INTELLIGENT VEHICLES

In-vehicle applications of ITS use vehicle-mounted sensors and communications devices to assist with the safe operation of vehicles, prevent crashes, and mitigate the consequences of crashes that do occur. Collision avoidance systems monitor a vehicle's surroundings and provide warnings to the driver regarding dangerous conditions that may lead to a collision. Driver assistance systems provide information and, in some cases, assume partial control of the vehicle to assist with the safe operation of the vehicle. With the aim of speeding aid to victims after a crash occurs, collision notification systems alert responders when a crash occurs, with more advanced systems providing additional information on crash characteristics that can aid medical personnel.

Vehicle infrastructure integration represents an opportunity to improve a number of the vehicle-based ITS applications described in the following chapters. Updated information provided to vehicles through in-vehicle technologies could, for example, provide warnings of cross traffic at approaching intersections or enable navigation systems to avoid congested areas based on current traffic conditions.

INTELLIGENT VEHICLES: ITS APPLICATIONS

Collision Avoidance

Driver Assistance

Collision Notification

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ITS APPLICATION OVERVIEW

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COLLISION AVOIDANCE

AN INTEGRATED COUNTERMEASURE SYSTEM COULD PREVENT OVER 48 PERCENT OF REAR-END, RUN-OFF-ROAD, AND LANE CHANGE CRASHES.

VEHICLES

Collision avoidance systems use sensors and telecommunication networks to communicate with other vehicles as well as with the roadway infrastructure. In-vehicle warning systems are triggered, warning drivers when their vehicles are about to collide with another vehicle or with the roadside infrastructure. To improve the ability of drivers to take countermeasures, collision avoidance systems continue to be tested and deployed.

- Intersection collision warning systems (CWS) are designed to detect and warn drivers of approaching traffic and potential right-of-way violations at intersections.
- Obstacle detection systems use vehicle-mounted sensors to detect obstructions—such as other vehicles, road debris, or animals—in a vehicle's path or projected path and alert the driver.
- Lane change warning systems have been deployed to alert bus and truck drivers of vehicles, or other obstructions, in adjacent lanes when the driver prepares to change lanes.
- Lane departure warning (LDW) systems warn drivers that their vehicle is unintentionally drifting out of the lane.
- Rollover warning systems notify drivers when they are traveling too fast for an approaching curve, given their vehicles operating characteristics.
- Road departure warning systems warn drivers that their vehicle is about to leave the roadway, whether they are approaching a curve too fast, or about to drift off the road on a straight roadway segment.
- Forward collision warning (FCW) systems, also known as rear-end collision avoidance systems, warn drivers that they are in a conflict situation with a lead vehicle. These conflicts can arise when the lead vehicle is stopped, slowing, or traveling at a constant speed.
- Rear-impact warning systems warn the lead vehicle driver that they are in conflict with a following vehicle. The warning can be presented by the lead vehicle or transmitted from the following vehicle to an in-vehicle warning system in the leading vehicle.

The Integrated Vehicle-Based Safety System initiative, a major ITS initiative being conducted by U.S. DOT, will field test several collision avoidance technologies including forward collision warning. The initiative aims to accelerate deployment of advanced driver safety systems in all new light vehicles and heavy trucks. These safety systems have the potential to help drivers avoid the most common types of fatal collisions: rear-end, lane-change, and roadway departure. The U.S. DOT is partnering to field test the next generation of safety systems in 2008. For more information, visit the ITS JPO's Web site: *www.its.dot.gov/ivbss*.

COLLISION AVOIDANCE CATEGORIES IN THE ITS KNOWLEDGE RESOURCES

Intersection Collision Warning

Obstacle Detection

Lane Change Assistance

Lane Departure Warning

Rollover Warning

Road Departure Warning

Forward Collision Warning

Rear Impact Warning

Findings

Benefits

Table 18 summarizes the research to date on collision avoidance systems and documents the potential safety benefits for each type of warning system evaluated. Several of the studies project positive impacts based on the prevalence of the particular crash types addressed, and the likelihood that the deployed systems could address these crashes. Others evaluated the performance of the systems in field deployments on test vehicles.

Forward collision warning systems can reduce crashes and improve safety for commercial vehicles;[518] however, these technologies can have high initial costs making it difficult to deploy cost-effective solutions for fleets that experience few crashes.[519] For passenger vehicles, CWS can have much broader impacts. Working with industry, the U.S. DOT estimates that widespread deployment of integrated countermeasure systems could prevent over 48 percent of rear-end, run-off-road, and lane change crashes.[520] This would represent 1.8 million target crashes.

