet the objectives.

The results of this first phase of research is expected to result in:

- Identification of ITS applications that are specific to Marine Highway services and that will minimize waste and optimize resource utilization in the intermodal transfer during the first and last leg of freight deliveries.
- Describe performance measures for evaluating the applications' efficiencies and public benefit.
- Quantify public benefits of increased Marine Highway utilization.

Phase two research will focus on deploying selected pilot projects. The research will establish a baseline for service and determine potential efficiencies and cost savings. Performance measurement evaluations will be conducted to test and validate the efficiencies and benefits produced from these applications. Upon project completion, the Maritime Administration and the ITS Program will determine whether to deploy additional ITS deployments and develop best practices for fleet-wide dissemination.

ITS Exploratory Research

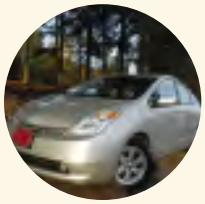
The ITS Program recognizes that technology evolves rapidly and that the community is filled with new, creative ideas for approaches to connectivity, safety, mobility, and environmental mitigation. While the programs of research described in this document will lead to solid benefits, these are not the only areas of research with potential. The ITS Exploratory Research program is intended to provide an avenue to solicit creative ideas for new technology options that are deserving of consideration and that further the **ITS Strategic Research Plan** goals for the next five years.

At this point in time, two new activities have been defined under the Exploratory Research element of the ITS Program:

- The ITS Exploratory Solicitations
- The ITS Rail Exploratory Initiative

ITS Exploratory Solicitations

To ensure that the ITS Program is flexible and aware of new innovations, the ITS Program will add a new program element to solicit new ideas. The ITS Exploratory Solicitations effort will offer research opportunities to the community through a variety of solicitation processes yet to be defined.



Photos, top to bottom: © iStockphoto.com/jfmdesign; thad; dlewis33; globo; Jon Patton; nashvilledino2.

ITS Rail Exploratory Initiative….

…is a research effort designed to explore whether IntelliDrive℠ offers increased safety benefits within the rail environment. The research will also determine the requirements for rail-based communications and ITS technologies.

The vision for the ITS Rail Exploratory Initiative research is to improve rail safety and lower operational costs through real-time data exchange and ITS applications.

Image 16: Heavy Rail.
© iStockphoto.com/buzbuzzer

Image 17: Commuter Trains
© iStockphoto.com/hfng

Research Goal:

To investigate the application of IntelliDrive℠ technologies and their benefits within the rail environment.

Research Outcomes:

To establish the feasibility of using DSRC and non-DSRC-based communications technologies to improve rail safety and lower operational costs.

Research Plan

The objective of this exploratory research initiative is to determine whether V2V or V2I IntelliDrive℠ application can offer potential safety benefits for commuter, freight, or heavy rail. The research will also focus on the feasibility of developing applications.

Currently, IntelliDrive℠ safety applications address the automobile platform and use DSRC. This research will investigate if DSRC is appropriate for rail-to-rail, rail-to-infrastructure, or rail-to-automobile communications. Additionally, this research will assess if existing rail communications or other modes of communication (Cellular, Wi-Fi, WiMAX, etc.) can be used for rail safety applications.

The research questions will focus on the current communication capabilities used within the rail environment, and how these technologies might interface with DSRC communications. Rail cars, including locomotives, have different architectures than automobiles, potentially adding greater complexity to IntelliDrive℠ rail applications. In particular, the institutional and policy issues will need to be assessed, as the business, policy, and jurisdictional models employed within the rail industry differ significantly from other transportation industries.

If the V2V and V2I safety applications for heavy rail and other rail modes are feasible, the benefits to travelers are immense and include lives saved through improved safety and lower repair costs for the infrastructure and rail vehicles.

Areas that will be assessed for their viability to implement IntelliDrive℠ communications technologies and safety applications include the following:

- Positive train control (PTC) for freight and commuter rail
- Communication-based train control (CBTC) on commuter, heavy rail, and light rail
- Grade crossing and blocked crossing for commuter rails
- Vehicle and track surveillance (Right-of-Way or intrusion detection) on commuter, heavy rail, and light rail.

