

# DRIVING SAFELY INTO THE FUTURE WITH APPLIED TECHNOLOGY.



# IVI - HELPING DRIVERS AVOID HAZARDOUS MISTAKES

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Each year, more than 6 million crashes occur on our nation's highways. They kill more than 41,000 people, injure approximately 3.4 million others, and cost more than \$150 billion per year. Over the last several decades, driving has become safer through public information and education campaigns, making safety features standard equipment, and improving vehicle crashworthiness and highway design. Driver error, however, remains the leading cause of highway crashes.

Through the Intelligent Vehicle Initiative (IVI), the Department of Transportation (DOT) hopes to reduce crashes by helping drivers avoid hazardous mistakes. IVI aims to accelerate the development and commercialization of vehicle-based driver assistance products that will warn drivers of dangerous situations, recommend actions, and even assume partial control of vehicles to avoid collisions.

## **Part of ITS**

IVI is a segment of a larger DOT initiative called the Intelligent Transportation Systems (ITS) program. Under the ITS program, DOT has conducted research and development to improve driving safety and efficiency. The IVI program is a cooperative effort of the Federal Highway Administration, Federal Transit Administration and the National Highway Traffic Safety Administration.

## **Increasing Safety Through Driver Assistance**

The results of previous research indicate that major benefits are offered from the widespread use of certain driver assistance systems. The IVI will capitalize on the performance of these systems both individually and as part of the integrated systems. Along with collision avoidance capabilities, the IVI includes consideration of

information and driving assistance features that will increase driving efficiency as well as safety. For these reasons, the IVI fits well with DOT's vision of helping to provide a roadway system where Americans operate in a significantly safer environment and enjoy greater mobility.

## **The Federal Role**

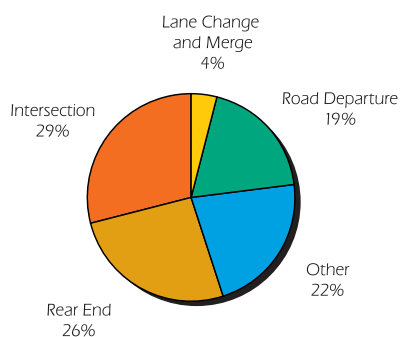
The IVI will be successful only if products, both in-vehicle and related infrastructure components, achieve widespread deployment—something DOT wishes to accelerate. The motor vehicle industry and local transportation agencies will develop and deploy IVI-related services, while DOT's role will be to facilitate and encourage the installation and use of effective systems. Working together with industry and other stakeholders, DOT will develop performance guidelines, specifications, architectures, and standards, and will test and evaluate promising configurations.

DOT will research and evaluate the benefits of IVI driver assistance systems, including the integration of driver information systems. Then through the combined efforts of DOT's modal administrations, the motor vehicle, trucking, and bus industries, state and local governments, and other stakeholders, DOT will work to expedite the deployment of effective vehicle-based and infrastructure-cooperative driver assistance systems.

# PROMISING IVI SOLUTIONS

## Eight Major Problem Areas

Despite advances over the past 100 years, no aspect of automotive technology has ever tried to accomplish what the human driver does with his or her own eyes. Providing drivers with additional in-vehicle information is a complex endeavor that—unless technologies are carefully designed—may even compromise driver safety and efficiency.



Proposed IVI services will address the eight major problem areas.

### Rear-End Collision Avoidance

Rear-end collisions account for one in four crashes or over 1.5 million crashes a year. New technologies will be used to sense the presence and speed of vehicles up ahead and provide warnings to avoid collisions. Early versions will use extensions of adaptive cruise control capabilities to detect and classify stationary objects and to determine the level of threat from vehicles in front. This will complement the limited speed control of adaptive cruise control systems.

For this reason, DOT has carefully selected certain IVI services that it considers “prime candidates” for improving driver performance because they (1) improve safety or (2) may impact safety. The selection and integration of these driver assistance services may vary among the four platforms: light, commercial, transit, and specialty vehicles.

NHTSA estimates that driver warning systems alone would be effective in preventing 49 percent of rear-end crashes, or 759,000 crashes each year. Several projects have been completed and others are in progress, including a major operational test of a rear-end crash warning system for passenger vehicles. Rear-end crashes are also a significant problem for transit buses. The same technology developed for passenger cars will help reduce the number and severity of transit bus crashes.

