Joint Transportation Research Program

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SPR-4123 2019

Strategic and Tactical Guidance for the Connected and Autonomous Vehicle Future

Introduction

Autonomous vehicle (AV) and connected vehicle (CV) technologies are rapidly maturing, but the timeline for their wider deployment is currently uncertain. State and local transportation agencies need to understand what this means for them and consider what they need to do now and in the next few years to prepare for the AV/CV future.

The objectives of this research are to do the following:

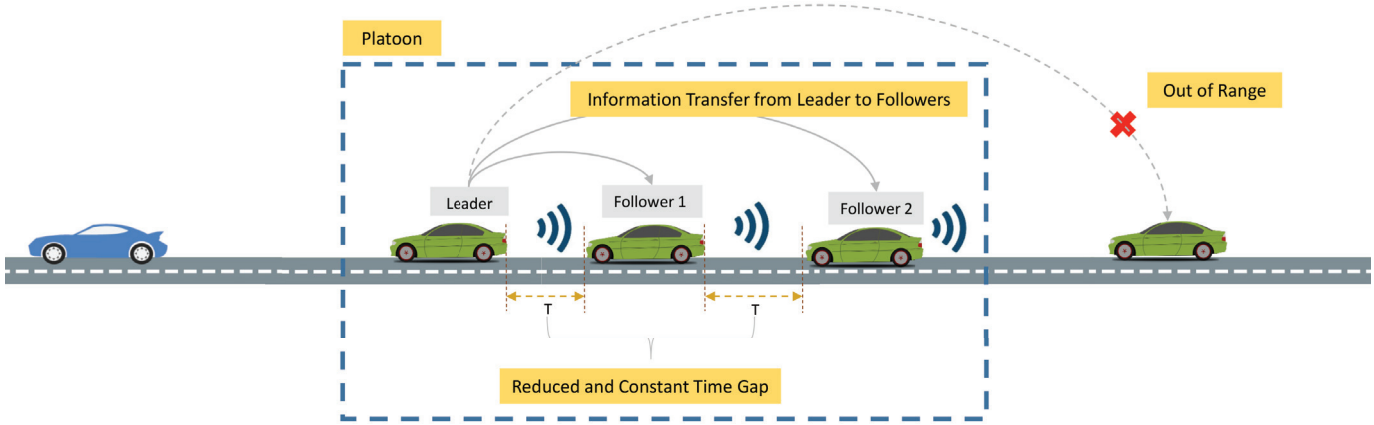
1. Synthesize the existing state of practice for AV and CV vehicles and analyze how other state agencies are addressing the pending transition to an AV/CV environment.
2. Estimate the impacts of an AV/CV environment on traffic operations, including headway distribution and traffic signal coordination, traffic control devices, and intersection crashes.
3. Provide a strategic roadmap for INDOT to prepare for and respond to potential issues.

Findings

- It is imperative for INDOT to join pooled fund studies and the smart coalition. In addition, INDOT should prioritize the preparation of its infrastructure networks for AV/CV technology by installing clear lane markings and DSRC radios on traffic signals and ensuring the standardization of road design and signage. We also recommend testing both direct short-range communications (DSRC) and fifth-generation wireless (5G) on a single corridor to understand the pros and cons of both.
- Based on AV modeling in VISSIM, we saw an increase in average vehicle speeds near merging sections (at least 1.2%) with percentages as low as 20% of SAE 1 and above.
- For SAE 2 onward, we observed a decrease in the tendency of AVs to deviate from the center of the lane (50% for SAE 2 and 87% for SAE 4), which indicates that lane widths can be decreased in an AV-only traffic scenario.
- We found that outside operational design domain (ODD) conditions (such as unclear pavement markings) significantly affect mobility with SAE Level 4 and saw a 50% drop in average speed with SAE 4 compared to a fully autonomous SAE 5.
- From a traffic volume analysis of the I-70 and I-465 freeway interchange with full saturation of different SAE levels, we observed a significant increase in volume throughput (33% for SAE 1 and 150% for SAE 5), indicating significant increases in road capacity.
- Conflict analysis of AVs indicates a decrease in the number of conflicts based on time to collision (30% for SAE 1 and 90% for SAE 5), implying an increase in safety.
- We observed that benefits of intentional platooning with cooperative adaptive cruise control (CACC)–equipped vehicles only materialize with higher percentage composition of CVs and higher flow rates. This may warrant introducing dedicated lanes for platoon formation when CACC penetration is low and/or flow rate is low.
- We observed that the most common platoon size is 2, but platoon sizes as large as 13 were also observed for 90% penetration and above with ad-hoc platoon formation technique at a flow of 800 veh/h/lane. This indicates the need for modifications in present traffic management techniques to allow for smooth movement of large groups of vehicles moving together.

Implementation

Based on this synthesis study, we prepared a roadmap for INDOT divided into short-term, medium-term, and long-term objectives to incorporate AV/CVs on Indiana's roadways. Important considerations that to take into account when investing in an AV/CV future were also listed.



A platoon of three cars.

To understand the impacts of AV/CV on mobility and safety, we developed microsimulation software—VISSIM-based simulation models—that can be further employed to understand the following:

- Impacts of AV-only lanes for trucks and cars
- Impacts on mobility and safety due to a mix of AV classes (cars and trucks)
- Impacts of autonomous intersections
- Assessment of surrogate safety measures for AVs
- Mobility and safety impacts of truck only platooning
- Impacts of dedicated lanes for platoons
- Assessment of CV performance with SPaT messages

We also developed a VISSIM-based microsimulation framework to simulate connectivity and identify the different features in traditional versus CV-based signal control. Any algorithm of interest to INDOT can be fully integrated and tested in a future project using this framework.

Recommended Citation for Report

Ukkusuri, S., Sagir, F., Mahajan, N., Bowman, B., & Sharma, S. (2019). *Strategic and tactical guidance for the connected and autonomous vehicle future* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2019/02). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284316879

View the full text of this technical report here: https://doi.org/10.5703/1288284316879

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