SWZDI
Smart Work Zone Deployment Initiative

Investigation of Autonomous/Connected Vehicles in Work Zones

tech transfer summary

To maximize safety and efficiency when deploying autonomous truck platoons near work zones, it is important to educate the public on proper driving behavior around the platoons.

Background

Autonomous truck platooning refers to a system by which multiple trucks can follow a leading truck using technology such as cooperative adaptive cruise control (CACC). Anticipated benefits include a shortened headway resulting in more efficient use of existing capacity and reduced fuel usage via drafting.

Government and public agencies, including the Federal Highway Administration (FHWA), as well as private trucking companies with fleets, are exploring autonomous truck platooning. Since the US relies heavily on trucking, the expectation is great that such a system can transform the current freight system.

Problem Statement

Because truck platooning is a new technology that is being developed, its potential impacts on surrounding traffic is unknown. Even more challenging is the deployment of such a system in work zones given they can involve various atypical roadway and geometric configurations, including lane drops and the reduction of lane width and shoulders.

Research Description and Goal

It would be beneficial to investigate and anticipate potential issues in preparation for widespread deployment of such systems in the US. Some of the issues include the effectiveness of public education, the use of rear mounted signage on trucks, and the number of trucks in a platoon. The goal of this research was to discover the driver behavioral effects of public education, truck-mounted signage, and the number of trucks in a platoon.

Example of truck signage investigated

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RESEARCH PROJECT TITLE
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The Smart Work Zone Deployment Initiative (SWZDI) is a transportation pooled fund that supports research investigations into better ways to improve the safety and efficiency of traffic operations and highway work in work zones. The primary objective is to promote and support research and outreach activities that focus on innovative practice-ready policies, processes, tools, and products that enhance the implementation and constructability, safety, and mobility impacts of all types of work zones. The fund is administered by Iowa State University's Institute for Transportation, and the lead agency is the Iowa Department of Transportation.

IOWA STATE UNIVERSITY
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Research Methodology

A networked or federated simulator system was used to investigate the issues surrounding truck platoons in work zones. The simulator system was composed of a driving simulator that allowed the detailed analysis of human driver behavior. The system also involved a trucking simulator that replicated realistic human driving to mimic the leading truck in a truck platoon.

The experiment scenarios involved a human subject driving in a lane that was to be closed when approaching a work zone. As the human subject approached the work zone, they encountered a truck platoon in the lane that would remain open. The subject would need to change to the open lane while deciding whether to bypass the platoon or follow it through the work zone.

The table lists the 10 scenarios encountered by each human subject in the experiment, and the order used for each combination was randomized to avoid sequence bias, also known as learning bias. As shown, the scenarios involved the following:

- Either lack of or delivery of education
- Either 2 or 4 trucks in a platoon
- One of three different sign options: no sign, Truck Platoon, or # of Trucks

Certain scenarios were always presented before others. No Sign scenarios 1 and 2 were always given to participants first. The concern was that, once the subjects had seen the signage, they would retain the mental picture of the signage.

Post-education scenarios came after all pre-education scenarios were completed. Again, the concern was that, once a subject had been educated, they would retain that knowledge.

Education referred to the experiment host explaining to the human subject the meaning of truck platoon and the signage. The following standardized script was read to ensure uniformity in the information delivered to each human subject:

"A 'platoon' means that a team of vehicles are travelling together, and they interact with each other within the platoon. A truck platoon means these trucks are moving together as a team. The display on the back of the trucks indicates either trucks are in a platoon, or the number of trucks in this platoon."

A post-simulator survey complemented the simulator results by asking participants questions about their preferences.

Key Findings

Some noteworthy quantitative results and analysis are as follows.

The use of education resulted in a 12.9% increase in speed and 30% decrease in headways (which increase capacity) for the two-truck platoon and an 8.6% increase in speed and 28.8% decrease in headways for the four-truck platoon. Thus, regardless of the number of trucks in a platoon, education led to an increase in speed even though the speeds were still around the work zone speed limit of 50 mph.

Given that education led to a decrease in headways, one interpretation is that knowledge of truck platooning leads to drivers driving more efficiently through a work zone.

The use of truck signage resulted in a 6.4% to 17.8% increase in the number of vehicles that bypassed the platoon. Thus, drivers understood the truck signage and acted in an, arguably, undesirable fashion.

Simulator scenarios

Scenario	Education	Number of Trucks	Sign	Order
1	No	2	No	Randomized
2	No	4	No	
3	No	2	Truck Platoon	Randomized
4	No	4	Truck Platoon	
5	No	2	2 Trucks	
6	No	4	4 Trucks	
7	Yes	2	Truck Platoon	Randomized
8	Yes	4	Truck Platoon	
9	Yes	2	2 Trucks	
10	Yes	4	4 Trucks	

Despite the increase in the percentage of bypassing vehicles, the knowledge of the platoon might prevent drivers from cutting into the middle of a platoon. However, there were no significant vehicle cut-in data from this experiment to validate this hypothesis.

It was interesting to analyze the increase in bypassing in conjunction with the post-simulator survey results. While 94% of the subjects indicated that they believed it was safer to follow than to bypass, 34% replied that they would nonetheless choose to bypass the platoon, as was also found in the driver behavior in the simulator experiment.

In terms of the type of sign message—Truck Platoon versus # of Trucks—no significant difference was found in driver behavior, although 78% of the subjects indicated that they preferred the # of Trucks sign.

Implementation Readiness and Benefits

Even though widespread deployment of truck platooning is still in the future, transportation departments can proactively work with transportation companies to develop policy and guidance concerning truck platooning near work zones.

Going back to the issue of education, it would be important to not only educate on the meaning of a truck platoon but also how to drive safely near a platoon, especially in the context of work zones. Early public education and outreach could help to facilitate the co-existence of platoons with regular traffic.