Performance of these systems may be enhanced in the future by combining them with route guidance and cooperative communications with highway infrastructure systems.



ITS technologies could help to prevent 49 percent of rear-end crashes per year.



Lane change and merge collisions could be cut in half by ITS technologies.

### Lane Change and Merge Collision Avoidance

Collisions during lane changes and merges also represent a major problem area, accounting for 1 in 25 of all crashes, with 90 percent caused by lane changes and 10 percent by merges. Primarily angle or sideswipe impacts, this problem requires in-vehicle technology to help detect and warn drivers of vehicles in adjacent lanes. These systems monitor the lane position and relative speed of other vehicles beside and behind the equipped car, and advise drivers of the potential for collision.

It is estimated that these systems could apply to 192,000 of the approximately 200,000 lane change/merge crashes each year. A project currently underway is studying the special needs of transit buses.

### Road Departure Collision Avoidance

The road departure collision category is dominated by the single-vehicle crash—where the vehicle leaves the road first and not because of a collision with another vehicle. In fact, one in five crashes is reported as a single-vehicle roadway departure. NHTSA estimates that these systems could apply to about 458,000 of the 1.2 million crashes each year.

Systems to avoid road departure collisions will warn the driver when his or her vehicle is likely to deviate from the lane of travel. These systems track the lane or road edge and suggest safe speeds for the road ahead. Future capabilities may integrate an adaptive cruise control function to adjust vehicle speed for the shape of the road, based on input from a map database and navigation system. Eventual cooperative communication with the highway



ITS technologies could prevent about 1.2 million deadly road departure crashes per year.

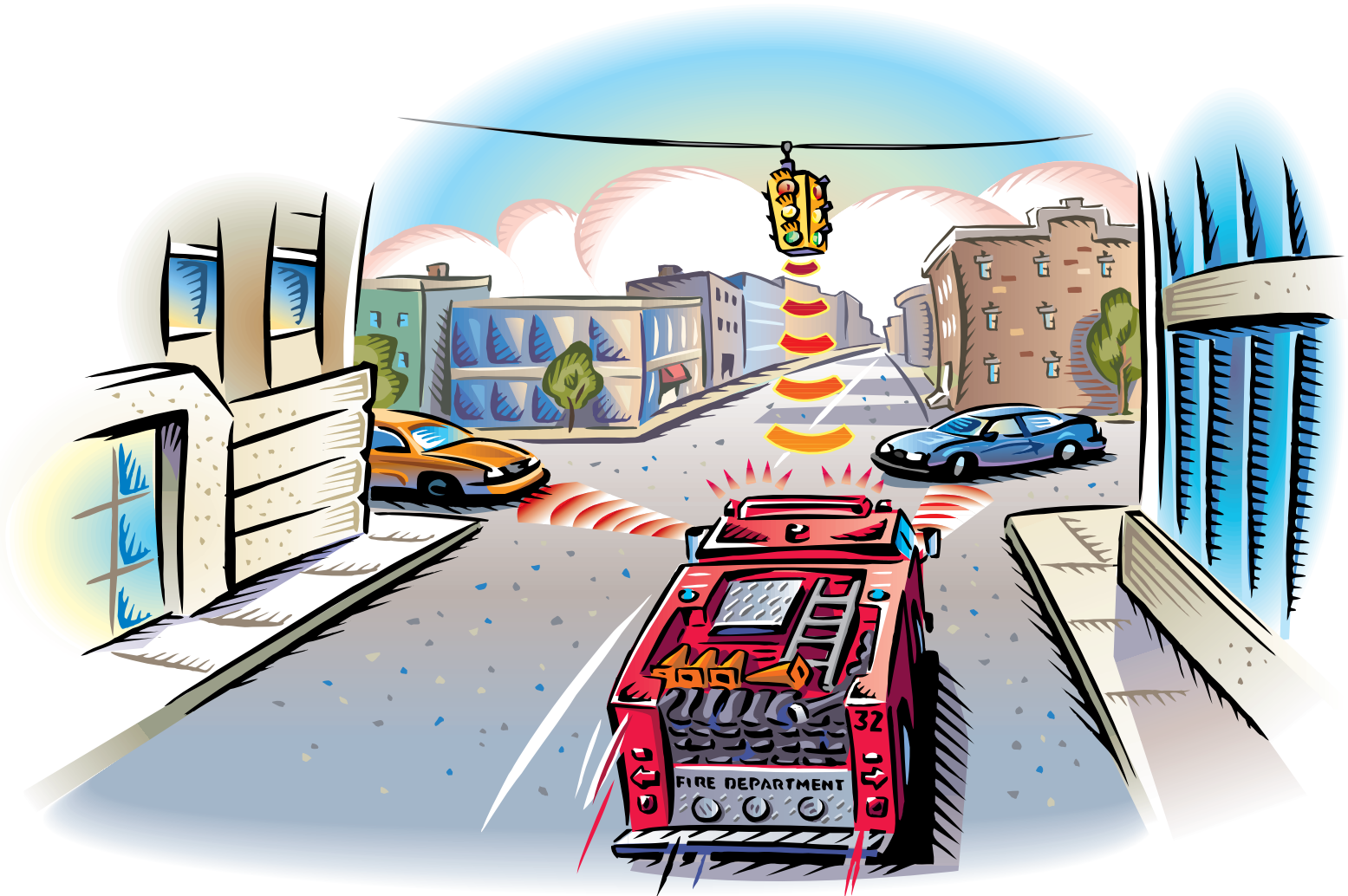
infrastructure or use of in-vehicle sensors to assess road surface conditions (e.g., wet, icy, etc.) could improve the performance of the system. Drowsy driver advisory systems may be incorporated as another enhancement.