The research will be led by the F'TA and involve a partnership with the FRA, transit experts, and stakeholders. The research will investigate the development and adoption of standards for data interoperability and communication between rail vehicles, rail to light vehicles, and rail to infrastructure. It will develop one or more business models that support sustainability and industry innovation, and it will investigate national policy and regulations. Finally, the research will identify target markets or locations for potential application demonstrations which will be determined after the feasibility research is successfully completed.

ITS Cross-Cutting Support

The ITS Program's Cross-Cutting Support are those functions that ensure the effective and successful implementation and use of ITS. These programs are the mechanism through which the ITS Program directly gathers and assesses the data on ITS needs; they are also the ITS Program's mechanisms for ensuring that implementers understand both the value of ITS and the uses for ITS technologies, systems, models, and strategies that are produced through the research initiatives. From 2010–2014, the ITS Program will provide six cross-cutting programs in support of IntelliDrive℠ and ITS modal research:

- ITS Standards
- National ITS Architecture
- ITS Technology Transfer
- ITS Professional Capacity Building
- ITS Evaluation
- ITS Outreach and Communications

ITS Standards

From 2010–2014, the primary focus of the ITS Standards program will be the further development, refinement and testing of DSRC and other standards required to support IntelliDrive℠ deployment. These standards development efforts will be informed by results of ongoing IntelliDrive℠ development activities, findings from the VII proof-of-concept tests and other domestic and international technolgocal developments. While it is possible that the recommended changes will address the problems detected during the proof-of-concept tests, it is not a given that the changes will lead to fixes that work effectively in the field and ensure the successful operation of IntelliDrive℠. Therefore, it is the intent of the ITS Program to test implementations of the revised standards based on a set of test plans and procedures that will verify that: 1) the prototype implementations conform to the appropriate standard; and 2) the standard supports the capability needed to advance IntelliDrive℠ toward deployment. A critical step in the completion of the IntelliDrive℠ standards is the ability to prototype and test new and revised standards in the IntelliDrive℠ test bed.

The program will also fund further updating and testing of other standards including those covering infrastructure, vehicle, transit, and motor carrier, and other ITS technologies. The program will identify and execute opportunities to improve these standards and will apply life-cycle management principles to future standards efforts.

National ITS Architecture

The National ITS Architecture provides a definitive and consistent framework to guide the planning and deployment of ITS. The programs facilitate the ability of jurisdictions to operate collaboratively and to harness the benefits of a regional approach to transportation challenges.

The National ITS Architecture Program will support continued evolution of the architecture to incorporate technological developments and evolving user needs, with a particular focus on updating the documents to reflect the IntelliDrive℠ requirements. The program will also provide deployment support for public agencies to assist with development, maintainance and improvement of their regional ITS architectures along with compliance with applicable FHWA regulations.

ITS Technology Transfer

Technology transfer is a new element in the ITS Program. It reflects a desire to institute a process that is focused on ensuring that the results of ITS research become commercially viable and are adopted by the transportation community. While the function has yet to be fully defined, there are multiple efforts being pursued by the ITS Program:

- Research will be initiated to review best practices in technology transfer at other Federal and State agencies, National Laboratories, and universities. NASA, for instance, has a well-established set of procedures for facilitating research products to market and for addressing associated issues around patents, licenses, intellectual property, and market incentivization.
- An important function of the IntelliDrive[SM] test beds is to support technology transfer and learning. The technology transfer function will coordinate closely with the ITS Professional Capacity Building (PCB) and the ITS Communications and Outreach programs.

ITS Professional Capacity Building

The goal of the ITS PCB Program is to provide the knowledge and technology transfer required by a multi-modal ITS workforce in support of effective deployment and use of ITS technologies. Adoption of new technologies, and in particular fast and successful adoption, is highly dependent upon a workforce that is:

- Aware of the new technologies and research results;
- Knowledgeable about procurement and specifications;
- Skilled in incorporating them into existing systems;
- Trained to oversee the implementation process from a systems perspective; and
- Capable of putting them into use.

To ensure that the new as well as existing ITS technologies are effectively transferred into use, the ITS PCB Program strategy is being restructured and reinvigorated to address the new and anticipated challenges. This new focus is intended to complement the traditional focus that has provided an effective approach to meeting public and private sector workforce development needs over the years.

