



# Automated Vehicles – Driver Assistance

## ITS Benefits, Costs, and Lessons Learned: 2018 Update Report

### Driver Assistance

- Navigation / Route Guidance
- Driver Communication
- Vision Enhancement
- Object Detection

### Adaptive Cruise Control

- Connected Eco-Driving
- Intelligent Speed Control

### Lane Keep Assistance

- Roll Stability Warning
- Drowsy Driver Warning
- Precision Docking

### Platooning

- In-Vehicle Monitoring

### Highlights

- Connected Eco-Driving is showing large potential for reduction in fuel consumption and emissions for individual drivers as well as fleets.
- ACC Technologies are becoming more widely available and cost effective allowing more people to realize benefits from the technology.
- Vehicle platooning has great potential to combine several technologies for safety, mobility, and environmental benefits for drivers and the transportation system.

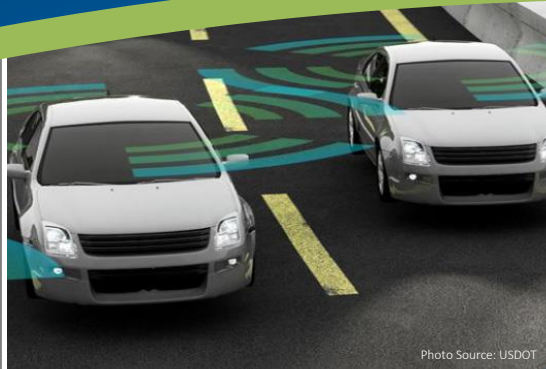


Photo Source: USDOT



Photo Source: Thinkstock

## 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.*

Controlling the speed of traffic flow either on freeways or arterials can have large impacts on the performance of the roadway in terms of mobility and environment. The basic implementation of this is an intelligent speed control system that limits the maximum speed of a vehicle by sending a message from the roadside infrastructure. Going a step further would involve interactions with other vehicles on the roadway to allow them to all follow a similar speed and smooth traffic flow. Adaptive cruise control systems set specific speeds to automatically follow; if there is a lead vehicle, a gap can be set for the vehicle to automatically keep. In the future, new communication technologies and connected vehicles will make vehicle platooning a realistic option. Platooning consists of vehicle platoons where two or more vehicles travel with small gaps/headways, reducing aerodynamic drag. Platooning relies on vehicle-to-vehicle (V2V) communication that allows vehicles to accelerate or brake with minimal lag to maintain the platoon with the lead vehicle. The reduction of drag results in reduced fuel consumption, greater fuel efficiency, less pollution for vehicles, and increased traffic flow.

Connected vehicle technologies and V2V communications allow things like Cooperative Adaptive Cruise Control (CACC) and vehicle platooning to be possible. Vehicles with these technologies can greatly increase mobility, decrease environmental impacts, and with the continuing development of better autonomous vehicle controls, increase safety.

**Partially automated vehicles that use dedicated short-range communication (DSRC) message sets to interact with advanced signal control systems can reduce travel times up to 64 percent.<sup>1</sup>**

Today many high end luxury cars are already equipped with some form of an ACC system. As the technology improves and becomes more economical, it will be seen more often in less expensive vehicle models.

All of these in-vehicle technologies are advanced aspects of eco-driving. Eco-driving is simply changing driver patterns and styles to reduce fuel consumption and emissions. When used in combination with in-vehicle communications, customized real-time driving advice can be given to drivers so that they can adjust their driving behavior to save fuel and reduce emissions. This advice includes recommended driving speeds, optimal acceleration, and optimal deceleration profiles based on prevailing traffic conditions and interactions with nearby vehicles. Feedback may be provided to drivers on their driving behavior to encourage driving in a more environmentally efficient manner. Vehicle-assisted strategies where the vehicle automatically implements the eco-driving strategy such as ACC and platooning are a great way to make eco-driving easier for the driver.

## Benefits

Figure 1 shows safety, mobility, and environmental benefits of these technologies. The ACC and platooning with automated control of the vehicles provides the safety benefits of crash reductions. All of the technologies lead to environmental benefits including emissions reduction (usually of Carbon dioxide) and fuel consumption reduction.

Eco-Speed Harmonization and Eco-Connected Adaptive Cruise Control applications evaluated as part of the AERIS Program show results of up to a 22 percent reduction in energy and a 33 percent reduction in travel time. ([2015-01036](#))

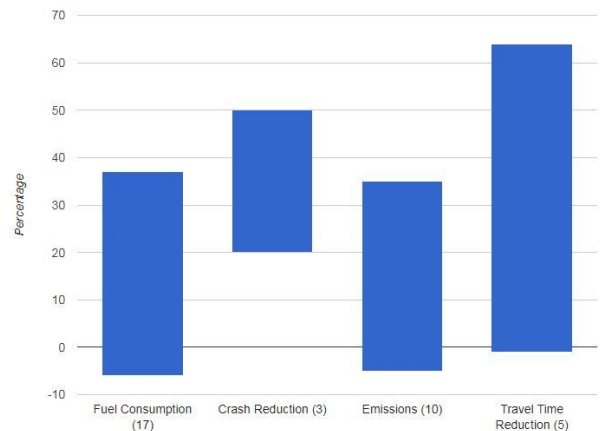
Field testing and evaluation of GlidePath Cooperative Adaptive Cruise Control (CACC) systems installed on partially automated vehicles show these system can improve fuel economy by 17 to 22 percent and reduce travel time up to 64 percent. ([2017-01173](#) and [2017-01203](#)). Other research shows that with increasing market penetration Eco-CACC algorithms with merging protocols can improve freeway capacity by at least two-thirds. ([2015-01036](#))