### Intersection Collision Avoidance

The problem of intersection collisions requires systems that warn drivers when the potential for such collisions exist. These systems monitor a vehicle's speed and position relative to the intersection, along with the speed and position of other vehicles in the vicinity, advising the driver of appropriate actions to avoid a right-of-way violation or impending collision.

The intersection collision problem is complex and must have infrastructure cooperation to work on 100 percent of the problem. While this service will be implemented first through in-vehicle systems, it will be augmented with information from map databases and cooperative communication with the highway infrastructure. Technologies would sense the position and motion of other vehicles at intersections and determine whether they are slowing, turning, or violating right-of-way laws or traffic control devices.

An analysis of crash data concludes that 30 percent of all crashes, or 1.8 million, were intersection/crossing path in nature. This



Emergency vehicles could benefit from intersection collision avoidance systems.



Vision enhancement technologies are already being introduced by manufacturers.

problem area affects each of the IVI vehicle platforms. Light and specialty vehicle projects include specific attention to this problem.

### **Vision Enhancement**

Reduced visibility is a significant factor in 42 percent of all vehicle crashes and contributes to the danger inherent in any maneuver requiring a fast and accurate visual response. Reduced visibility can be caused by lighting and weather conditions such as glare, dawn, dusk, dark, artificial light, rain, sleet, snow, and fog.

Analyses suggest that of incidents having reduced visibility as a

cause, one-third involve single-vehicle roadway departure crashes and one-fifth are rear-end collisions. Further, more than one-half of pedestrian incidents occur at night and include reduced visibility as a significant factor. Vision enhancement services will likely be introduced through in-vehicle systems that use infrared radiation from pedestrians, animals, and roadside features to give drivers an enhanced view of what's ahead. Future versions may include information from highway infrastructure improvements such as infrared reflective lane-edge markings. Night vision enhancement products are already being introduced by manufacturers.



An in-cab device would alert truck drivers to the potential for vehicle instability.

### Vehicle Stability

This problem area requires that vehicles be equipped with systems to enhance their stability on the road. Current efforts are focused on commercial vehicles, as their higher centers of gravity and coupling points make them more prone to jackknife or roll over. Most incidents of heavy vehicle instability are triggered either by braking or rapid steering movements. Because heavy vehicle instability often results in rollover, this problem is particularly serious in terms of its potential to cause loss of life, injuries, property damage, and traffic tie-ups.

