Driver Assistance: Connected Eco Driving, Intelligent Speed Control, Adaptive Cruise Control, Platooning

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

Introduction

This factsheet is based on past evaluation data contained in the ITS Knowledge Resources database at: 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 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.

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.

A research project funded by the Department of Energy evaluated the fuel consumption reduction of a pair of platooned Class 8 tractor-trailers on a test track over a range of highway truck speeds, following distances, and weights that would represent the conditions of driving on public roads. The platooning demonstration system consists of radar systems, Dedicated Short-Range Communication (DSRC) vehicle-to-vehicle (V2V) communications, vehicle braking and torque control interface, cameras and driver displays. The throttle and braking on the rear truck are controlled using a combination of inputs including, but not limited to: radar-measured distance, GPS locations and speeds of both vehicles, lead vehicle wheel-based speed, torque request and braking application. The system does not control lateral position so the trailing truck driver is still responsible for steering, which is a possible source of variation in the tests.

The lead tractor consistently demonstrated an improvement in average fuel consumption reduction as following distance decreased, with results showing 2.7 percent to 5.3 percent fuel savings. The trailing vehicle achieved fuel consumption savings ranging from 2.8 percent to 9.7 percent. Team\textsuperscript{\textdagger} fuel savings, considering the platooned vehicles as one, ranged from 3.7 percent to 6.4 percent, with the best combined result being for 55 mph, 30-ft following distance.  

Recent eco-driving research shows significant fuel savings and emissions reductions. The eco-driving benefits in Figure 1 vary from simply providing eco-driving training to drivers or fleet companies to providing real-time driving feedback to the driver while in the vehicle. Both show great potential for fuel and emissions reduction. One study evaluated the potential of an on-board eco-driving application to help commercial drivers improve engine performance and reduce fuel consumption with auditory and visual alerts. Drivers in the field study with 15 vehicles from 7 companies reduced fuel use on average of nearly eight percent (2014-00941).

Costs

Costs for these in-vehicle systems change rapidly as the technology is changing and improving. For example in 2006 it was estimated that on luxury vehicles ACC systems cost an additional $3,000 (2008-00175). Today for the most advanced ACC system in one luxury vehicle the cost is estimated at $2,000. This system would include features like automatically slowing the vehicle down if an issue ahead is detected and giving audio or visual warning to the driver to retake control of the speed of the vehicle. The system also works at any speed. The same auto manufacturer also offers a $500 ACC system with basic features that works at speeds 25 mph and higher [2]. That is over an 80 percent decrease in price in 7 years.
Case Study – Safe Road Trains for the Environment (SARTRE)

The overall concept of Safe Road Trains for the Environment (SARTRE) is to have a group of vehicles driving together with a lead vehicle, driven normally by a trained professional driver, and several following vehicles driven fully automatically by the system with small longitudinal gaps between them. Driving in this way, in a platoon, brings benefits in fuel consumption, safety and driver convenience. In addition to investigating the concept, a demonstrator system has been developed consisting of five vehicles: a lead truck, a following truck, and three following cars. An offboard system has also been developed to allow a potential SARTRE driver to find, and navigate to, a suitable platoon, although this has not been fully integrated into the vehicle system.

The project investigated the human factors aspects of platooning from the point of view of the lead driver, the following drivers, and the other road users. The demonstration system has been successfully tested on test tracks and public motorways, and demonstrated to industry stakeholders as well as members of the press. Using these vehicles, the fuel consumption benefits of platooning have been measured. The SARTRE project measured the fuel consumption individually for each vehicle in order to compare it with the fuel consumption while platooning. The distances tested for the full platoon system were 5, 6, 7, 8, 9, 10, 12, and 15 meters. A two-truck platoon was also tested at 20 and 25 meter gaps. Measurements of the fuel consumption are not available for cars in the full platoon system at gap sizes of 7 meters and below.

The results show that there is an important decrease in fuel consumption when platooning at shorter distances. For example, the following truck saw the highest fuel savings of 16 percent at a gap of 5 meters. When the gap was increased to 15 meters, the following truck still showed fuel savings of just over 8 percent. The following vehicles fuel savings ranged from 15 percent at a 7-meter gap to just over 4 percent at a 15-meter gap. This behavior follows a similar trend to what has been previously researched and also similar to that of the simulation results. Figure 2 shows all of the results by gap distance and vehicle location.

Figure 2: Percentage of fuel savings of each vehicle in the platoon at varying gaps (Source: SARTRE Final Report).
References


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