National Center for Sustainable Transportation

POLICY BRIEF

How Intelligent Vehicle Technologies Can Improve Vulnerable Road User Safety at Signalized Intersections

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Issue

Motor vehicle crashes are the leading cause of accidental deaths in the US. In 2020, 38,824 people lost their lives in car-related crashes. Bicyclists and pedestrians are particularly susceptible—7,448 of these "vulnerable road users" were killed nationwide in 2020, and 29% of all reported crash-related fatalities in California were vulnerable road users. Often, crashes involving vulnerable road users occur at intersections. Factors influencing crashes between vehicles and vulnerable road users include drivers' behavior, intersection condition, weather, bicycle and automobile speeds, obscured automobile driver vision, vehicle types, and road design.

A variety of intelligent vehicle technologies hold promise for improving bicycle and pedestrian safety. Sensors in vehicles and/or used by vulnerable road users themselves could alert travelers of potential conflicts, giving them more time to react. However, these technologies all have unique technical, operational, and financial characteristics, and they might perform differently in different environmental conditions and at different levels of deployment. Little research has been done on how these technologies might affect safety.

Researchers at the University of California, Davis combined aggregate historical crash data analysis and micro transportation simulation to examine the safety impacts of four different intelligent vehicle technologies: blind spot detection, a sensor-based system equipped in the vehicle that can trigger a warning when objects appear in the detection area; a vulnerable-road-user beacon system carried by bicyclists or pedestrians that can send messages alerting vehicles of the carrier's presence; bicycle/pedestrian-to-vehicle communication, a two-way system in which vulnerable road users and vehicles can alert each other of their presence; and intersection safety, a centralized system that identifies approaching vehicles, bicyclists, and pedestrians and provides safety guidance. The researchers developed an empirical microsimulation tool to quantify the safety impacts of these technologies on vulnerable road users based on average collision counts over multiple simulations.

Key Research Findings

A statistical analysis of historical crash data found evidence that adverse weather conditions do not lead to greater numbers of severe vulnerable road user collisions. The impact of weather conditions on collision severity can be multifaceted, influencing vehicle speed, traffic volume, and exposure.

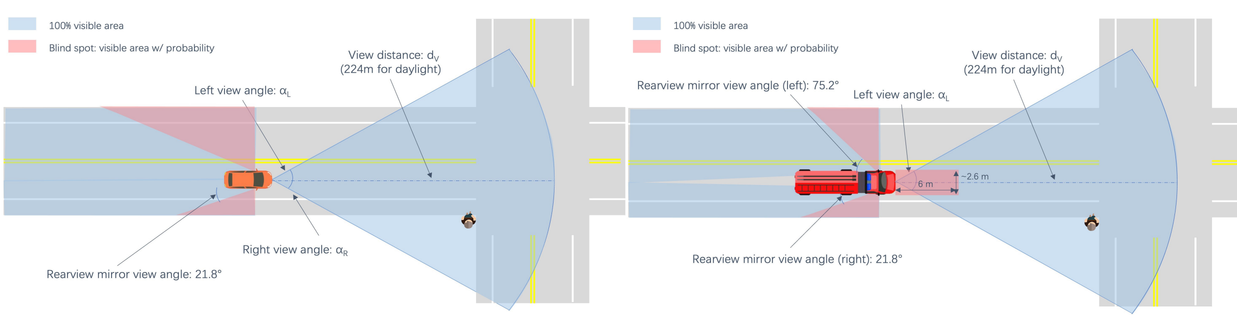

Figure 1. Visible areas and blind spots when driving without intelligent vehicle technology, passenger cars (left) and trucks (right)

On the other hand, severe or fatal collisions involving vulnerable road users are much more likely when the collision is at nighttime.

Intersection safety technology can be the most efficient technology to significantly reduce average collision counts for collisions involving turning passenger cars and oncoming vulnerable road users. In contrast, blind spot detection has the least effects on these types of collisions. While intersection safety technology is expensive, its central sensing module is not dependent on vehicles or vulnerable road users being equipped with sensing equipment.

