



U.S. Department of Transportation

# Driver Assistance: Navigation / Route Guidance, Driver Communications, In-Vehicle Monitoring, and Safety

## ITS Benefits, Costs, and Lessons Learned: 2017 Update Report

### Driver Assistance

#### Navigation / Route Guidance

Eco-Routing

#### Driver Communication

With Other Drivers

With Carrier / Dispatch

#### Vision Enhancement

#### Object Detection

Adaptive Cruise Control

Connected Eco-Driving

Intelligent Speed Control

#### Lane Keeping Assistance

#### Roll Stability Control

Drowsy Driver Warning Systems

Precision Docking

Platooning

#### In-Vehicle Monitoring

Cargo Condition

Safety and Security

Vehicle Diagnostics

Event Data Recorders

### Highlights

- Following on success of in-vehicle navigation, driver assistance technologies are now moving into the marketplace.
- Many of these driver assistance technologies show benefits in reducing safety incidents and lowering fuel consumption and emissions.
- Costs for DSRC based On-Board Equipment for Connected Vehicle Technology are expected to be in the \$200-233 range in 2017 for aftermarket devices.



## Introduction

This factsheet is based on past evaluation data contained in the ITS Knowledge Resources database at: [www.itskrs.its.dot.gov](http://www.itskrs.its.dot.gov). The database is maintained by the U.S. DOT's ITS JPO Evaluation Program to support informed decision making regarding ITS investments by tracking the effectiveness of deployed ITS. The factsheet presents benefits, costs and lessons learned from past evaluations of ITS projects.

Driver assistance refers to a collection of capabilities and associated technologies to help augment key driving tasks, such as navigation, speed control, and parking. This fact sheet focuses on in-vehicle mobility assistance:

- 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 re-routing decisions on-the-fly can also save time and money, and improve productivity.
- 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.

## Benefits

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 provide updated routing instructions that account for current and predicted traffic conditions.

Over the past decade, on-board and portable navigation systems have frequently been purchased and used by drivers to assist with driving directions and routing around congestion. Combining navigation systems and traveler information can create powerful tools to assist drivers.

**Eighty-three (83) percent of the audible alerts received by drivers were rated as either good or neutral, and only 13 percent were rated as bad. The alerts enhanced drivers' situational awareness and improved safety on freeways.**

The tables below show the benefits of these technologies in reducing fuel consumption and vehicle emissions.

**Table 1: Benefits of Navigation/Route Guidance.**

ITS Goal	Selected Findings
Energy & Environment	<p>In the Buffalo-Niagara region of New York, a green routing system for passenger vehicles showed:</p> <ul style="list-style-type: none"> <li>• An average Carbon Monoxide (CO) emissions reduction of 16.77 percent, with only a 3.33 percent increase in the average travel time when the route was based on CO reduction.</li> <li>• When the route was based on reducing Nitrogen Oxides (NOx), a 19.47 percent decrease was seen, with an 11.04 percent increase in travel time.</li> <li>• When the route was based on reduced fuel consumption there was an average decrease of 5.55 percent gallons of gasoline used with a 12.7 percent increase in travel time (<a href="#">2013-00866</a>).</li> </ul> <p>For a long haul truck case:</p> <ul style="list-style-type: none"> <li>• An 18.65 percent reduction in CO was seen with a 2.46 percent increase in travel time (<a href="#">2013-00866</a>).</li> </ul>
Energy & Environment	<p>Eco-routing features that assist drivers with navigation can improve fuel economy by 15 percent by identifying more fuel efficient routes and save them up to 30 percent in mileage when searching for a parking space when appropriate information is provided. Overall, combining multiple eco-driving applications was projected to reduce fuel consumption by 20 percent.</p> <p>AVL systems can help commercial motor vehicles find more efficient routes which in effect can reduce VMT. An AVL/OBD technology solution identified eliminated 44,000 pounds of greenhouse gas emissions annually from the City of Napa's vehicle fleet. (<a href="#">2012-00791</a>)</p>
Energy & Environment	<p>An ecological route search system can use fuel consumption prediction technology and route search technology to advise drivers of fuel efficient routes.</p> <p>To evaluate the system a comparative driving experiment was conducted using an ecological route search and a conventional time priority route search.</p> <p>Results indicated that fuel consumption on the ecological route was nine percent less than that the time priority route, even though the travel time on the ecological route was nine percent longer. (<a href="#">2014-00900</a>)</p>
Customer Satisfaction	<p>A research team collected data from over 800 professional truck drivers and motor carrier executives. In total, there were 677 driver survey respondents and 169 carrier survey respondents.</p> <p>Results suggested relatively high-levels of use and trust in the navigation system technology used by industry stakeholders, especially among new drivers and large carriers. The driver survey indicated that approximately 73 percent of drivers were either somewhat trusting (67 percent) or very trusting (6 percent) of navigation systems. Carriers, however, were less trusting with only 62 percent reporting that they were somewhat trusting or very trusting of navigation system accuracy. (<a href="#">2014-00945</a>)</p>

Table 2: Benefits of Driver Communication.