Key elements of a refocused program are: continued training on effective deployment skills; migration to new web-based and virtual training technologies; significant upgrades to the ITS Standards training resources; and establishment of new partnerships, such as with University Transportation Centers, to create additional depth and breadth for ITS training and education.

ITS Evaluation

The objective of the ITS Evaluation program is to determine the effectiveness and benefits of deployed ITS, and the value of ITS program investments. Evaluations are critical to ensuring progress toward the vision of integrated intelligent transportation systems and achieving ITS deployment goals. Evaluations are also critical to an understanding of the value, effectiveness, and impacts of the ITS Program activities, and to allow for the continual refinement of the ITS Program's strategy.

To that end, a new ITS Deployment Evaluation program plan is under development that will define six newly refined processes for measuring the impacts of deployments.

(1) **ITS Research Evaluation** – Planning for, conducting, and reporting on independent evaluations of ITS Program research activities.

(2) **ITS Deployment Tracking Surveys** – Planning for and developing deployment tracking surveys and analyzing the results.

(3) **ITS Deployment Evaluation** – Planning for, conducting, and reporting on evaluations of deployments conducted outside of the ITS Research Program.

(4) **ITS Program Evaluation** – Planning for, conducting, and reporting on the overall effectiveness of the ITS Program.

(5) **Knowledge Management** – Collecting, organizing, and analyzing information and findings from research, deployment, program evaluations, and deployment tracking surveys.

(6) **Knowledge Transfer** – Reporting research, deployment, and program evaluation results and implications to stakeholders both internal and external to ITS. Identifying and applying Knowledge Transfer "best practices", including user-friendly media and formats, user skill-building efforts, application demonstrations, etc., to encourage and facilitate deployment.

With the capture of new ITS deployment tracking data, the ITS Evaluation program will continue to add to the successful, on-line ITS Benefits, ITS Costs, and ITS Lessons Learned databases. New research is planned to measure the impact of the previous ITS initiatives; and new analysis is being initiated to measure value of ITS investment and ITS research.

ITS Outreach and Communications

The ITS Program is dedicated to publicizing the results of research and ensuring the transfer of knowledge and technology to stakeholders within the Department and externally. This is the primary purpose of the outreach and communications function. Outreach is targeted at supporting the ITS research programs with technical reports and design of stakeholder interactions through meetings and forums. Additional outreach activities will include upgrade and maintenance of the ITS Program website; exploration of new media and methods for communicating with stakeholders; development, and distribution of publications and materials; exhibiting at industry tradeshows; and coordination with RITA Office of Public Affairs for media events and communication.

Benefits

The benefits of a transformed transportation system—fully connected, data-rich, information-intensive and able to address safety, mobility, and environmental impacts—are wide-ranging and powerful. They will be felt by every one of us, delivering greater livability to our communities and to our daily lives.

The concept of transportation connectivity, once it has developed from theory into practice, will bring with it benefits that we are just beginning to understand:

- **Travelers are the primary beneficiaries.** They will experience improved safety of travel, including reduction in fatalities, injuries, and the costs associated with crashes. Travelers will also benefit from real-time, multi-modal information that will lead to more efficient and eco-friendly choices regarding travel routes and modal choices. Informed travelers may decide to avoid congestion by taking alternate routes or modes such as walking, biking, or public transit, or by rescheduling their trip—all of which can make their trip more fuel-efficient and eco-friendly.
- **Transportation agencies** benefit by being able to see and respond dynamically to conditions on the transportation network as they evolve and expand across all of the modes. Operators will have the tools to manage the multi-modal system more efficiently, saving fuel, and reducing environmental impact. For example, data generated from IntelliDrive^{SM} systems can provide transportation operations centers with detailed, real-time data on traffic volume, speeds, transit schedule status, parking availability, evolving weather conditions, and other roadway conditions. This information can be used to optimize the transit capacity, traffic signal timing or ramp meter operations, corridor management, incident and emergency response, variable speed limits, dynamic road pricing, road weather surface treatments, and improved real-time travel alerts and advisories, among others.
- **Industry benefits** with the introduction of a new marketplace in support of IntelliDrive^{SM} technologies, applications, and products. A key component of each of the research programs described in this **ITS Strategic Research Plan** is the focus on catalyzing new markets and the assurance that resulting policy supports market sustainability in support of dynamic IntelliDrive^{SM} launch efforts and growth. In addition, IntelliDrive^{SM} will deliver a new platform that will enable new and creative private sector products.