Two technologies look promising. The first is an in-cab device that shows the rig's rollover threshold and the driver's margin to it at any particular time. The second is a system for multiple-trailer combinations that will stabilize the rig by selectively applying braking at individual wheels. This system is intended to reduce a phenomenon called rearward amplification, where each successive trailer has a more severe reaction to an initial steering move by the driver. For this system to work, the entire combination must be equipped with

electronically controlled braking systems (ECBS). Although ECBS is now a production option from one tractor manufacturer, it is not yet offered on production trailers in the United States.

### Driver Condition Warning

Truck driver fatigue is a factor in 3 to 6 percent of fatal crashes involving large trucks. Fatigue is also a factor in 18 percent of single-vehicle, large-truck fatal crashes, which tend to occur more frequently in the late-night, pre-dawn hours. Commercial drivers themselves recognize fatigue and inattention as significant risk factors, having identified these conditions as priority safety issues at a 1995 Truck and Bus Safety Summit.

Driver condition warning systems alert drivers of conditions such as drowsiness, a problem area for which DOT is currently developing a real-time, on-board monitor which measures the degree eyelids are covering the pupils, the best known predictor for the onset of sleep.



Drowsy driving crashes could be reduced through driver condition warning systems.



Driver information systems can impact safety if not properly integrated and tested.

Technologies are also being used to provide overall drowsiness status through feedback mechanisms, allowing the driver to formulate better sleep habits. This service will probably be introduced first on commercial vehicles.

#### **Safety-Impacting Services**

More than 90 percent of crashes are the result of driver error. This statistic raises a concern over the effect of all the in-vehicle information systems being introduced. Of particular interest for IVI is the

integration of these and other driver assistance systems and the resulting impact on the driver. Great care must be taken in presenting information to the driver, or driver distraction could be further compounded. Examples of safety-impacting services include: Route Guidance and Navigation Systems, Adaptive Cruise Control, Automatic Collision Notification, Cellular Telephone, In-Vehicle Computing, and Commercial Vehicle Diagnostics/Prognostics.

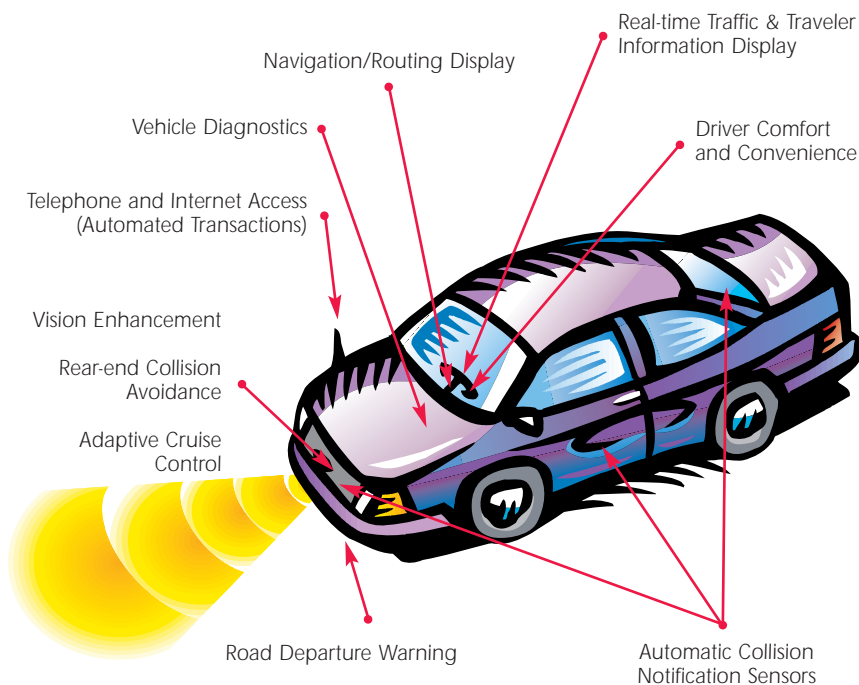


# THE FOUR PLATFORMS

As mentioned, IVI is addressing problem areas in four classes or “platforms” of vehicles: light, commercial, transit, and specialty vehicles. Classifying vehicles into these four platforms allows DOT to focus on the unique problems posed by each and will expedite the commercial availability of driver assistance systems across all platforms. IVI relies on the planned coordination and cooperation among the platforms. Each platform will be conducive to particular services that can then be applied to the other platforms. While the vast majority of crashes occur in the light vehicle platform, other platforms will permit field tests of particular systems sooner, before they are ready to be tested on light vehicles.

