Transportation Consortium of South-Central States (Tran-SET)

Investigating the Impacts of Truck Platooning on Transportation Infrastructure in the South Central Region

Investigating mobility, environmental, safety, and pavement impacts of truck platooning through a series of modeling case studies

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Providing an efficient movement of freight is a critical component to the economy of the U.S.– especially to states in Region 6 (AR, LA, NM, OK, and TX). Truck platooning is a connected and automated vehicle (CAV) application of interest to the freight industry due to its potential energy savings, safety benefits, and ability to reduce highway congestion. However, the short following distances maintained between trucks and more precise lane-keeping lead to a higher concentration of load on the transportation infrastructure. It is unclear how these greater weight concentrations and new load configurations will impact traffic operation, traffic safety and the deterioration of pavements. The main objectives of this study are: to examine the operational, environmental (fuel savings, emissions), and safety impacts of various truck platooning configurations through a series of modeling case studies at both the corridor- and network-level and impacts on the structural pavement resulting from these truck platooning implementations using finite element (FE) modeling.

Background

Connected and automated vehicle (CAV) technologies offer potentially transformative societal impacts, including significant mobility, safety, and environmental benefits. One CAV application of particular interest to the freight industry is truck platooning. Truck platooning describes several trucks equipped with CAV technology closely following one another in a "platoon." Benefits of truck platooning include energy savings from aerodynamic drag reduction, reduced highway congestion due to short following distances, and safety improvements from faster reaction times and automated support systems

Self-driving truck technology is continually being developed and will grow increasingly available on public roadways. Even though this technology is not available to the public, it is envisioned to include short following distances and accurate lateral positioning (i.e., limited lateral wander). It is unclear how these greater weight concentrations and new load configurations will impact the deterioration or damage to pavements. Also, it is unclear what will be the impacts of truck platooing on traffic safety at different traffic conditions. Addressing this uncertainty is critical, especially considering the current state of severe financial constraints in which not all state-owned infrastructure can be maintained.

Project Summary

The main objectives of this study are to : (i) quantify the operational (network delay), environmental (fuel savings, emissions), and safety impacts of various truck platooning implementations, configurations at both the corridor- and network-level through a series of modeling case studies located in Region 6, (ii) quantify the impact on structural pavement layers and long-term performance resulting from truck platooning using finite element (FE) modeling; and (iii) implement feasibility study to compare the (potential) operational, environmental (fuel savings, emissions), and safety benefits of truck platooning with the (potential) increase in maintenance costs associated with the limited tire wandering. The study recommended optimal platoon size based on the economic feasibility analysis to reduce the overall cost and adverse impacts of platooning on the network.

Status Update

A detailed literature review was conducted to figure out the appropriate platooning configurations for scenario development. From the literature review, performance indicators for traffic operation, environment, and safety were selected. The scenarios with truck platooning were simulated using Vissim. Figure 1 shows the percentage change result of the indicators from the reference scenario.

A network-level simulation was performed to capture the effects of truck platooning on I-35 in

Austin. Flow density curves for different platoon size and market penetration rates were established (Figure 2).

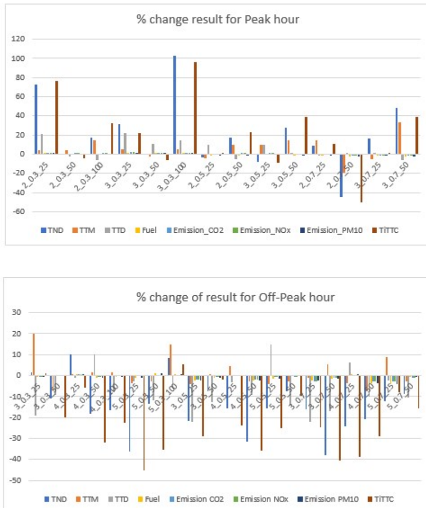

Figure 1. Percentage change result visualization for Peak and Off-Peak hour.

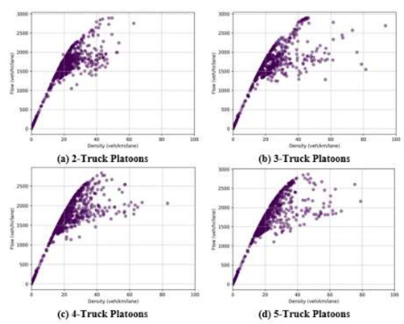

Figure 2. Flow-density plots for different platoon sizes.

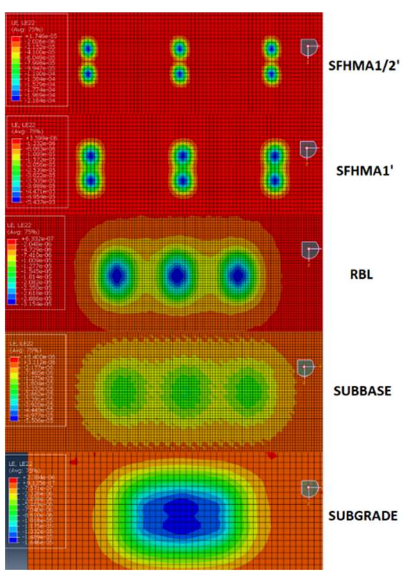

Figure 3. Vertical strain at the mid-depth of pavement layers.

The impact of truck platooning on the pavement were simulated using the elastic and dynamic-viscoelastic finite element method (FEM) models. The mechanical response obtained from the simulations was implemented to predict platooning effects due to limited wandering (lateral movements of truck tires).

Impacts

The corridor-level analysis found that the truck platooning deteriorates traffic operations and safety during peak hours. On the other hand, it performed very well in the off-peak hour period, where most of the scenarios were observed to improve traffic operation, environment, and safety impacts. The network-level analysis showed a stable traffic flow as the platoon size decreases and the market penetration rate increases. The finite element method study concluded that wandering could affect fatigue life and permanent deformation damage, which can impose significant maintenance costs on road networks. Compared to the normal distribution, The permanent deformation (rutting) value over a fixed period increased by a factor of 1.2 to 2.9 and the fatigue life can be reduced in the range of 13.9% to 34.5%,

An economic feasibility analysis was performed to quantify the operational, environmental, and safety impacts of platooning. This analysis recommended a smaller platoon size during peak hours and a larger platoon size during off-peak hours. Most of the scenarios performed poorly in peak hours with an overall higher cost than the reference scenario. The analysis also confirmed a range of 13% to 46% increase in present construction-maintenance cost due to pavement damage if fixed-path wandering is implemented in the truck platooning.

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

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