Table 18—Collision Avoidance Benefits Summary

	Safety	Mobility	Efficiency	Productivity	Energy and Environment	Customer Satisfaction
Intersection Collision Warning	●					
Obstacle Detection	●					
Lane Change Assistance	●					
Lane Departure Warning	●				●	
Rollover Warning	●					
Road Departure Warning	●					
Forward Collision Warning	●					
Rear Impact Warning						

● Substantial positive impacts
❍ Negligible impacts
✖ Negative impacts
✚ Positive impacts
✱ Mixed results
blank Not enough data

Costs

CWS are still somewhat in the experimental stage and have had only limited application to date.[521] Rollover warning or roll stability control systems have limited commercial availability. Rear-impact warning or rear-end impact prevention systems are still in the research and development phase.[522] Some of the collision avoidance systems are available as factory-installed options, as standard items included in the base cost of a vehicle, or as a component of an upgrade package.

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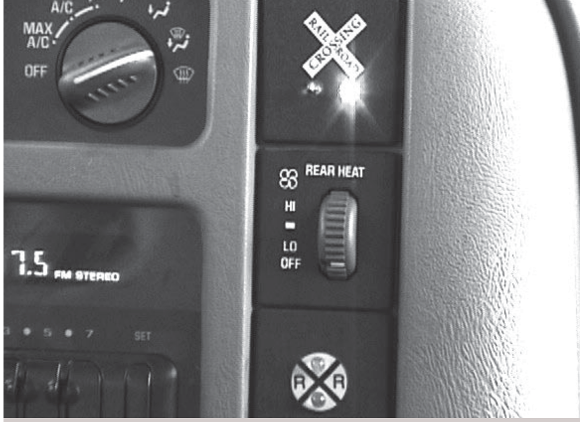

Selected Highlights from the ITS Knowledge Resources on Collision Avoidance

Lane Departure Warning

Lane departure warning systems warn drivers that their vehicle is unintentionally drifting out of the lane.

Lane Departure Warning	
Benefits	
ITS Goals	**Selected Findings**
Safety	In the Netherlands, a five-month field operational test (FOT) of 20 cars equipped with LDW systems found that the number of unintentional lane crossings decreased by 35 percent on secondary roads and 30 percent on highways due to the use of LDW. Drivers also kept better course to prevent warnings.[523]
Energy and Environment	In-vehicle computer visioning technology designed to detect and warn truck drivers of lane departure and driver drowsiness reduced fuel consumption by 15 percent, increased safety, and provided drivers with more comfortable working conditions.[524]
Lane Departure Warning	
Costs	
Sample Costs of ITS Deployments	
United States: LDW systems were originally developed for heavy-duty trucks and are transitioning to passenger vehicles. These systems have been available in Japanese automobiles since 2002 and entered into the U.S. market beginning with certain 2005 model vehicles. The cost of LDW systems is difficult to quantify because they are often bundled with other option packages or require the purchase of an additional technology package.[525]	

Rollover Warning

Rollover warning systems notify drivers when they are traveling too fast for an approaching curve, given their vehicle's operating characteristics. This has been primarily a focus of heavy trucks.

Rollover Warning	
Benefits	
ITS Goals	**Selected Findings**
Safety	Based on driving data collected during an operational test of several collision warning technologies installed on Freightliner trucks, in-vehicle rollover advisory control warning messages were expected to prevent 20 percent of rollover crashes caused by excessive speed in curves. For the national fleet of approximately 110,000 tanker trucks, the warning messages have the potential to prevent 34 crashes, 21 injuries, and 2 to 3 fatalities per year.[526]

Forward Collision Warning

In the application area of forward collision warning systems, microwave radar and machine vision technology help detect and avert vehicle collisions. These systems typically use in-vehicle displays or audible alerts to warn drivers of unsafe following distances. If a driver does not apply brakes properly in a critical situation, some systems automatically assume control and apply the brakes in an attempt to avoid a collision.

Forward Collision Warning	
Benefits	
ITS Goals	**Selected Findings**
Safety	Based on data collected from a FOT involving 10 vehicles and 66 drivers, an integrated system of forward collision warning and adaptive cruise control (ACC) functions was projected to prevent about 10 percent of all rear-end crashes, and 10 to 20 percent of severe near-crashes (with a minimum time-to-collision of less than 3 seconds with a peak deceleration level by the host vehicle of over 0.3g).[527]

LESSONS LEARNED

Incorporate proven technologies and false alarm reduction strategies in the design of future automotive collision avoidance systems.