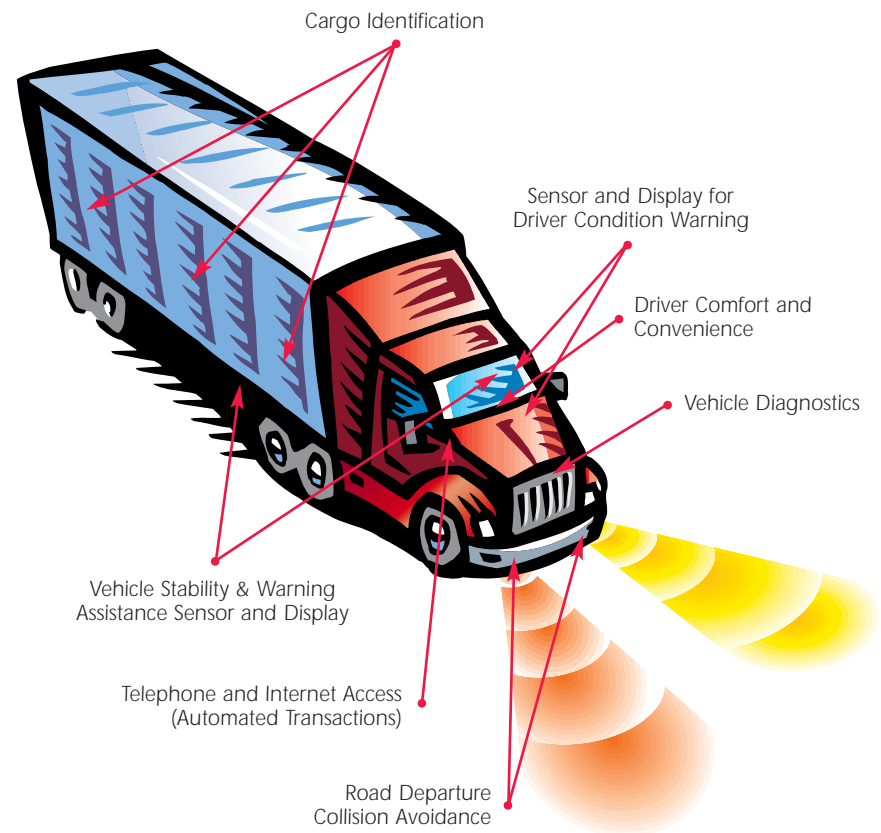
## Light Vehicles

The passenger vehicle in the “light” category requires development of systems that are adaptable to the widest variety of driver and vehicle characteristics. Initial performance specifications are almost complete



Intelligent Transportation System technologies for light vehicles.

