Impact of Autonomous Truck Platooning and Driver Assist on Trucking Operations

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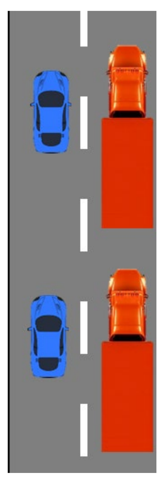
Freight Automation with Autonomous Trucks can be Optimized on Multiple Fronts

Truck Fuel Consumption

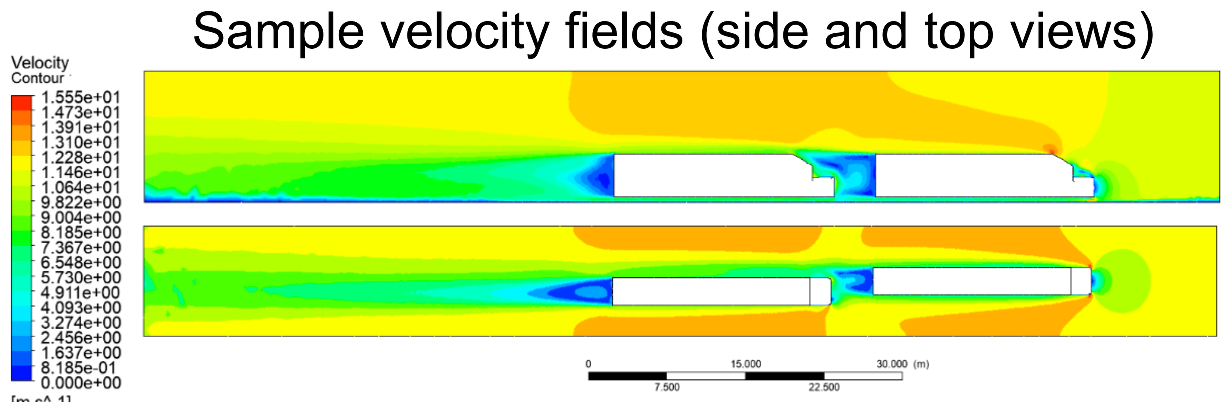


Truck platoons could **change their fuel savings** by altering their platooning configuration, i.e., spacing between consecutive trucks and truck positions within the lane.

Surrogate-based fluid dynamics model for truck platoons was trained by dataset obtained from CFD simulations.

CFD simulation
Given the parametric model of trucks, average drag coefficient of truck system could be obtained by CFD analysis.

Sample velocity fields (side and top views)



Surrogate-based model
After obtaining different set of data (truck parameters, drag coefficients), a **machine learning model** was developed to predict the average drag force for the unseen scenario.

Result Summary of Different Surrogate Models

Method	Prediction Error
Linear Regression	19.21%
Gaussian Process	7.78%
Generalized Additive Model	4.53%

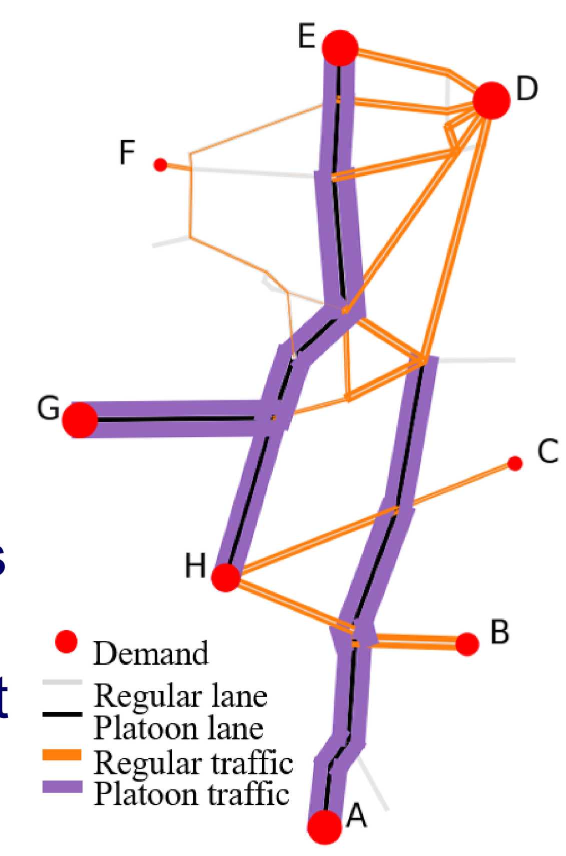
Network Optimization

Operation cost can be optimized using both agency and user costs. The optimization would result in connected freight efficiency increase and infrastructure life enhancement.

Bi-level model network framework was built to support autonomous and connected truck platoons to enhance efficiency and sustainability of highway-based freight transportation.