A field operational test of automotive collision avoidance systems (ACAS) was successful in building a production-intent, rear-end crash avoidance system in a passenger vehicle. This system integrated state-of-the-art technologies that performed forward collision warning and adaptive cruise control functions. In addition, this program produced a small, reliable fleet of ACAS-equipped vehicles that were used by lay people in an FOT as their own personal cars to experience ACAS functions under different naturalistic driving conditions.

- Consider state-of-the-art system design issues and technologies for ACAS.

The FCW function of ACAS incorporates state-of-the-art sensor technologies for short-term deployment plans. However, improved signal processing and threat assessment algorithms would enhance FCW alert efficacy by recognizing slower lead vehicles transitioning out of the path of the host vehicle. This scenario generated numerous unnecessary crash-imminent alerts during the FOT and even forced the ACC to automatically brake in response to lead vehicles exiting the freeway.

(Continued on next page.)

Forward Collision Warning
Costs
Sample Costs of ITS Deployments
United States: The U.S. DOT sponsored an independent evaluation of an FOT of three advanced intelligent vehicle safety systems: CWS, ACC, and advanced braking systems. The three systems were in or nearing commercial production at the time of the FOT and were designed for use in commercial trucks. The CWS is based on forward radar sensors. If the system detects a potential crash, a warning system notifies the driver to take corrective action through in-cab visual displays and audible alarms. For the installed costs, the CWS was assumed to range from **$2,000 to $3,000 per tractor**. The costs were estimated based on consultation with manufacturers and suppliers, and engineering analysis of similar systems.[528]
Benefit-Cost Studies
United States: The cost-effectiveness of CWS was evaluated for large trucks and tractor-trailers. The results indicated that there was little or no economic justification for deploying these systems on all large trucks. With respect to tractor-trailers, however, future deployments were economically justified if relative deployment costs were lower.[529]

LESSONS LEARNED

(*Continued from previous page.*)

- Conduct additional research to reduce false alarm rates.

Additional research may be necessary to reduce the rates of false and nuisance alerts of FCW and to enhance the timing of crash-imminent alerts for mid-term deployment plans. Proceeding with further FCW enhancement activities may depend on successful results from short-term deployments and sufficient market penetration levels.[530]

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DRIVER ASSISTANCE

ON-BOARD SAFETY SYSTEMS ARE OFFERED AS AN OPTION ON SOME VEHICLES, OFTEN PACKAGED WITH COMFORT, CONVENIENCE, AND ENTERTAINMENT SERVICES.

VEHICLES

Driver assistance refers to a collection of capabilities and associated technologies to help augment key driving tasks, such as navigation, speed control, and parking. These technologies continue to gain interest in the marketplace.

- In-vehicle navigation and route guidance systems with global positioning system (GPS) technology may reduce driver error, increase safety, and save time by improving driver decisions in unfamiliar areas.
- Integrated communication systems that enable drivers and dispatchers to coordinate rerouting decisions on-the-fly can also save time and money, and improve productivity.
- In-vehicle vision enhancement improves visibility for driving conditions involving reduced sight distance due to night driving, inadequate lighting, fog, drifting snow, or other inclement weather conditions.
- Object detection systems, such as parking aids for passenger vehicles, warn the driver of an object (front, side, or back) that is in the path of or adjacent to the path of the vehicle.
- Adaptive cruise control (ACC), intelligent speed control, and lane-keeping assistance assist drivers with safe vehicle operation.
- Roll stability control systems take corrective action, such as throttle control or braking, when sensors detect that a vehicle is in a potential rollover situation.
- Drowsy driver warning systems alert the driver that he or she is fatigued which may lead to lane departure or road departure.
- Precision docking systems automate precise positioning of vehicles at loading/unloading areas.
- Coupling/decoupling systems help vehicle operators link multiple vehicles, such as buses or trucks, into platoons.
- On-board monitoring systems track and report cargo condition, safety and security status, and the mechanical condition of vehicles equipped with in-vehicle diagnostics. This information can be presented to the driver immediately, transmitted off-board, or stored. In the event of a crash or near-crash, in-vehicle event data recorders can record vehicle performance data and other input from video cameras or radar sensors to improve the post-processing of crash data.

Many of these driver assistance systems have begun to emerge in production automobiles.