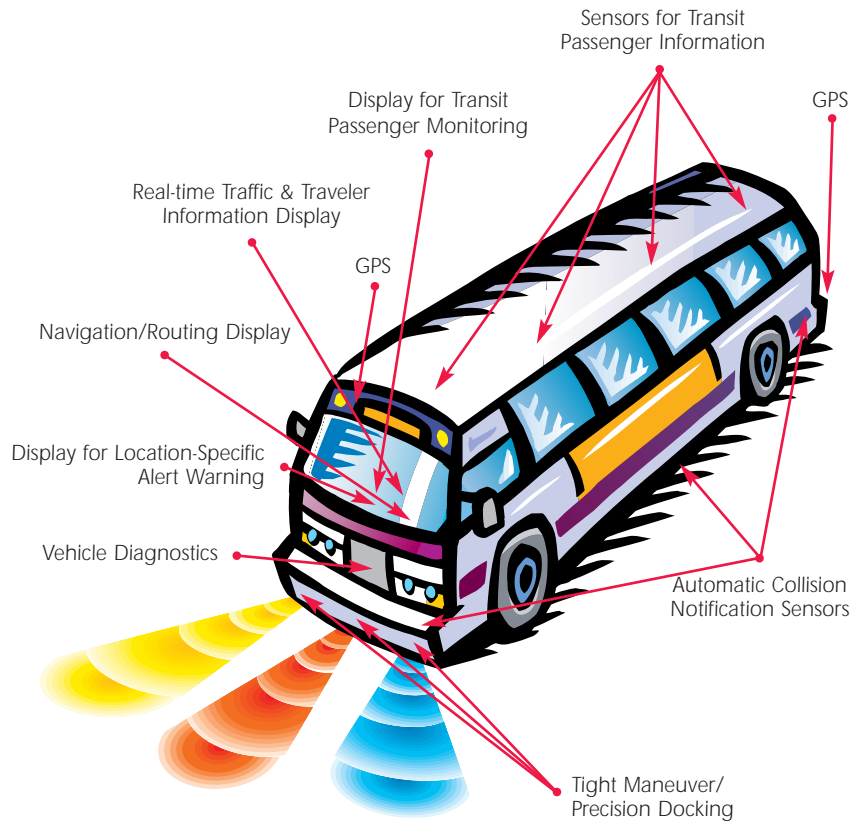
for rear-end, lane change and merge, road departure, and intersection collision avoidance systems. Tests and evaluations have been completed for intelligent cruise control and automatic collision notification systems. Manufacturers and suppliers are already installing systems with limited capabilities for these and other IVI functions.



Intelligent Transportation System technologies for commercial vehicles.

## Commercial Vehicles

Development of IVI systems for commercial vehicles will take advantage of the capabilities and interests of professional drivers and fleet operators, while considering such relevant factors as vehicle stability, driver drowsiness and fatigue, and vehicle diagnostics (e.g., monitoring of safety-related functions like tire pressure and brake integrity).



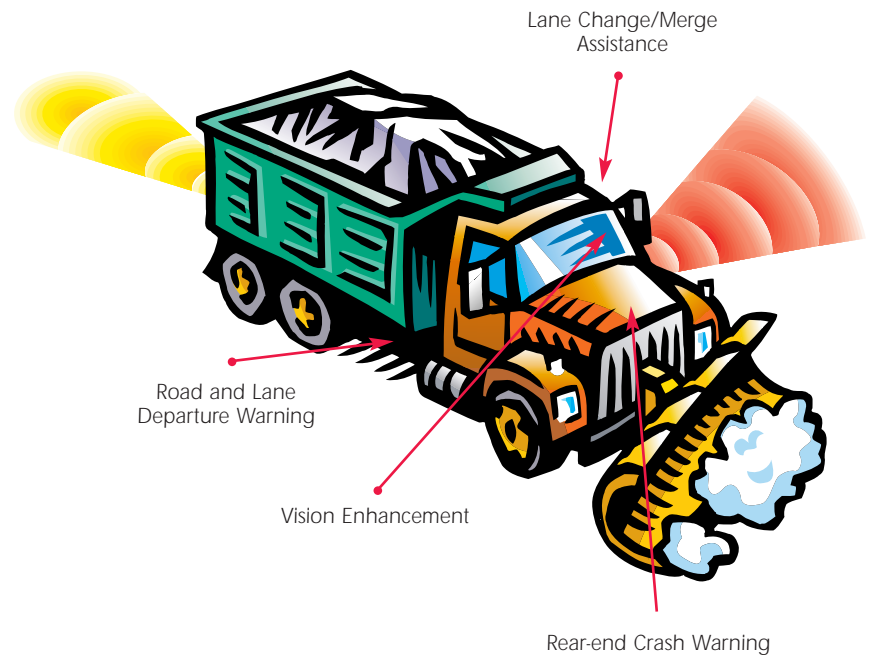
Intelligent Transportation System technologies for transit vehicles.

## Transit Vehicles

Over the past five years, 30,000 bus crashes have caused 17,000 deaths and injuries. The Federal Transit Administration (FTA) estimates that deaths and injuries from bus crashes account for \$800 million in annual insurance claims. IVI technologies will take into account congested urban environments and the increased driver distraction that goes with serving and driving among the general public. IVI functions include vehicle sensing, control intervention, driver warning, and, potentially, warnings to nearby drivers and pedestrians.