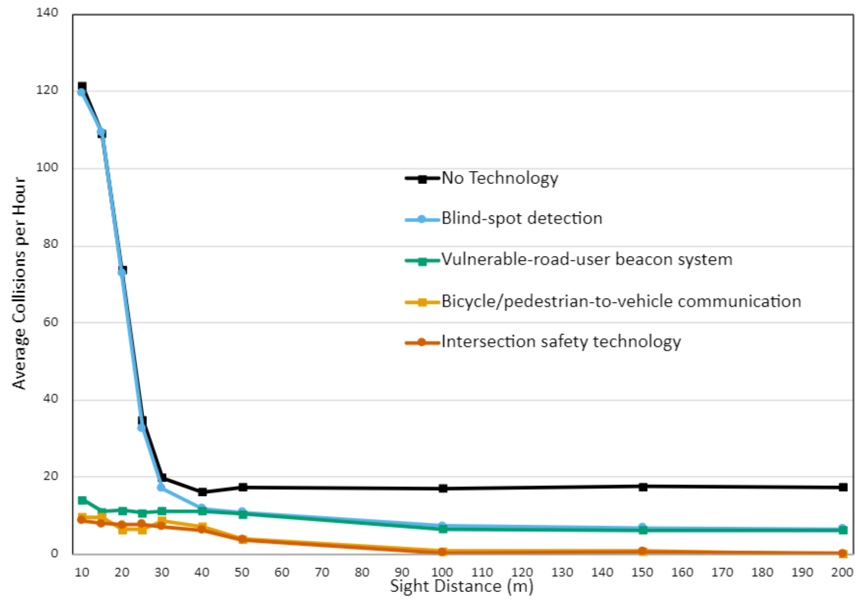

Figure 2. The simulated average frequency of collisions between (i) passenger cars and trucks, and (ii) bikes and pedestrians, for different vehicle sight distances, when using different intelligent technologies. This representative graph shows the collision frequency for one of six modeled accident types; in this type the vehicle and bike/pedestrian are traveling straight through an intersection at right angles to each other.

All of the intelligent vehicle technologies simulated can improve truck-related crash safety for pedestrians. This is true for collisions in which trucks encounter a pedestrian while proceeding straight through an intersection or turning. Because trucks have larger blind spots than passenger cars (Figure 1), technologies that alert truck drivers to the presence of vulnerable road users can have even greater safety impacts.

Bicycle/pedestrian-to-vehicle communication and intersection safety technologies can achieve 100% collision reduction for most types of crashes at high adoption rates. However, in extremely high traffic conditions, these technologies can reduce certain crashes involving thru-traffic collisions with bicyclists by only 50%. High adoption rates of blind spot detection and vulnerable-road-user beacon systems have less significant effects on the reduction of crash rates.

Bicycle/pedestrian-to-vehicle communication and intersection safety technologies, followed by the vulnerable-road-user beacon system, have the best performance in reducing collision probability in adverse weather conditions when sight distance is less than 30 meters (Figure 2). In the absence of intelligent vehicle technologies (black line in Figure 2), average collision counts increase significantly when sight distance is less than 30 meters. These technologies significantly improve safety, particularly for crash types involving vehicles passing straight through an intersection.

More Information

This policy brief is drawn from "Analysis of Intelligent Vehicle Technologies to Improve Vulnerable Road Users Safety at Signalized Intersections," a report from the National Center for Sustainable Transportation authored by Xiaodong Qian, Miguel Jaller, Runhua (Ivan) Xiao and Shenyang Chen of the University of California, Davis. The full report can be found on the NCST website at https://ncst.ucdavis.edu/project/analysis-intelligent-vehicle-technologies-improve-vulnerable-road-users-safety-signalized.

For more information about the findings presented in this brief, contact Xiaodon Qian at xdqian@ucdavis.edu.

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