Several other chapters in this report discuss ITS applications related to driver assistance technologies. Many of the technologies that enable the warning systems discussed in the Collision Avoidance chapter also support the driver assistance capabilities discussed in this chapter. Traveler information programs can provide important data to in-vehicle navigation systems, improving the performance of these devices. Data recorded by in-vehicle devices can be archived and monitored over time to improve vehicle performance and facilitate vehicle safety studies for future enhancements to vehicle technology.

The Vehicle Infrastructure Integration (VII) initiative, which seeks to enhance communication between vehicles and the roadside infrastructure, will have an impact on the deployment of ITS applications for driver assistance in the coming years. The availability of enhanced information on traffic conditions has the potential to improve the performance of in-vehicle navigation systems. For example, information transmitted from the roadside also has the potential to enhance lane keeping assistance. VII has the potential to impact many other aspects of ITS deployment discussed throughout this report. Additional information on the VII initiative is available at the ITS JPO's Web site: *www.its.dot.gov/vii*.

DRIVER ASSISTANCE CATEGORIES IN THE ITS KNOWLEDGE RESOURCES

Navigation/Route Guidance

Driver Communication
- With Other Drivers
- With Carrier/Dispatch

Vision Enhancement

Object Detection

Adaptive Cruise Control

Intelligent Speed Control

Lane Keeping Assistance

Roll Stability Control

Drowsy Driver Warning Systems

Precision Docking

Coupling/Decoupling

On-Board Monitoring
- Cargo Condition
- Safety and Security
- Vehicle Diagnostics
- Event Data Recorders

ELECTRONIC STABILITY CONTROL REDUCES THE RISK OF FATAL SINGLE-VEHICLE CRASHES BY 59 PERCENT FOR SUVS AND 53 PERCENT FOR CARS.

OTHER ITS KNOWLEDGE RESOURCE CATEGORIES RELATED TO DRIVER ASSISTANCE

Refer to other chapters in this document.

Traveler Information

- Pre-Trip Information
- En Route Information

Information Management

- Data Archiving

Collision Avoidance

- Obstacle Detection
- Lane Change Assistance
- Lane Departure Warning
- Road Departure Warning
- Forward Collision Warning
- Rear Impact Warning

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Findings

Benefits

As shown in table 19, evaluations have documented the performance of in-vehicle navigation systems, driver communication systems, ACC, and roll stability control.

In-vehicle navigation and route guidance systems have gained mainstream acceptance and are widely available in private vehicles. Studies of the systems from the mid-to-late 1990s identified the ability of the devices to provide mobility benefits and improve safety by routing travelers to limited-access freeways and major arterials. When linked to sources of current traffic congestion information to provide dynamic routing, one study found that the devices could reduce traffic congestion and thereby provide additional network capacity. These studies also found travelers had favorable impressions of the devices.

Several studies have been completed assessing the potential of ACC, which is now available in some private vehicles. The most recent studies have found that the systems are most effective at improving safety when bundled with collision warning systems. With widespread deployment, ACC has the ability to reduce vehicle emissions and increase the capacity of roadways. Drivers have demonstrated an acceptance of ACC.

While both cars and sport utility vehicles (SUVs) benefit from electronic stability control systems, the reduction in the risk of single-vehicle crashes was significantly greater for SUVs (49 to 67 percent) than for cars (33 to 44 percent).[531] With respect to fatal single-vehicle crashes, however, the impacts were similar (59 percent reduction for SUVs and 53 percent reduction for cars).[532]

Table 19—Driver Assistance Benefits Summary	Safety	Mobility	Efficiency	Productivity	Energy and Environment	Customer Satisfaction
Navigation/Route Guidance	✚	●	●			●
Driver Communication				●		
Vision Enhancement						
Object Detection						
Adaptive Cruise Control	●		✚		✚	●
Intelligent Speed Control						
Lane Keeping Assistance						
Roll Stability Control	●					
Drowsy Driver Warning Systems						
Precision Docking						
Coupling/Decoupling						
On-Board Monitoring						

● Substantial positive impacts ✚ Positive impacts
❍ Negligible impacts ✱ Mixed results
✖ Negative impacts **blank** Not enough data

Costs

On-board safety systems are offered as an option on some vehicles, but more often than not these systems are being packaged with comfort, convenience, and entertainment services. A consumer willing to pay for ACC, for example, may forgo the purchase if required to buy a more expensive package that includes unrelated and unwanted features such as climate-controlled front seats and a rear-view monitor. As a result, this bundling approach is deterring consumers from purchasing safety systems. Another side effect of bundling is the difficulty in determining the cost of each individual ITS technology.[533]

Selected Highlights from the ITS Knowledge Resources on Driver Assistance

Navigation/Route Guidance

In-vehicle navigation systems with GPS technology may reduce driver error, increase safety, and save time by improving driver decisions in unfamiliar areas. The systems may be linked to traveler information services to provided updated routing instructions that account for current traffic conditions.

