NATIONAL LABORATORY OF THE ROCKIES

Analysis of Truck Platooning on Rural Highways

Tyler Christeson and Michael Lammert

Key Takeaway

On rural Ohio highways, platooning technology operated for 40% of observed driving distances, which could result in savings of about $1,200 (or 319 gallons of diesel) per year. It shows potential to further increase cost savings through reduced gap distances and increased system usage. The demonstration also showcased platooning's potential to enhance freight efficiency and safety.

Figure 1. Photo from Ohio Department of Transportation

The National Laboratory of the Rockies (NLR) partnered with the Ohio Department of Transportation's DriveOhio, the state's center for smart mobility, to analyze the effectiveness of truck platooning technology on Ohio's rural highways. Platooning electronically connects vehicles through sensors and direct communication links, allowing them to travel more closely together in the same lane and reducing aerodynamic drag on the trailing vehicles. Platooning can increase both fuel savings and safety, as the following truck will brake in conjunction with the lead vehicle in the case of a cut-in or emergency event, reducing driver reaction delays.

Between May 17, 2023, and February 6, 2024, the Ohio Department of Transportation partnered with EASE Logistics to test Class 8 tractor platooning technology. The trucks operated on routes ranging from urban to rural environments, and one-lane roads to multilane interstate highways.

NLR analyzed 10-Hz data on the two vehicles—International Motors LLC tractors—using Bosch's prototype truck platooning system. The two tractors had a combined 24,422 vehicle-miles across 54 days of operation, resulting in an average of approximately 226 miles traveled per day per vehicle. Due to permit requirements from the state patrol, the system was set for a 180-foot following distance. While this distance does not allow for maximum energy savings, it allowed for a demonstration of the robustness of the system.

Platoon Engagement Analysis

Platooning engagement status refers to whether the prototype platooning system is electronically linking the trucks (engaged), or if the trucks are operating only under driver control (disengaged). Because the vehicles did not always have the same delivery destinations, engagement of the truck platooning system varied. The distribution of platoon engagement as a percentage of total daily distance is shown in Figure 2.

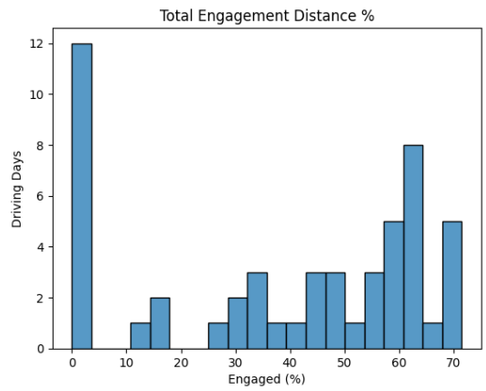

Figure 2. Distribution of engagement percentages of daily distance driven

To understand when the trucks would most likely engage the platooning system, the operations data were split into multiple speed brackets. Figure 3 shows the platooning engagement of the vehicles as a percentage of the daily distance driven, while at a given speed.

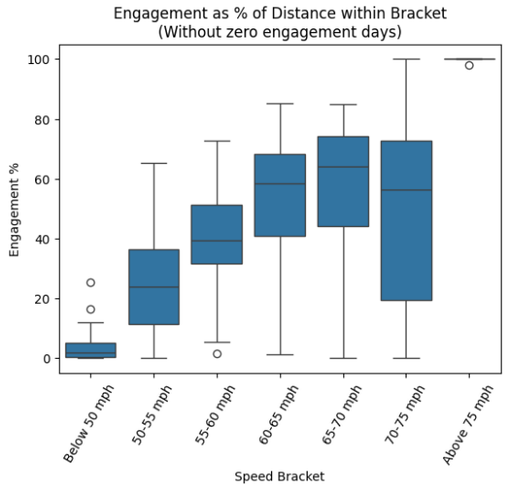

Figure 3. Engagement percentage of distance within each speed bracket

The platooning system is more often engaged while driving at higher speeds (greater than 55 mph), as the system is designed for highway use and the platooning aerodynamic benefit increases with speed. Additionally, highway driving segments allow the trucks to maintain a steady speed and following distance with fewer interruptions than on surface roads. Interruptions to platooning engagement force the driver to take control, as the trucks are no longer in steady-state operations. This can increase fuel consumption as the platoon attempts to reengage to enter steady state after the interruption and, if such events are common, can cause the drivers to choose not to use the system.

Energy expenditure of the trailing truck was calculated to determine if these tractors were experiencing the improved fuel savings benefits of platooning. Figure 4 shows the energy consumed by the trailing truck in platooning formation (engaged) and outside of the platoon (disengaged).

