DRISI
Caltrans Division of Research,
Innovation and System Information

Research Results

Partial Automation for Truck Platooning

Examine the potential to improve freight operations in California by developing, testing and demonstrating three-truck platoons.

Advanced Research

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Project Title:
Partial Automation for Truck Platooning

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WHAT IS THE NEED?

FHWA awarded grants under the Exploratory Advanced Research (EAR) Program for research projects that could lead to transformational changes and revolutionary advances in highway engineering and intermodal surface transportation in the United States. Truck platooning was one element of the solicitation and the subject of a recently completed EAR Program supported research project led by California PATH.

Earlier research, discussions during the Transportation Research Board (TRB) Vehicle Automation Workshop, along with related Defense Department research results, suggest that truck platooning could lead to significant safety, mobility, emissions, and energy efficiency benefits in the highway system. As the platooning concepts can be realized at different levels of automation, a progressive path toward deployment can be envisioned.

Caltrans sponsored the grant application at the request of Gateway Cities Council of Governments and Los Angeles Metro who are seeking ways to increase truck throughput and at the same time reduce congestion and mitigate environmental impacts (primarily air quality). The results of the project are intended to lead to technology enhancements of the dedicated truck lanes that are planned for the I-710 first and then be adapted more broadly to the entire Southern California Region.

WHAT WAS OUR GOAL?

Successful development, demonstration and experiments with closely spaced three-truck platoons through the integration of commercially available ACC systems with high-speed vehicle-to-vehicle communications.

WHAT DID WE DO?

The project investigated the potential to improve freight operations by building on previous research and development of two-truck platoons to develop and test three-truck platoons. "Platooning" is where groups of trucks (or cars or buses) operate in a coordinated manner in a close-spaced formation.

Vehicle-vehicle (V2V) dedicated short-range communications communication (DSRC) radios were added to trucks equipped with factory adaptive cruise control (ACC) technology. The addition of truck-to-truck communications with ACC creates a cooperative adaptive cruise control (CACC) system. The high-speed communications allows the trucks to "talk" to one another and coordinate both braking and acceleration. This in turn allows trucks to safely follow each other more closely and accurately than they otherwise could, giving the trucks the capability to speed up and slow down as a unit (almost like a train).

Phase one of the project began with an identification of the trucking industry needs that could be served by application of CACC for truck platooning. Outreach was performed both locally in the I-710 corridor and more broadly at the regional and national levels by gathering inputs from major fleets. Based on those needs, concepts of operation for truck platoon operations were defined and then simulated to understand their relative strengths and weaknesses. Particular attention was given to identifying ways in which the roadway infrastructure can support the truck CACC functionality, especially in dedicated truck lanes such those planned for I-710. These initial assessments of the operating concepts and their influences on traffic flow and energy consumption were completed during the second year, supporting the decision about proceeding into the subsequent experimental phase.

Phase two of the project was devoted to designing and developing the truck CACC system, starting from the existing Volvo production ACC system and DSRC communications and the truck platooning work of the European SARTRE project. The control design was simulated on the computer and driver interface concepts were evaluated on a driving simulator before being implemented on the test trucks. The three-truck platoon was equipped and tested to verify reasonable performance.

In phase three, the project team explored four potential benefits of heavy truck platooning: increased throughput from shorter gaps between vehicles, reduced fuel consumption due to improved aerodynamics, emission reductions from reduced fuel consumption and safety improvement due to high-speed communication and coordinated maneuvering. The project team also investigated commercial vehicle driver acceptance of the heavy truck CACC system, primarily the comfort level of drivers based on the smaller than normal gaps between vehicles.

The results of those tests were then modeled and used as inputs to develop new simulation estimates of benefits, which were presented to the stakeholders and the broader public as part of public demonstrations of truck platooning. The first demonstration was at the ITS America Annual Meeting in San Jose, CA. A second demonstration was held in Southern California, in collaboration with the Gateway Cities I-710 project. A third demonstration was held in September 2017 in the Washington DC area.

Under this project the three truck platoon was driven 5,500 miles in live traffic on the State Highway System at 55 mph without any incident. An additional 2,500 miles were driven on a test track for fuel consumption experiment. The combined incident free mileage driven with CACC assistance was nearly 8,000 miles.

WHAT WAS THE OUTCOME?

The results from project experiments and computer simulation showed that trucks using CACC systems could be operated in a coordinated fashion and the space between trucks could be reduced in a safe manner. Short spacings and coordinated truck operations have the potential to reduce fuel use and both criteria pollutants and greenhouse gases by up to 14%. Using the results from the truck development and testing in simulations show that significant increases in freight throughput can be achieved (increasing the number of trucks per lane per hour).

While fully automated trucks are not likely to be commercially available and on public highways for many years, cooperative adaptive cruise control (CACC) is the next step in the development and deployment of driver assist partial automated systems. CACC sytems could start being deployed and the benefits of truck platooning operations realized within the next few years.

Based in large part on the results from this project, the Federal Highway Administration is moving forward with plans to fund additional development and operational tests of truck platoons in actual freight operations.

WHAT IS THE BENEFIT?

Successful integration of adaptive cruise control (ACC) with Vehicle-vehicle (V2V) DSRC communications has produced a cooperative adaptive cruise control (CACC) system that can reduce fuel use and emissions, improve traffic flow stability and increase highway capacity, all while maintaining a high level of safety. The V2V communication capability also enables the trucks to coordinate their maneuvering so that the lightest or most agile trucks can automatically moderate their maneuvers to match the more limited capabilities of the most heavily loaded trucks, improving safety. The V2V communications provide advance warning of problems that any of the cooperative trucks may encounter so that the other trucks are alerted in advance of the need to respond in order to maintain safety. These modest levels of truck platooning capability can be deployed relatively quickly and easily and could act as precursors for future implementation of more advanced forms of truck platooning.

The project has been successful in quantifying actual reductions in fuel use from fuel consumption experiments performed in partnership with Transport Canada (Canada's Department of Transportation). Tests at their test facility showed fuel savings ranging from 5 percent to 14 percent, based on a number of factors including the gaps between trucks.

The modeling and simulation work identified potential benefits to both highway operations and freight operations by allowing the trucks to safely travel closer. Freight throughput could theoretically double and the vehicle to vehicle coordination smoothens traffic flow which will improve highway operations by reducing congestion.

LEARN MORE

https://path.berkeley.edu/research/connected-and-automated-vehicles/truck-platooning