Navigation/Route Guidance	
Benefits	
ITS Goals	**Selected Findings**
Safety	In Orlando, Florida, a simulation study of navigation devices found that drivers using the devices reduced their crash risk by four percent as a result of improved wrong turn performance and the tendency of the system to select routes with improved (normally safer) facilities.[534]
Mobility	***Summary Finding:*** In-vehicle navigation/route guidance devices can reduce travel times by 4 to 10 percent under normal traffic conditions or recurring traffic congestion.[535]
Efficiency	A simulation study of roadways in Orlando, Florida found that, assuming a market penetration of 30 percent, dynamic route guidance would allow the road network to handle a 10 percent increase in vehicle volumes.[536]
Customer Satisfaction	In San Antonio, Texas, 60 percent of drivers of paratransit vehicles equipped with in-vehicle navigation devices reported that they saved time and felt safer than using paper maps.[537]
Costs	
Sample Costs of ITS Deployments	
United States: Navigation units are available as optional or standard equipment on many vehicle models. Based on available market data, increased sales in both types of purchases are likely. Navigation units are often integrated with other top-selling, on-board electronics. Several after-market products are also available, with prices around **$1,300 to $1,500** for equipment plus about **$15 per month** for subscription to a satellite service.[538]	

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Driver Communication

Integrated driver communication systems enable drivers and dispatchers to coordinate re-routing decisions on-the-fly and can also save time and money, and improve productivity.

Driver Communication	
Benefits	
ITS Goals	**Selected Findings**
Productivity	An advanced routing and decision-making software communications program for commercial vehicles helped dispatchers organize and route time-sensitive delivery orders. The system increased the number of deliveries per driver-hour by 24 percent.[539]

Driver Communication
Costs
Sample Costs of ITS Deployments
Michigan: The Flint Mass Transportation Authority (MTA) developed a plan to deploy ITS technologies to improve the effectiveness and efficiency of transit service in Genesee County. To provide communication between the driver and the dispatch center, the plan included the deployment of mobile data terminals on 250 vehicles. Costs are estimated at **$4,000 per unit**, or $1 million for the fleet. Operations and maintenance (O&M) costs are estimated at **$100,000 per year**.[540]

Vision Enhancement

In-vehicle vision enhancement improves visibility during night driving, inadequate lighting, fog, drifting snow, or other inclement weather conditions. These systems may also monitor vehicle blind spots to assist the driver in making safe lane changes.

Vision Enhancement
Costs
Sample Costs of ITS Deployments
United States: Blind spot monitoring provides warnings to drivers that another vehicle is in one of the "blind" spots to the side and rear of the car. One such system available on the U.S. market utilizes digital camera-based sensors mounted on the exterior side mirrors and provides a visual warning when another vehicle is in the blind spot. This system is available as an option and is priced at approximately **$500 per vehicle**. Other mirror-mounted blind spot detection systems are in development, but will utilize 24 GHz radar. Production costs for these systems, installed on both side mirrors, are estimated at **$400 to $500 per vehicle**.[541]

Adaptive Cruise Control

ACC systems maintain a driver-set speed without a lead vehicle or a specified following time if there is a lead vehicle and it is traveling slower than the set speed.

Adaptive Cruise Control	
Benefits	
ITS Goals	**Selected Findings**
Safety	A field evaluation in Michigan tested ACC combined with forward collision warning to form an automotive collision avoidance system (ACAS). The study found that ACAS could reduce exposure to driving conflicts leading to rear-end crashes by 8 to 23 percent and estimated that the combined system could eliminate about 10 percent of all rear-end crashes.[542] An earlier study of stand-alone ACC found that the technology was effective at reducing risky lane changes in response to slower traffic, but drivers of these vehicles took 0.3 seconds longer than manually-controlled vehicles to respond to lead vehicle brake lights.[543]
Efficiency	In Michigan, an evaluation of ACC indicated that the technology would improve roadway capacity under conditions of high velocity and short time-headway settings (one second), and reduce road capacity if longer time-headway settings (two seconds) were used.[544]

