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TRANSIT SAFETY RETROFIT
SAFETY APPLICATIONS DEVELOPMENT

LIMIT 35

Connected vehicles have the potential to transform the way Americans travel through the creation of a safe, interoperable wireless communications network that links cars, buses, trucks, trains, transportation infrastructure, and personal mobile devices. Connected vehicle applications provide connectivity between and among vehicles, infrastructure, and wireless devices to:

- Enable crash warnings
- Enable safety, mobility, and environmental benefits
- Provide continuous real-time connectivity to all system users.

The Transit Safety Retrofit Project is a key research effort within the U.S. Department of Transportation (USDOT) Intelligent Transportation Systems Joint Program Office (ITS JPO) Connected Vehicle Research Program, in cooperation with the Federal Transit Administration (FTA). The two year research project is to develop and demonstrate vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) safety applications on transit buses to determine the effectiveness of these applications at reducing crashes and to show how real-world drivers will respond to these safety applications in their vehicles.

Project Scope

The Transit Safety Retrofit Project has equipped three University of Michigan transit buses with safety onboard equipment for use during the USDOT's Connected Vehicle Safety Pilot Model Deployment in Ann Arbor, Michigan. This one-year model deployment has created a highly concentrated environment of up to 3,000 cars, trucks, and transit vehicles equipped with wireless connected vehicle devices operating on public streets to test safety applications using dedicated short-range communications (DSRC).

To test transit safety applications, the safety devices installed in the transit buses include radios that transmit and receive the Basic Safety Message (BSM) via DSRC. An android tablet inside each retrofitted bus serves as the driver-vehicle interface (DVI), which provides visual and audible warnings to drivers.

The model deployment also includes some roadside equipment (RSE) that transmit the Traveler Information Message (TIM), Signal Time and Phasing (SPaT) messages, and MAP messages.

Hardware and Technology

- **University of Michigan Buses:** 3 Gillig Hybrid Buses

- **Samsung Galaxy Tab 8.9:** Tablet Display
  - Provides warnings to driver
  - Houses the PCW and VTRW applications
  - 802.11 a/n wireless

- **MS SEDCO:** SmartWalk XM
  - Crosswalk Occupancy Detector; 24.125 GHz microwave transmitter/receiver that uses a microprocessor-analyzed Doppler detection method
  - Two per crosswalk, set to detect motion
  - Minor modifications made by MS SEDCO to limit the number of false detections by vehicles

- **DENSO:** Wireless Safety Unit (miniWSU)
  - DSRC radio module compliant with 802.11p, 1609.x, and J2735 Standards
  - CAN, Ethernet interfaces
  - Houses the CSW, EEBL, and FCW applications

- **University of Michigan Transportation Research Institute:** Data Acquisition System
  - Unattended turnkey "field operational test" mode
  - Proven reliability over millions of miles
  - Cell modem for remote monitoring
  - Engineering mode with graphical user interface

- **Battelle:** Application and Hardware Developer and Integrator
  - Driver Interface
  - Vehicle Turning Right in Front of Bus Warning Application
  - Pedestrian in Signalized Crosswalk Warning Application

U.S. Department of Transportation

Research and Innovative Technology Administration

The Safety Applications

The Transit Safety Retrofit Project is using the retrofitted transit buses to test three basic safety applications and two transit-specific applications. The basic safety applications include:

- **Forward Collision Warning (FCW):** Warns a bus driver if there is a risk of a rear-end collision with a vehicle in front of the bus. (This V2V app is being tested throughout the model deployment geographic area.)

- **Emergency Electronic Brake Lights (EEBL):** Warns a bus driver when there is a hard-braking event ahead of the bus, from a vehicle in the lane ahead of the bus or in an adjacent lane. The vehicle initiating the hard-braking may be several vehicles in front of the bus. This application addresses chain-reaction collisions. (This V2V app is being tested throughout the model deployment geographic area.)

- **Curve Speed Warning (CSW):** Warns a bus driver if approaching a curve too quickly for safe navigation. Relies on roadside equipment and therefore is only available at designated locations. (This V2I app is being tested in one location in the model deployment geographic area—at the Bonisteel Blvd./Murfin Ave. curve.)

Photo Source: USDOT

The project has also developed and is testing the following new transit-specific applications:

- **Vehicle Turning Right in Front of Bus Warning (VTRW):** Warns a bus driver when another vehicle is passing on the left and turning in front of the bus, either to re-enter the right-hand lane or to complete a right turn in front of the bus, as a bus is leaving a bus stop. This situation often occurs when a bus stop is located prior to an intersection and the bus is stopped in the right lane at the bus stop loading and unloading passengers. Another vehicle traveling behind the bus (and planning to turn right at the intersection) is unsure of the bus' dwell time. As a result, the other vehicle passes the bus on its left and attempts to make a right turn at the intersection. If the bus is pulling away from the bus stop at the same time the other vehicle is turning, there is a potential for a collision. (This V2V app is being tested at 17 bus stops in the model deployment geographic area—along the University Transit North and South Commuter Route.)

- **Pedestrian in Signalized Crosswalk Warning (PCW):** Warns a bus driver if the vehicle is about to collide with a pedestrian in a crosswalk while making a left or right turn at a signalized intersection. The app relies on RSE for transmission of SPaT and MAP messages. The SPaT message contains pedestrian presence and detection data objects, and the MAP message contains intersection geometric data objects. (This V2I app is being tested at one intersection in the model deployment geographic area—at Fuller Road and E Maiden Lane.)

Benefits and Value of the Transit Safety Retrofit Project

The retrofitted buses will help to:

- Test the interoperability and performance of the transit safety application

- Assess driver acceptance of the transit safety applications

- Support the model deployment's testing of V2V and V2I light and heavy vehicle safety applications to provide necessary information for a potential rulemaking by the National Highway Traffic Safety Administration (NHTSA) on the future of connected vehicle technology.

Connected vehicle technology will change the transportation system paradigm by giving people the tools to avoid crashes and make travel faster, easier, more accessible, and environmentally friendlier. The vision for transit connected vehicle research is to leverage the evolving connected vehicle communications capability to achieve desirable transit safety, mobility, and environmental outcomes.