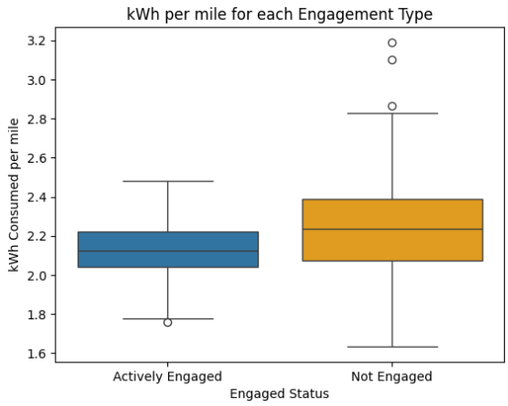

Figure 4. Daily energy consumed in kWh/mi of trailing truck while engaged and disengaged

NLR calculated the daily energy consumption in kilowatt-hours from the engine torque and speed J1939 CAN messages and normalized by daily miles in each engagement status. Figure 4 illustrates that the average energy consumption of the trailing truck was 0.109 kWh/mi lower than while not platooning, although the range of values has significant overlap. Assuming $3.76/gal, the average U.S. diesel price per gallon in 2024, and an average thermal efficiency of 33%, this difference in energy use results in a cost savings of approximately $0.034/mi. Considering 40% of miles with platooning engaged in this deployment, that would result in savings of about $1,200, or 319 gallons of diesel per year. Given that this study did not aim for maximum energy savings, this result underperforms typical expectations of platooning benefits; however, reducing the gap distance and increasing the system usage rate could significantly increase fuel savings.

To evaluate the area of operation where platooning was most beneficial to fuel savings, the data were split into the same previous speed brackets, the results of which can be seen in Figure 5.

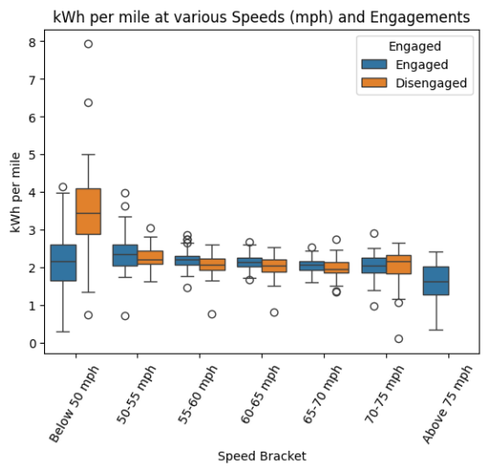

Figure 5. Daily energy consumed in kWh/mi of the trailing truck while engaged and disengaged at various speeds

The impact to fuel savings from platooning engagement at highway speeds does not appear to be discernable in this dataset, likely due to a combination of the 180-foot following distance and variety of road segments, cargo mass, traffic, and weather variables included in the aggregated dataset. The longer following distance likely increases the impact of the other exogenous variables, as the wake providing aerodynamic benefit to the following truck becomes less stable at longer distances. The differences in energy shown in the lowest speed bin are driven in part by system operating requirements, as the platooning system is not engaged during the lowest and most energy-intensive speeds. A more controlled analysis of energy impacts on specific segments of road, or a controlled A-to-B experiment on fuel savings, would be needed for definitive answers.

Geospatial Analysis

Beyond observing the fuel economy benefits of platooning, NLR also identified routes where the trucks were regularly using the platooning capability. Figure 6 illustrates the routes for these vehicles, with blue lines indicating that platooning was used and red lines indicating that the platooning system was never used. Some of these red areas around Columbus, Ohio, are smaller towns, highways not meeting system parameters, or possibly areas of heavy traffic in the Columbus metro zone.

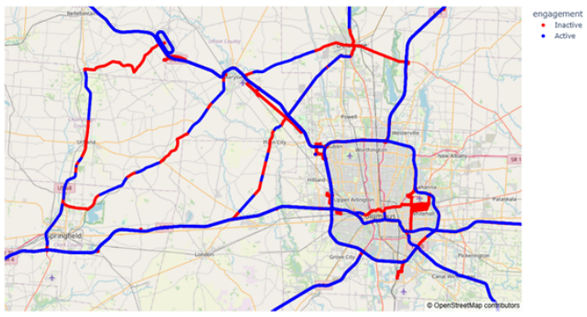

Figure 6. Vehicle operations in the Columbus metro zone

These types of maps can give insight into where platooning is most feasible and where it may be more challenging to implement for improving the fuel savings of heavy-duty vehicles without further technology advancements. Challenges can include traffic congestion, road conditions, or driver preference in that area, though specific reasons were not given by the operators.

Conclusion

Platooning promises to improve the fuel savings and safety of heavy-duty vehicles if the system can be broadly deployed on all types of routes on which Class 8 trucks operate. This analysis revealed that platooning is used less in urban areas but showed the robustness of platooning functionality over varied highway driving environments, with platooning engaged in about 40% of driving distance while deployed in commercial service. Significant cost savings can be realized through platooning, especially through reduced gap distances and increased system usage. Future work should look to add fuel rate signals to provide a more direct fuel consumption measurement, as well as expand the operating environment to explore more use cases.

This work serves to evaluate the effectiveness of platooning technology for commercial freight operations on a wide range of routes and highway types and to further identify situations where platooning may be of benefit to commercial freight operators.

Acknowledgments

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National Laboratory of the Rockies
15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nlr.gov

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