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Adaptive Cruise Control	
Benefits	
Energy and Environment	Driver response and vehicle dynamics were recorded for one ACC vehicle and two manually-operated vehicles in a single lane of freeway traffic. The ACC vehicle attempted to smooth traffic flow by minimizing the variance between acceleration and deceleration extremes. Simulation models based on collected field data estimated a fuel savings of 3.6 percent during scenarios with frequent acceleration and deceleration.[545]
Customer Satisfaction	Survey data collected from tractor-trailer drivers with one to three years of experience driving with intelligent vehicle safety systems—including radar-based collision warning systems (CWS), ACC systems, and advanced electronic braking systems—indicated that in-vehicle safety systems lowered their perceived workload by 14 to 21 percent over a range of driving conditions (good conditions, heavy traffic, and low visibility).[546]
Costs	
Sample Costs of ITS Deployments	
United States: The U.S. DOT sponsored an independent evaluation of a field operational test (FOT) of three advanced in-vehicle safety systems: CWS, ACC, and advanced braking systems. The three systems were in or nearing commercial production at the time of the FOT and were designed for use in commercial trucks. The cost of adding ACC to a vehicle already equipped with CWS was estimated at **$300 per truck**. ACC can be bundled with CWS as an integrated complementary package. Bundled packages of CWS and ACC cost approximately **$2,300**; the cost is approximately **$6,300** if an advanced braking system is added.[547] **United States:** ACC is now available on most high-end automobiles. The cost to the consumer was estimated at **$3,000 per vehicl**e.[548]	
Benefit-Cost Studies	
United States: A 2007 societal benefit-cost analysis of the installation of a bundle of ACC, a CWS, and an advanced braking system on tractor-trailer commercial vehicles found the installation of the systems to be economically justified in two of six modeled scenarios (with benefit-to-cost ratios ranging from 1.1:1 to 1.3:1). None of the six evaluated scenarios for deployment of the technologies on all types of commercial vehicles yielded a benefit-to-cost ratio greater than 1:1.[549]	

Intelligent Speed Control

Intelligent speed control systems limit maximum vehicle speed via a signal from the infrastructure to an equipped vehicle.

Intelligent Speed Control	
Benefits	
ITS Goals	**Selected Findings**
Customer Satisfaction	In the southern Swedish town of Eslov, 25 personal vehicles were equipped with governors (speed controllers) activated by wireless beacons at city points-of-entry to limit inner city vehicle speeds to 50 km/h. The vast majority of participants preferred this adaptive speed control over other physical countermeasures such as speed humps, chicanes, or mini-roundabouts.[550]
Benefit-Cost Studies	
Illinois: In the central area of Chicago, a feasibility study for proposed dedicated truck facilities indicated that driver assistance technologies including speed control, steering control, and fully automated driving would help to make the proposed network cost-effective by lowering construction costs, improving truck travel times, and increasing capacity on the proposed roadways.[551]	

Roll Stability Control

Roll stability control systems take corrective action, such as throttle control or braking, when sensors detect that a vehicle is in a potential rollover situation.

Roll Stability Control	
Benefits	
ITS Goals	**Selected Findings**
Safety	An analysis of the effectiveness of electronic stability control in reducing single-vehicle crashes in passenger cars and SUVs (using 1997-2002 crash data from five states) suggested that single-vehicle crashes were reduced by 35 percent for passenger cars and by 67 percent for SUVs.[552]

Precision Docking

Precision docking systems automate precise positioning of vehicles, typically transit vehicles, at loading/unloading areas.

Precision Docking
Costs
Sample Costs of ITS Deployments
Worldwide: Costs data were obtained from various bus rapid transit (BRT) projects either underway or planned and made available to transit professionals and policy makers in planning and decision making related to implementing different components of BRT systems. The data are representative of BRT development costs. Hardware integration for on-board precision docking systems costs approximately **$50,000 per vehicle**. Optical/magnetic sensors cost approximately **$4,000 per station**.[553] **Illinois:** Precision docking technologies, used for easy boarding and alighting of transit passengers, were one of several technologies evaluated in a case study of transportation problems facing the central area of Chicago. The costs of the in-vehicle components were approximately **$14,000** when only several hundred units would be produced. The costs dropped significantly to **$2,700** when production levels would be closer to 10,000.[554]
Benefit-Cost Studies
Illinois: In the central area of Chicago, an economic feasibility assessment of precision docking technologies for cross-town routes found that deployment of the technologies would be economically justifiable if they provided reductions in dwell time of 2.5 seconds per stop.[555]

On-Board Monitoring

On-board monitoring applications track and report cargo condition, safety and security, and the mechanical condition of vehicles equipped with in-vehicle diagnostics. This information can be presented to the driver immediately, transmitted off-board, or stored. In the event of a crash or near-crash, in-vehicle event data recorders can record vehicle performance data and other input from video cameras or radar sensors to improve post-crash processing of data.