ITS Goal	Selected Findings
Energy & Environment	<p>A modeling study found that alerting drivers to the status of upcoming traffic signals led to smoother decelerations to the intersection.</p> <p>Results showed that the drivers alerted to the red signal 360 m (1200 ft) ahead of the intersection reduced fuel consumption and CO<sub>2</sub> emissions by up to 40 percent for passenger vehicles and 38 percent for pick-ups and SUVs at the posted speed limit of 65 km/h (40 mph). (<a href="#">2011-00751</a>)</p>
Safety Customer Satisfaction	<p>Audible "slow traffic ahead" alerts can improve drivers' situational awareness and increase safety on freeways.</p> <p>The metric measuring variability in speed as drivers approached a queue supported the test hypothesis and confirmed that during the alert week, drivers experiencing the alerts exhibited smoother driving profiles.</p> <p>When the system worked as intended, 83 percent of the alerts received by drivers were rated as either good or neutral, and only 13 percent were rated as bad. (<a href="#">2013-00823</a>)</p>
Energy & Environment	<p>Commercial motor vehicles (CMV) can use Access Management applications such as Pre-Pass to improve motor carrier safety and efficiency. These systems allow participating transponder-equipped commercial vehicles to bypass designated inspection stations and continue to move freight and reduce shipment times. In 2009, Pre-Pass saved an estimated 21 million gallons of fuel for commercial vehicles. (<a href="#">2012-00791</a>)</p>

Table 3: Benefits of In-Vehicle Monitoring.

ITS Goal	Selected Findings
Safety	<p>Participating drivers from two motor carriers (identified as Carrier A and Carrier B) drove a vehicle equipped with a Driving Behavior Management System (DBMS) for 17 consecutive weeks while they made their normal, revenue-producing deliveries.</p> <p>For severe safety-related events, a 59.1 percent reduction in mean rate of severe safety-related events per VMT was observed at Carrier A and a 44.4 percent reduction was observed at Carrier B. (<a href="#">2011-00698</a>)</p>
Productivity Customer Satisfaction	<p>By using an In-Vehicle Data Recorder (IVDR) to enable pay as you drive (PAYD) car insurance, drivers can save up to 60 percent on their car insurance premiums.</p> <p>A Brookings Institution study estimates that 63.5 percent of all households would experience savings with PAYD insurance, and such savings would amount to an average of \$270 per vehicle and \$496 per household, among households that do save. (<a href="#">2011-00717</a>)</p>
Productivity Energy & Environment	<p>Idle-off stop-start systems integrated into vehicle designs can also be monitored by fleet management systems to reduce truck emissions up to 83 percent at truck rest stops. (<a href="#">2012-00791</a>)</p>

# Costs

## Costs and Outlook of On-Board Equipment for Connected Vehicles ([2013-00288](#))

Respondents of the Connected Vehicle (CV) Technology Industry Delphi study overwhelmingly reaffirmed the consensus that Dedicated Short Range Communication (DSRC) is needed for cooperative, active safety systems, while third generation (3G) and fourth generation (4G) cellular communications tend to be thought of as appropriate for other applications.

DSRC was commonly viewed as being standard equipment by 2017. The majority think the applications will be built-in by that point. Below are consensus unit costs to include on-board DSRC equipment in vehicles:

- Cost to Vehicle Manufacturers of Embedded DSRC - In both rounds of the study, when asked how much it will cost vehicle manufacturers (in US\$) to add a DSRC radio as embedded equipment, respondents gave a median response of \$148 to \$175 for 2017 and \$73 to \$75 for 2022. The second round means were \$148 for 2017 and \$73 for 2022.
- Cost Added to Base Vehicle Price for Connected Vehicle Technology - Regarding what connected vehicle technology will add to the base cost (in US\$) of a new vehicle for the consumer, the median in both rounds was \$350 for 2017 and \$300 for 2022. The second round means were \$335 for 2017 and \$260 for 2022.
- Consumer Cost to Add DSRC as Aftermarket Equipment – The cost to the consumer (in US\$) to add DSRC as aftermarket equipment, had a media estimate of \$200 for 2017 and \$75 for 2022. The second round means were \$233 in 2017 and \$113 in 2022.

