PROJECT SUMMARY

Cost/Benefit Analysis of Fuel-Efficient Speed Control using SPaT Data

Project Location:
Connected Corridor (TH-55)

Start – Finish Date:
August 2020 – March 2023

Project Status:
Complete

Project Partners:
University of Minnesota

MnDOT Project Cost:
$219,000

Projects with Similar Characteristics:
Connected Corridor
SPaT and MAP Data Sharing

Technical Summary Link:
https://mdl.mndot.gov/items/2023306TS

Project Description:
MnDOT's Connected Corridor project in 2020 contributed to progress in the development and deployment of technology for vehicle-to-infrastructure communications. Using signal phasing and timing (SPaT) data from signalized intersections to control driving speed, this project completed a cost benefit analysis for use of SPaT data in connected vehicles (CVs) and its effect on fuel efficiency. The analysis was performed by:

- Outfitting four vehicles with communications and tools to record SPaT data, geometric lane data, vehicle trajectories, and speed / acceleration profiles.
- Developing a traffic flow prediction model and speed control method from the previously collected data which could predict upcoming traffic and calculate the vehicle's optimal speed to minimize fuel consumption.
- Re-driving the test corridors to refine the model and speed control method.
- Performing laboratory testing to predict and evaluate fuel savings from CVs driving the corridor.

The analysis was completed for diverse traffic scenarios at different CV market penetrations ranging from 10% to 90%.

Project Objective:
The objective of the project was to gain an understanding of the impact on fuel consumption when signal phasing and timing (SPaT) data broadcasts interacted with connected vehicles (CVs) to control speed along connected corridors by minimizing stopping, starting, and acceleration through the corridor.

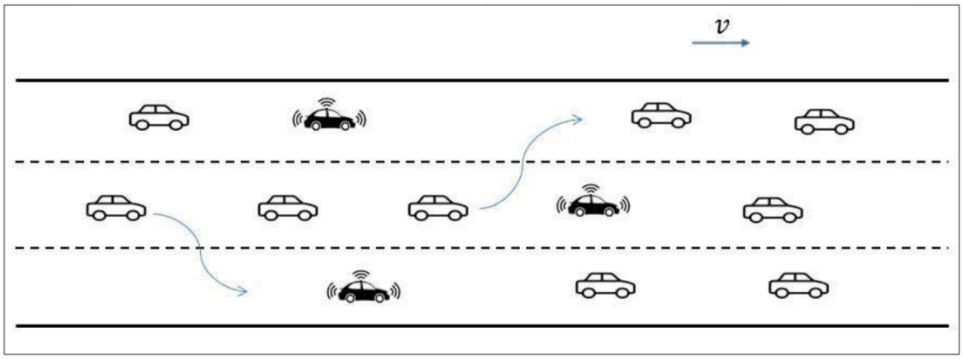

Figure 1: Illustration showing that the traffic flow prediction model factors in realistic lane-changing behavior into the traffic models.

Project Accomplishments:
- Successfully determining SPaT impacts to CV fuel efficiency.
- Successfully determining the monetary benefit of additional SPaT data unit installation compared to the cost of fuel savings.

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Key Findings:

Realistic Traffic Flow Sample Data Results

Using realistic traffic flow samples for testing the traffic flow prediction model and speed optimization method in the connected corridor displayed an approximate 12% fuel savings in CVs.

Lab Testing Results

Using the co-optimization method, traffic flow prediction model, and speed control method in the lab displayed an approximate 11% fuel savings in CVs compared to the base vehicles.

CV Market Penetration Impact

The simulation methodology showed an increase in fuel savings as CV market penetration rates increased.

Cost / Benefit Analysis

The research team estimated a 10-year total cost of approximately $300,00 for deploying SPaT units at 17 intersections. By adding 3 prospective SPaT locations with a 10% CV market penetration, the research team estimated a fuel savings benefit ranging from 1.7 to over 4.5 times the cost of the corridor.

Lessons Learned:

- Multiple methods of testing allowed for a comparison in results to verify the testing method reliability.
- Multiple rounds of testing allowed for refinement of the methods used for determining results.

Potential Next Steps for MnDOT:

- Continue to leverage SPaT data where it is existing and identify additional intersections that could benefit from deploying SPaT units.
- The findings of this analysis positioned MnDOT to provide infrastructure to accommodate CVs once market penetrations see a meaningful increase.
- Integrate Cost / Benefit results into educational / outreach material for Connected Vehicles.