On-Board Monitoring
Costs
Sample Costs of ITS Deployments
United States: Concierge services widely available through systems provided by ATX® and OnStar® assist motorists by connecting the vehicle to a remote operator who can then contact and dispatch emergency personnel to the scene of a crash. Typically, the hardware (estimated at **$350 per unit**) and the first year's subscription costs are included in the retail price of the vehicle with subsequent subscriptions sold on an annual basis. The basic safety-related OnStar® service is **$199 per year** which also includes a remote diagnostics system that is linked to sensors monitoring the condition of the engine and electronic systems.[556] **Michigan:** The Flint MTA developed a plan to deploy ITS technologies to improve effectiveness and efficiency of transit service in Genessee County. The plan includes on-board diagnostics for 100 vehicles to support more efficient maintenance operations and on-road trouble-shooting. The capital costs were estimated to be **$200,000**; the O&M costs were estimated to be **$20,000 annually.**[557]

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COLLISION NOTIFICATION

REPORTS FROM THE PRIVATE SECTOR INDICATE BASIC IN-VEHICLE SAFETY AND SECURITY PACKAGES NOW INCLUDE ADVANCED SAFETY FEATURES SUCH AS ADVANCED ACN.

VEHICLES

Collision notification systems detect and report the location and severity of incidents to agencies and services responsible for coordinating appropriate emergency response actions. These systems can be activated manually (Mayday) or automatically (automated collision notification or ACN), and typically establish wireless data and voice communications with call centers who then relay the information to emergency response services. Data transmitted include vehicle location and the description and nature of the emergency. More advanced ACN systems use in-vehicle crash sensors, global positioning system (GPS) technology, and wireless communications systems to automatically determine the severity, location, condition, and orientation of vehicles in a crash, and communicate this information to emergency responders. Advanced ACN data can assist responders in determining the type of equipment needed in an emergency (basic or advanced life support emergency medical services), mode of transport (air or ground), and the location of the nearest trauma center.

Over a dozen commercial Mayday/ACN products are available. Many of these products are available as factory-installed options on high-end luxury cars; others are installed as after-market products. The typical Mayday/ACN product utilizes location technology, wireless communication, and a third-party response center to notify the closest public safety answering point (PSAP) for emergency response.

The emergency management chapter also discusses automated collision notification systems. In addition, the traffic incident management chapter discusses enhanced 9-1-1 service as a means of detecting incidents.

In addition to the ITS technologies profiled in this chapter, the Next Generation 9-1-1 (NG9-1-1) initiative, a major ITS initiative currently being conducted by U.S. DOT, will improve emergency communication, which would, in turn, improve notification of traffic incidents. The Next Generation 9-1-1 initiative will establish the foundation for public emergency services in this wireless environment and enable an enhanced 9-1-1 system to be compatible with any communications device. The goal of the NG9-1-1 initiative is to enable the transmission of voice, data, or video from different types of communication devices to PSAPs and on to emergency responder networks. For more information, visit the ITS JPO's Web site: *www.its.dot.gov/ng*911.

Findings

Benefits

The U.S. DOT tested the feasibility of a Mayday system designed to deliver telematics-based emergency calls to a PSAP as if they were conventional telephone calls to 9-1-1. While initial acceptance testing indicated that the system was a viable concept, researchers indicated that the cost of implementing and operating such a nationwide system would be disproportionately high considering the small representation of telematics-initiated 9-1-1 calls.[558] Currently, telematics service providers continue to use emergency advisory personnel to receive Mayday calls and manually interface with 9-1-1 call takers.

COLLISION NOTIFICATION CATEGORIES IN THE ITS KNOWLEDGE RESOURCES

Mayday/Automated Collision Notification

Advanced Automated Collision Notification

BASED ON A RECENT STUDY OF PRIVATE SECTOR DEPLOYMENT OF ITS, THE COST OF TELECOMMUNICATIONS- AND LOCATION-BASED SERVICES DESIGNED TO ASSIST MOTORISTS WAS ESTIMATED AT $350 PER UNIT.