## Connected Vehicle DSRC equipment and related costs for In-Vehicle Technology and at Intersection technology

In the National Highway Traffic Safety Administration (NHTSA), *Vehicle-to-Vehicle Communications Readiness of V2V Technology for Application Report*, researchers evaluated vehicle equipment cost scenarios including aftermarket devices ([2014-00321](#)), new vehicle installation ([2014-00322](#)), and future cost estimates ([2014-00323](#)). The USDOT in partnership with Transport Canada, AASHTO and in cooperation with other nationwide stakeholders, conducted analyses leading to a preliminary general concept of a national Connected Vehicle (CV) field infrastructure footprint and associated costs including: DSRC Field Infrastructure at Intersections ([2014-00325](#)), Connected Vehicle signal controller upgrades ([2014-00326](#)), and maintenance costs ([2014-00329](#)).

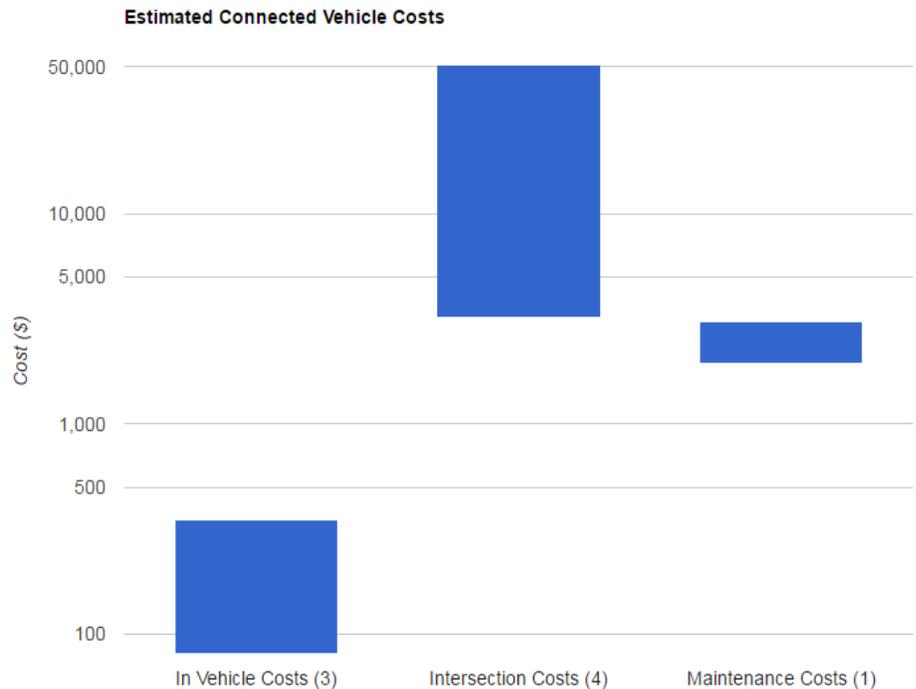


Figure 1: Range of Costs for Connected Vehicle Technologies In-Vehicle and at Intersections (Source: ITS Knowledge Resources).

## Lessons Learned

### Consider New Approaches to Address Distracted Driving when Designing and Developing ITS Applications ([2013-00651](#))

The SafeTrip-21 Initiative advanced knowledge and technological solutions to reduce distracted driving. The U.S. DOT tested a variety of technologies in a number of locations in California as well as along the I-95 corridor on the east coast. Below are some of the lessons learned during the evaluation of the SafeTrip-21 Initiative that focused on improving safety with the deployment of these applications:

- Assess vehicle location, speed and direction along with the ability to predict potential driving path conflicts and transmit alerts to the driver to provide needed capability to minimize driver distraction.
- Communicate alerts designed to orient drivers to general traffic conditions ahead, and therefore, make them more attentive to the driving environment to help reduce driver distraction.
- Use "Geofencing" as an approach to limiting driver distraction.
- Continue to explore avenues for advancements in technology to prevent driver distraction as well as instilling a safety culture mindset to support the goal of a change in driver behavior.