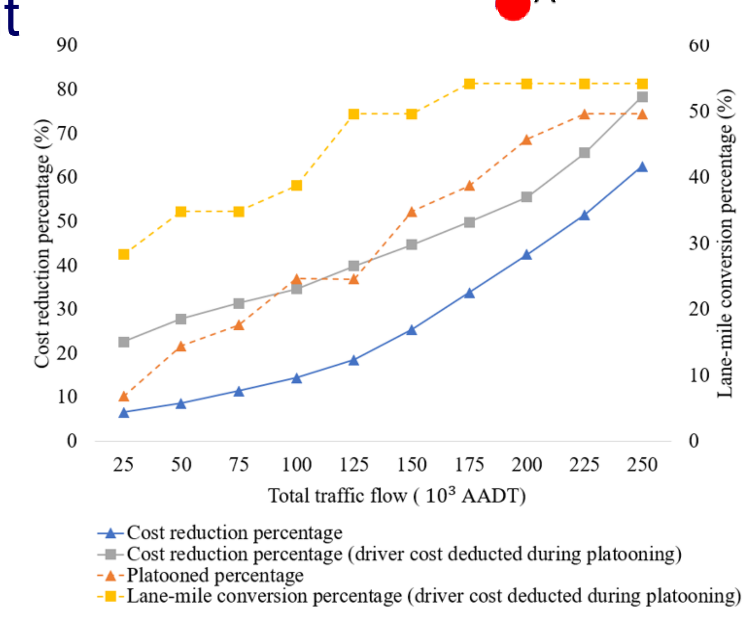
- Upper-level: **Network design model** that optimizes the *layout* of platoon subnetwork and *toll fee*
- Lower-level: **Traffic assignment model** that determines *link flow* in the network at *traffic equilibrium*

Network Optimization

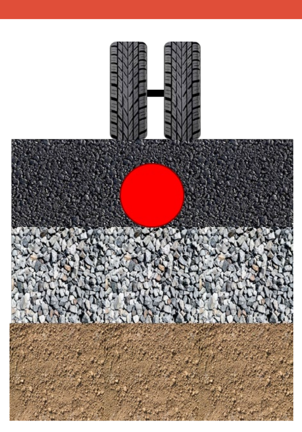


A **generalized link travel cost function** is development for platooned trucks that minimizes fuel consumption and pavement preservation cost through an optimal platoon configuration and pavement rehabilitation scheduling strategy.

Study showed **Illinois freeway network** truck platoons manifest strong economy of scale and improve systemwide efficiency and sustainability.