## Specialty Vehicles

For specialty vehicles such as snowplows and ambulances, bad weather and roadway conditions are key factors. More importantly, though, is their frequent use on pre-established known routes. This will allow them to take the greatest advantage of cooperative infrastructure systems, such as those in place for incident management (e.g., 911). DOT is currently assessing the variety of safety problems for specialty vehicles that may benefit from advanced technologies.



Intelligent Transportation System technologies for specialty vehicles.

# WHERE WE ARE GOING

## The Future of IVI

DOT's mission with regard to the IVI program is to provide leadership, expertise, resources, and information to continually improve the quality of our nation's roads and the vehicles on them. DOT undertakes this mission together with all its partners to reduce crashes and the resulting injuries and fatalities.

**Strengthening Public-Private Partnerships.** The main goal of IVI is to improve driver safety through the development, introduction, and commercialization of vehicle-based driver assistance products

that can reduce crashes. To achieve this goal, DOT must work cooperatively with the organizations that can help get these systems to the marketplace. DOT is forming partnerships with the motor vehicle industry and infrastructure providers to carry out IVI. ITS America, serving as a federal advisory committee, provides stakeholder advice.

**Encouraging Cooperative Infrastructure.** To date, research on crash avoidance systems focused almost exclusively on autonomous in-vehicle systems. The required system performance for some



problem areas can only be achieved through cooperative systems. For this reason, IVI will address the role of infrastructure from an individual problem area viewpoint, as well as from a crosscutting perspective.

**Evaluating Multiple System Integration.** The performance of the IVI services addressing the eight problem areas may benefit from the ability to share information and resources among multiple systems. For example, both intersection and road departure collision avoidance systems could benefit from a digitized map database.

**Developing Generations of Vehicles.** The IVI program will focus on developing generations of vehicles with increasing capabilities. Each vehicle generation will serve as a benchmark from which to measure the progress of DOT's research investment and the qualifying factors for achieving the next generation of vehicles. To support this effort, IVI will develop standard measures and objective test procedures, and incorporate ongoing peer review into the program.

**Addressing Human Factors.** Recognizing the importance of human factors to the success of IVI, DOT will conduct research to ensure that individual services provide drivers with appropriate information that they can safely process and react to. Human factors research will help flag potentially troublesome issues related to making warning systems commercially available. Critical human factors research issues include how IVI services relate to one another and to equipment already on the vehicle, in terms of the driver's ability to handle the new services. Once services become commercially available, human factors research is needed to examine driver response and adaptation, as well as unintended safety consequences.

**Facilitating Peer Review.** DOT has engaged the Transportation Research Board to conduct an ongoing, multiyear review of IVI. The committee will annually review IVI to examine goals, program design and operation, strategic plan, and individual program elements. Eventually, the focus will shift to a review of individual partnerships, evaluation of program operations, development of promising technologies, and progress on achieving program goals, including the accelerated introduction of these technologies into the marketplace.

# DELIVERING ON IVI

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The DOT IVI program will also receive advice from ITS America and a public- and private-sector working group, and will be jointly managed within DOT by FHWA, FTA, and NHTSA. Guidance and direction will also be sought from all stakeholders not represented in the working group.

A product of common goals and shared best interests, the IVI program will help DOT fulfill its mission of improving our nations transportation system by offering near-term benefits of crash reductions and transport efficiency. By facilitating the deployment of vehicle-based safety and mobility-enhancing products and systems to accelerate their market availability, IVI is creating a safer and more efficient transportation system for all.

## **We're Here to Help**

The national IVI program involves several different Federal agencies in carrying out its mission, including the Federal Highway Administration, Federal Transit Administration, and the National Highway Traffic Safety Administration.

The overall program is coordinated by the United States Department of Transportation's Intelligent Transportation Systems Joint Program Office.

For additional information on any or all aspects of the IVI program, please contact: U.S. Department of Transportation, ITS Joint Program Office, Room 3401, HOIT, 400 7th Street, SW, Washington, DC 20590. Phone: (202) 366-9536. Facsimile: (202) 366-3302. Or visit our website at [www.its.dot.gov](http://www.its.dot.gov)



## INTELLIGENT VEHICLE SYSTEMS

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