FTA RESEARCH
FEDERAL TRANSIT ADMINISTRATION

REPORT SUMMARY

U.S. Department of Transportation
Federal Transit Administration

Connected Vehicle (CV) Infrastructure – Urban Bus Operational Safety Platform

Background

The Intelligent Transportation Systems Joint Program Office (ITS JPO), National Highway Traffic Safety Administration (NHTSA), Federal Highway Administration (FHWA), and Federal Transit Administration FTA) have made significant investments in Connected Vehicle (CV) safety and mobility research. This research includes Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) applications for multiple vehicle types, including transit buses.

As part the U.S. Department of Transportation Safety Pilot Model Deployment, Battelle Memorial Institute developed a suite of transit-focused safety applications called the Transit Safety Retrofit Package (TRP). The TRP application suite allowed transit vehicles to communicate using V2V and V2I technologies, with the goal of enhancing both transit vehicle and pedestrian safety. In 2013, as a part of the Safety Pilot Model Deployment, the TRP technology, including the Pedestrian Crossing Warning (PCW) and Vehicle Turning Right in Front of Bus Warning (VTRW) applications, was deployed on three University of Michigan transit buses. The benefits of the applications in conjunction with Dedicated Short-Range Communications (DSRC) wireless technology were tested and evaluated.

In 2015, as a part of the Innovative Safety, Resiliency, and All-Hazards Emergency Response and Recovery Research Demonstration (SRER) research program, FTA awarded Battelle $2.74 million to conduct the Connected Vehicle Infrastructure – Urban Bus Operational Safety Platform project, more commonly referred to as the Enhanced TRP (E-TRP) project, to enhance the CV transit-focused safety applications

.

Objective

The E-TRP project leveraged the foundational research and development performed under the earlier TRP project and enhanced and refined the capabilities of the PCW and VTRW applications. The changes included:

- Improved pedestrian detection system
- Improved locational accuracy of the transit vehicle
- Improved interface for the transit vehicle driver (visual and audible)
- Newer DSRC radios
- Remote system management
- Enhanced PCW (E-PCW) safety application to include additional intersection types and bus movements through intersections
- Enhanced VTRW (E-VTRW) safety application to be more versatile (e.g., removed requirement to designate bus stops for alert enabling)

Key technologies deployed include DSRC for V2V and V2I communication, High-precision Global Navigation Satellite System (GNSS) for vehicle tracking, and Forward Looking Infrared (FLIR) cameras for enhanced pedestrian detection.

The E-TRP was installed on 24 Greater Cleveland Regional Transit Authority (GCRTA) transit buses for field testing at 3 locations—one signalized intersection, one non-signalized intersection, and one mid-block crossing. The buses operated in revenue service for a period of six months to collect data for evaluation of the performance of the system, safety impacts, return on investment, and driver acceptance.

Findings and Conclusions

E-TRP showed a significant safety impact in terms of likely collision reduction, with a statistically significant increase in driver response rate (braking) to pedestrian warning situations along with a decrease in driver average reaction time (braking) to pedestrian warning situations.

System Performance – Of the E-PCW alerts analyzed, only 9% were false alarms, with 81% confirmed correct alerts, and 10% of the alerts correctly detected the presence of a pedestrian, but incorrectly classified their location. False alarms were caused primarily by lighting and environmental conditions, and the main driver of incorrectly classified alerts was the proximity of the pedestrian detection zones to each other based on the camera angle.

Safety Impact – Quantitative data analysis of driver braking within 2.5 seconds of the Warn Alerts showed that the E-PCW application increase driver response by more than 16%, from 12% to 14%. Additionally, the average driver reaction time was reduced by more than 18%, from 1.6 seconds to 1.3 seconds. These metrics are performance measures of likely collision reduction.

Return on Investment – In the five years of collision data provided, between April 2011 and May 2016, GCRTA recorded 14 events involving a pedestrian. The evaluation team reviewed the description of each event to estimate the Maximum Abbreviated Injury Scale (MAIS) classification and calculate the associated value of preventing these injuries. Comparing estimates of the average annual benefit of the system and the total deployment cost indicates that recuperating the investment in the form of risk reduction value from E-PCW may take more than 20 years. This result is highly dependent on the collision data for the reporting period, which included no fatalities. If one fatality over the five-year period was included, the return on investment period would drop from 20 to 5 years.

Driver Acceptance – Drivers who participated in the survey positively rated the system's usability and desirability but expressed mixed responses regarding perceived safety benefits and unintended consequences. Nearly two-thirds (63%) of drivers agreed that they would like the system installed on all buses they drive and more than half (55%) reported that they trusted the cautions and warnings. Note: There was low driver participation in the survey upon which these metrics are based; thus, conclusions drawn from the survey cannot provide statistically meaningful analysis of the system.

The independent evaluation did not include assessment of the E-VTRW performance because the deployment was limited to transit vehicles and did not include any DSCR-equipped passenger cars.

Benefits

Whereas transit is one of the safest modes for travel, there are still thousands of transit bus crashes each year, resulting in fatalities and injuries, including pedestrians struck by buses. Connected vehicle technologies such as E-TRP further empower transit drivers with the tools they need to anticipate potential accident situations and significantly reduce the number of crashes, injuries and lives lost each year. E-TRP showed a significant safety impact in terms of likely collision reduction – with a statistically significant increase in drivers' response rate (braking) to pedestrian warning situations along with a decrease in drivers' average reaction time (braking) to pedestrian warning situations.

Project Information

FTA Report No. 0133

This research project was conducted by Battelle Memorial Institute. For more information, contact FTA Project Manager Steve Mortensen at (202) 493-0459, steven.mortensen@dot.gov. All research reports can be found at **https://www.transit.dot.gov/about/research-innovation**.