A part of a connected vehicle field test in Seattle, Washington volunteer drivers equipped with CV technologies saw immediate value in intelligent speed control applications. A survey of 21 volunteer participants who drove DSRC equipped vehicles designed to collect speed and road weather data from other connected vehicles and infrastructure based systems suggested that on-board applications such as queue warning, speed harmonization, and weather responsive traffic management (WRTM) messaging systems enabled drivers to take action in advance of congestion, reducing the need to slow down or stop suddenly. ([2016-01102](#)).

As connected vehicle technology matures, impacts on congestion are expected to be realized first, followed by increasing safety benefits as the technology matures and market penetration levels increase. Simulation models show that a network of connected vehicles that support platoon-based intersection management applications can reduce average travel times by 4 to 30 percent when traffic volume is high. However, on busy arterials platoon based systems may result in slightly higher fuel consumption and emissions compared to non-platooned based vehicles in a multi-agent environment of adaptive signal control due to the added difficulty of forming and handling platoons in heavy traffic. ([2016-01082](#) and [2016-0183](#)).

## Costs

Costs for these in-vehicle systems change rapidly as the technology is changing and improving. Although most options are only available in luxury models, the technology is becoming more accessible as cameras, radar, and laser components get cheaper to manufacture and integrate into new vehicles. Additional features such as automated steering control functions can be a major cost driver. Observations of OEM driver assistance technology pricing over the last few years show these system can add from \$300 to \$10,800 to the purchase price of a new vehicle. Most systems are \$4500 or less. ([2017-00373](#))



**Figure 1: Range of Benefits for Connected Eco-Driving, Intelligent Speed Control, Adaptive Cruise Control, and Platooning (Source: ITS Knowledge Resources).**

*The online versions of the factsheets feature interactive graphs that contain all the data points included in the ranges. Here, each metric has a number after the text, representing the number of data points used to create the range; no number means only there was only one data point.*

# Case Study – Eco-Lanes Operational Scenario Modeling Report

(2015-01036)

This study performed modeling of the Eco-Lanes Operational Scenario defined by the Applications for the Environment: Real-Time Information Synthesis (AERIS) Program. The Eco-Lanes Operational Scenario constitutes six applications that use data available in a connected environment to help reduce fuel consumption and emissions by providing driving feedback and speed advice, and by promoting platooning and dedicated "eco-lanes." Two of the seven applications bundled under the Eco-Lanes Operational Scenario were simulated in this modeling effort: Eco-Speed Harmonization (ESH) and Eco-Cooperative Adaptive Cruise Control (Eco-CACC).

## Methodology

Simulation and modeling of the ESH and Eco-CACC applications was conducted on State Route 91 Eastbound (SR-91 E) in Southern California between the Orange County Line and Tyler Street in Riverside. Traffic demands, vehicle mix, origin-destination (OD) patterns and driver behavior for the SR-91 E model network were calibrated to field data collected on a representative summer weekday. With the Paramics microsimulation tool and the EPA's Motor Vehicle Emissions Simulator (MOVES) emissions estimation tool, individual vehicle movements were modeled per the scenario implemented, allowing for fuel consumption, emissions of vehicles, and average travel times to be accurately estimated. A variety of sensitivity scenarios were modeled, that included varying parameters such as vehicle demand of the network, connected vehicle (CV) on-board equipment (OBE) penetration rate, triggering distance for the Eco-CACC application, and intra-platoon clearance for the Eco-CACC application. Following the individual modeling of the two applications, they were combined to function simultaneously within the same modeling environment to assess their compatibility. A baseline model that assumed no application deployment (i.e., CV penetration rate set to zero) was also developed from the SR-91 E model and used for comparison purposes.

## Key Findings

The modeling study indicated that freeway facilities designed to support dedicated Eco-Lanes in addition to general purpose lanes can give drivers a choice to maximize travel time savings or minimize fuel consumption depending on traffic conditions and individual travel needs.

At lower traffic volumes, the general purpose lanes experienced a greater energy savings than the dedicated Eco-lane because of the small energy needed for platoon formation. In contrast, at the highest traffic volume, the dedicated Eco-lane experienced a greater energy savings than the general purpose lanes because of the increased capacity provided by Eco-CACC applications.

Overall, network benefits ranged from 4 to 22 percent savings for energy and -1 to 33 percent savings for travel time.

## References

[1] "GlidePath: Eco-Friendly Automated Approach and Departure at Signalized Intersections," *IEEE Transactions on Intelligent Vehicles*, Volume 2, Issue 4, Dec 2017, pp 266 – 277.

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