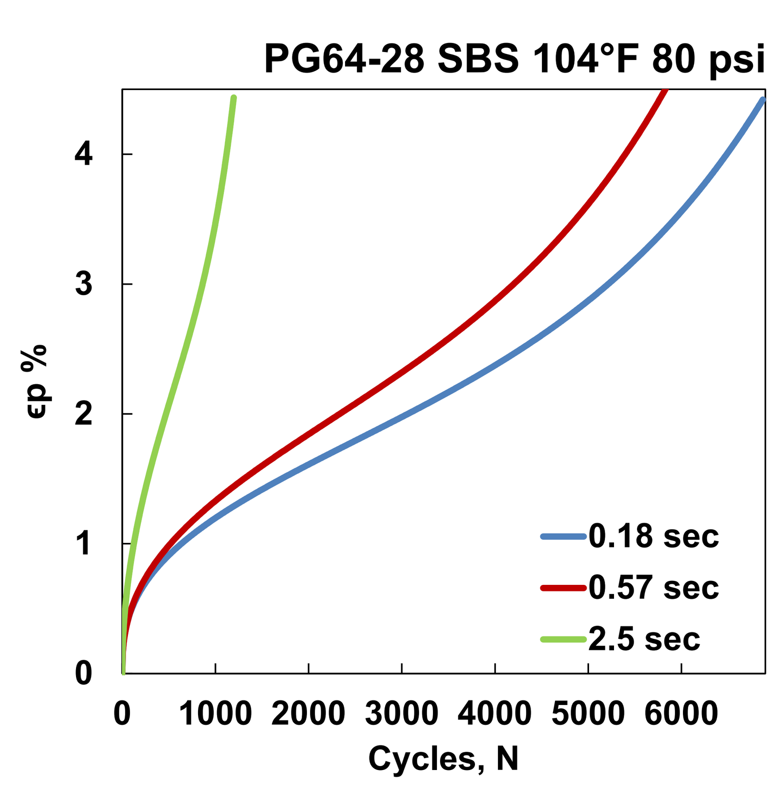
Pavement Damage

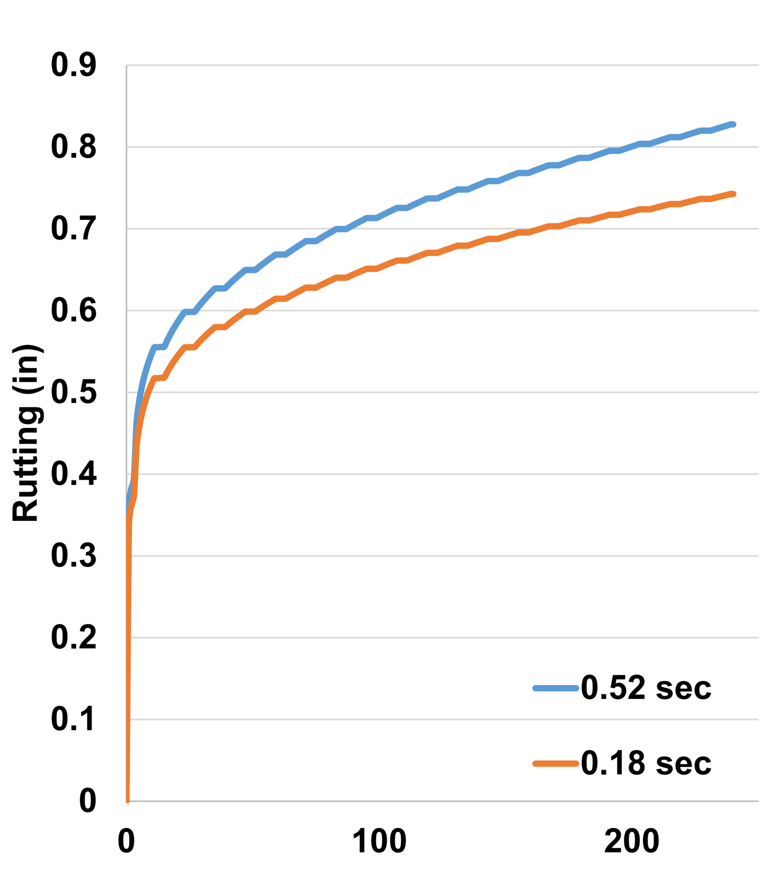


Pavement infrastructure may be impacted by connected trucks. Closely-spaced trucks would result in channelized loading causing pavement rutting.

Permanent Deformation Models were developed using triaxial experiments to identify the effect of rest period on different types of asphalt concrete mixes.

Permanent deformation increased with the rest period due to **hardening-relaxation mechanism.**





Master curves for rest period was obtained using experimental data.

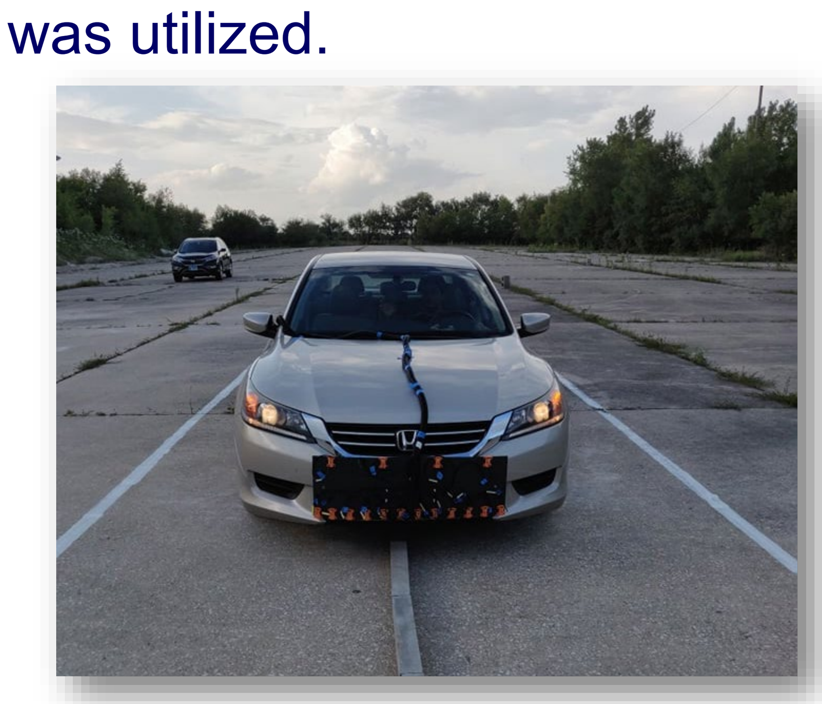
Rest-period shift factors were used to compute the equivalency factors for **various platooning scenarios.**

Pavement Passive Sensing

Lane positioning systems can be improved by placing electromagnetic (EM) sensing materials in the pavement surface. Change in EM field would indicate lane position.

Advanced Lane Positioning System, using passive sensing of EM waves, was utilized.

Top few inches of pavement was modified to create a **continuous EM signature** that accurately determines vehicle lateral position within the lane.



EM signatures on the road are detected in normal and adverse weather conditions by a sensor array mounted to the vehicle.