Conclusion

Collectively, the component programs of the **ITS Strategic Research Plan** form a cohesive approach to achieving the vision of a connected transportation environment and to demonstrate that transformation of our transportation system is possible.

It is the nature of research that, as answers emerge for these and other questions, new questions will arise. Therefore, this research plan will remain flexible; the ITS Program leadership is committed to tracking progress against milestones and providing programmatic reviews in order to adjust to new needs and changing directions in policy, technology, and the marketplace. However, the focus and vision of the program will remain consistent—to research and facilitate the delivery of a multimodal, surface transportation system that features a connected transportation environment among vehicles, the infrastructure, and portable devices to serve the public good by leveraging technology to maximize safety, mobility, and environmental performance.

Consistent with this administration's commitment to open government, the ITS Program will implement program management processes that assure:

- Transparency to provide citizens with information about what the ITS Program is doing so that it can be held accountable.
- Participation to actively solicit expertise from outside Washington so that it makes policies with the benefit of the best information.
- Collaboration that ensures that agencies work together with one another and with citizens as part of doing their job of solving national problems.

In conclusion, over the next five years, the ITS Program:

- Is committed to ITS research and specifically to IntelliDrive^{SM}. This Plan is intended to frame out a multi-year research process that brings research into implementation.
- Intends to move the state-of-the-art forward with a concerted focus on the Department's highest priority—safety. This Plan harnesses powerful trends in wireless technologies, both DSRC and non-DSRC, to pursue their innovative application to transportation and transform the system as we know it.

Endnotes

(1) The full ITS Strategic Research Plan will be available on the ITS JPO website (www.its.dot.gov) in May 2010.

(2) See ITS Research Results: ITS Program Plan 2008 at: http://ntl.bts.gov/lib/30000/30800/30867/ITS_Research_Results__ITS_Program_Plan_2008_-_ITS_Report.pdf.

(3) NHTSA Traffic Safety Fact Sheet at: http://www-nrd.nhtsa.dot.gov/Pubs/811170.pdf.

(4) NHTSA's National Center for Statistics and Analysis, Traffic Safety Facts: Research Note, October 2009 at: http://www-nrd.nhtsa.dot.gov/Pubs/811226.pdf.

(5) Blincoe, A., Seay E., Zaloshingia, T., et al. *The Economic Impact of Motor Vehicle Crashes, 2000*. May 2002. NHTSA Report No. DOT HS 809 446.

(6) Schrank, David and Lomax, Tim, *2009 Urban Mobility Report*, Texas Transportation Institute, July 2009, http://mobility.tamu.edu.

(7) EPA and Centers for Disease Control statistics at:

- http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/1069
- https://www.cdc.gof/nchs/data/series/sr_10_244.pdf
- https://www.cdc.gov/mmwr/preview/mmwrhtml/ss5608a.htm.

(8) Internal NHTSA analysis.

(9) FMCSA, 2007 Large Truck and Bus Crash Facts, 2007. January 2009, FMCSA Analysis Division, pages 41–42, table 35. http://www.fmcsa.dot.gov/facts-research/art-analysis_Large-Truck-and-Bus-Crash-Facts-2008.aspx

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Figure 1: Telematics Research Group, Inc.

Figure 2: Statistics from the International Telecommunications Union at: http://www.itu.int/ITU-D/ict/statistics/ict/graphs/mobile.jpg.

Figure 3: C.J. Driscoll & Associates, *"Interest of U.S. Consumers in Traffic Information Services"*, October 2006.

Page 6 Images: Car accident – © iStockPhoto.com/tillsonburg. Congestion – ©iStockphoto/ tillsonburg; Stouffer

Figure 4: Drawn internally for the DOT

Figure 5: Drawn internally for the DOT

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Figure 9: Drawn for FMCSA: http://www.fmcsa.dot.gov/facts-research/presentations/smart-roadside-workshop/Onder-and-Secrist-SR101.pdf

Figure 10: Drawn for FMCSA as part of ITS Research Results: ITS Program Plan 2008 at: http://ntl.bts.gov/lib/30000/30800/30867/ITS_Research_Results__ITS_Program_Plan_2008_-_ITS_Report.pdf. page 172

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