OTHER ITS KNOWLEDGE RESOURCE CATEGORIES RELATED TO COLLISION NOTIFICATION

Refer to other chapters in this document.

Traffic Incident Management

Surveillance and Detection—Wireless Enhanced 911

Emergency Management

Emergency Medical Services—Advanced Automated Collision Notification

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As shown in table 20, evaluations to date have documented strong customer satisfaction with ACN systems. These benefits include a heightened sense of safety, as reported by travelers testing an early deployment of the systems in Washington.[559] An evaluation of advanced ACN documented improved notification times for crashes reported by the ACN system, demonstrating a significant safety benefit that can be achieved using either type of ACN system.[560]

Table 20—Collision Notification Benefits Summary

	Safety	Mobility	Efficiency	Productivity	Energy and Environment	Customer Satisfaction
Mayday/Automated Collision Notification	●					●
Advanced Automated Collision Notification	●					

● Substantial positive impacts
❍ Negligible impacts
✖ Negative impacts
✚ Positive impacts
✱ Mixed results
blank Not enough data

Costs

The Mayday Plus project was a six-month field operational test conducted in 1999 and 2000 that evaluated an automated crash location and collision severity notification system. The project report included the cost data for several Mayday commercial off-the-shelf products. At the time, car manufacturers installed some of these products as factory-installed options, while others were installed after market. The cost range for after-market products was from $400 to $1,895. Monthly service fees ranged from $10 to $27 depending on the level of service offered. At the time the report was written, the Mayday market was rapidly changing with an increase in the number of commercial products becoming available.[561] In a recent study of private sector deployment of ITS, the costs of telecommunications- and location-based services designed to assist motorists were estimated at $350 per unit. The first year's subscription was included in the retail price of the vehicle with subsequent subscriptions sold on an annual basis. One basic safety and security subscription package cost $199 per year with other packages costing $399 and $799 per year. The basic safety and security package included advanced safety features such as advanced ACN. Telematics services appear to be on the decline as several automakers in former agreements to offer such services have discontinued the service due to lack of consumer interest.[562]

Selected Highlights from the ITS Knowledge Resources on Collision Notification

Mayday/Automated Collision Notification

The typical Mayday/ACN product utilizes location technology, wireless communication, and a third-party response center to notify the closest PSAP for emergency response.

Mayday/Automatic Collision Notification	
Benefits	
ITS Goals	**Selected Findings**
Customer Satisfaction	Several surveys of motor carriers asked them to indicate which, if any, technologies they planned to install in some or all of their fleet vehicles in the future. The most commonly selected technologies were Mayday/ACN systems (26 percent), remote diagnostic systems (23 percent), and rollover stability systems (23 percent).[563]
Costs	
Sample Costs of ITS Deployments	
United States: Concierge services widely available through systems provided by ATX® and OnStar® assist motorists by connecting the vehicle to a remote operator who can then contact and dispatch emergency personnel to the scene of a crash. Typically, the hardware (estimated at **$350 per unit**) and the first year's subscription are included in the retail price of the vehicle with subsequent subscriptions sold on an annual basis. The basic safety-related OnStar® service is **$199 per year** with other packages costing **$399 to $799 per year**.[564]	

Advanced Automated Collision Notification

Advanced ACN systems use in-vehicle crash sensors, GPS technology, and wireless communications systems to supply public/private call centers with crash location information, and in some cases, the number of injured passengers and the nature of their injuries.

Advanced Automated Collision Notification	
Benefits	
ITS Goals	**Selected Findings**
Safety	Between July 1997 and August 2000, the impacts of advanced ACN on incident notification were tracked for vehicles with and without ACN systems in urban and suburban areas of Erie County, New York. Based on a limited number of crash events, the average notification time for vehicles equipped with ACN was less than 1 minute with some notification times as long as 2 minutes, and the average notification time for vehicles without ACN was about 3 minutes with some notification times as long as 9, 12, 30, and 46 minutes.[565]
Costs	
Sample Costs of ITS Deployments	
United States: An ACN system that detects not only airbag deployment, but also determines the severity of a crash, direction of impact, multiple impacts, and rollover (if equipped with the appropriate sensors) is available in a basic safety and security subscription service package for **$199 per year**, as of 2003.[566]	

OPERATIONS/ITS HELPLINE

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ITS APPLICATION OVERVIEW

www.itsoverview.its.dot.gov

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