## Case Study – Sampling of Driver Assistance Safety Applications

- **Vision Enhancement, Object Detection - Rear-visibility systems are expected to prevent over one thousand backover injuries each year.** The NHTSA submitted a final rule requiring more stringent rear-visibility standards in light vehicles. Effective June 6, 2014 the regulation requires automakers to phase-in the installation of rear-visibility technology in all light vehicles by May 2018. As part of the Kids Transportation Safety Act of 2007, NHTSA conducted research to evaluate backover crashes and the need for appropriate countermeasures. Research indicated that approximately 210 fatalities and 15,000 injuries are attributable to light vehicle backover crashes each year. Children under five years old accounted for 31 percent of fatalities and adults 70 years or older accounted for 26 percent. The effectiveness of rear-view video systems was estimated to range from 28 to 33 percent which is substantially better than alternative "sensor-only systems" currently available. Applying the estimated effectiveness to the target population, the aforementioned systems were projected to save 58 to 69 lives per year assuming full market penetration by 2054 ([2014-00920](#)).
- **Lane Keeping Assistance - Electronic Stability Control (ESC) saved an estimated 1,144 lives among passenger vehicle occupants in 2012.** ESC systems use automatic computer controlled braking to help the driver maintain control in risky driving situations in which the vehicle is beginning to lose directional stability at the rear or front wheels. The percentage of passenger vehicles equipped with ESC has increased significantly as a result of implementation of the Federal Motor Vehicle Safety Standard (FMVSS) No. 126. As of September 1, 2011, all new passenger cars and light trucks and vans must be equipped with ESC and comply with this standard. In 2014, NHTSA updated ESC effectiveness estimated for personal cars and light trucks and vans. The report, "Updated Estimates of Fatality Reduction by Electronic Stability Control," by Chuck Kahane, provides estimates of 37.8 percent ESC effectiveness for passenger cars occupants and 55.9 percent effectiveness for light truck and van occupants. In 2012, ESC saved an estimated 446 lives among passenger car occupants, and 698 lives among light truck and van occupants, for a total of 1,144 lives saved among passenger vehicle occupants ([2014-00931](#)).
- **Lane Keeping Assistance - Driver Assist System improves bus operations, with bus speeds increasing by 3.5 mph.** In November 2010 as part of its Urban Partnership Agreement for congestion reduction, the Minnesota Valley Transit Authority (MVTA) implemented a Driver Assist System (DAS) for bus shoulder operations on Cedar Avenue (Trunk Highway 77). The DAS is a GPS based technology suite that provides accurate lane position feedback to the bus driver. It includes a head-up display (HUD) mounted at eye level in front of the driver that digitally displays the shoulder boundaries under all weather conditions. The evaluation looked at six broad areas: efficiency/productivity, technical performance, bus driver satisfaction, customer satisfaction, safety, and maintenance. Data were collected with and without DAS features made available to the driver. Researchers reported the following findings. ([2014-00916](#)).
  - All of the drivers drove faster when the DAS was in use, with an average increase of 3.5 mph (5.6 km/h).
  - In the bus driver surveys, 62.5 percent agreed or strongly agreed that the DAS made driving in the shoulder safer.
  - In the bus driver survey, 88 percent agreed or strongly agreed that the DAS was easy to use, and 64 percent agreed or strongly agreed that the DAS made driving in the shoulder less stressful.

- Some drivers indicated that the HUD was distracting. In contrast, the vibrating seat was highly regarded in both the survey and the focus groups.
- A total of 32 percent of bus drivers said their level of confidence in driving in the shoulder was greater when using the DAS, and 60 percent said it was the same.
- **Object Detection - Large trucks with blind spot warning systems have approximately 50 percent fewer safety-critical events.** This study evaluated the effectiveness of blind spot warning (BSW) systems to improve commercial motor vehicle safety. Twenty (20) commercial motor vehicles (CMVs) equipped with BSW systems were evaluated over an 11 month period during normal revenue-producing operations in North Carolina. The BSW system used infrared technology and an array of lasers to create a 3-D detection zone on the driver and passenger sides of the vehicle. LEDs mounted on side-view mirrors were used to alert drivers of objects or vehicles in blind spots. Evaluation data were collected before and after system features were activated on each truck. Potential safety benefits were determined based on operator driving behavior as measured by the rate of involvement in safety-critical events and changes to lane change/merge behavior after the BSW system was introduced. The rate of lane change/merge safety-critical events identified during the baseline and intervention conditions was significantly different. The intervention phase had nearly 50 percent fewer safety-critical events compared to the **baseline phase (2014-00913)**.
- **Object Detection – Full deployment of collision warning systems that have pedestrian detection and full auto brake features have potential to reduce pedestrian fatalities by 24 percent.** Crash data derived from German accident studies from 1999 to 2007 were used by a Volvo Cars Traffic Simulator (VCTS) to estimate the safety benefits of supplementing emergency brake assist (EBA) technology with collision warning systems that have full auto brake and pedestrian detection (CWAB-PD). Results indicated that the addition of CWAB-PD would reduce pedestrian fatalities by 24 percent and save roughly 400 lives each year. (2016-01086).

## References

All data referenced is available through the ITS Knowledge Resources Database, which can be found at <http://www.itsknowledgeresources.its.dot.gov/>.