Transit Safety and Mobility Applications in a Connected Vehicle World

Transit Safety Retrofit Package

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Transit Safety Retrofit Package (TRP)

- Part of USDOT Safety Pilot Model Deployment
  - Large-scale field demonstration of Connected Vehicle (CV) technology based on 5.9GHz Dedicated Short-Range Communications (DSRC) wireless radio
  - TRP provides the only source for retrofitted transit vehicle applications for vehicle and pedestrian safety leveraging vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications
TRP Applications

- 5 Collision Avoidance Safety Applications on 3 University of Michigan Transit Buses –

  - Transit-specific, identified as high-priority concerns by transit agencies
    - Pedestrian in Signalized Crosswalk Warning (PCW)
    - Vehicle Turning Right in Front of Bus Warning (VTRW)

  - Common with other Safety Pilot vehicles
    - Forward Collision Warning (FCW)
    - Emergency Electronic Brake Lights (EEBL)
    - Curve Speed Warning (CSW)
TRP Phases / Schedule

• Phase 1: FCW, EEBL, and CSW
  - August 2012: completed integration on buses; began live testing

• Phase 2: Data Acquisition System (DAS)
  - October 2012: completed integration on buses; began live testing

• Phase 3: PCW, VTRW, and bus driver training
  - January 2013: completed integration on buses
  - February-September 2013: 8 months of full-up live testing

• Phase 4: TRP revisions for Phase 3 lessons
  - January 2014: completed integration on buses
  - February-March 2014: 1 month of full-up live testing
TRP and DAS Components

TRP System
- Power Supply
- mini-WSU
- Network components

DSRC Antenna and Camera

Driver Display

Face Camera

Front-Left

Front-Right

Front Facing Cameras

Data Acquisition System (DAS)
TRP System Architecture
PCW Overview (Functional)

Provide bus driver a warning when a pedestrian is crossing the street as the bus is making a turn

- Application relies on infrastructure for pedestrian detection
  - Option 1 – This option includes sending an alert when the crosswalk call button has been activated (Caution alert)
  - Option 2 – This option includes the use of a pedestrian detector to detect the presence of a pedestrian in the crosswalk (Warning alert)
PCW Overview (Infrastructure)
PCW Roadside Equipment

Clockwise from top left:
- SmartWalk XP pedestrian detection sensor (24.125 GHz microwave transmitter/receiver that uses a microprocessor-analyzed Doppler detection method)
- Savari roadside equipment (RSE)
- SPaT interface device
PCW Location

Fuller Rd / Medical Center Dr
- Provides SPaT-enabled intersection with heavy pedestrian traffic, well suited for PCW application purpose
- On Commuter bus route which provides best VTRW bus stop locations

University Medical Center (school/employment)

Off campus housing (student/faculty/staff)
PCW Driver Interface

Computer-generated speech accompanies alerts:

- "Pedestrian Alert Left"
- "Pedestrian Alert Right"
- "Pedestrian Warning Left"
- "Pedestrian Warning Right"
PCW Demo Video

TRP Pedestrian Detection
Left Turn onto Medical Center Drive
PCW Deployment (Feb-Sept 2013)

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PCW Redeployment (Feb 2014)

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VTRW Overview (Functional)

Provides bus driver a warning when a vehicle turns right in front of a bus as the bus pulls away from a bus stop

Source: http://www.youtube.com/watch?v=9gXEgFw99_0
VTRW Overview (Infrastructure)
VTRW Locations (17)

Commuter North / South Routes

- Provide best nearside and non-pullout bus stops (where bus blocks traffic before intersection), well suited for VTRW application purpose
- Include Fuller Rd / Medical Center Dr intersection which provides best PCW location
VTRW Driver Interface

Computer-generated speech accompanies alerts:

- "Right Turn Vehicle Warning"
- "Right Turn Vehicle Alert"
VTRW Demo Video

TRP - Right Turn Vehicle
Vehicle On Left Warning
VTRW Deployment (Feb-Sept 2013)
VTRW Redeployment (Feb 2014)
Analysis

• PCW and VTRW event data was analyzed compared to ground truth (DAS), to assess the performance of the applications and determine lessons learned

• Original deployment analysis resulted in limited near-term TRP revisions for the redeployment

• Longer term recommendations for future systems
Near-term Revisions

• PCW revisions
  ▪ Adjustments to crosswalk detectors to decrease false alerts for detection of vehicles in the crosswalk rather than pedestrians
  ▪ Adjustments to lane tracking algorithm to decrease false alerts for buses traveling straight through the intersection instead of turning through the subject crosswalk
  ▪ Revisions had intended impact, though the false alert rate remained significant due to limitations of underlying technologies
Near-term Revisions (cont.)

• VTRW revision
  ▪ Revised to include transmission gear position as an additional criteria for determining the bus driver’s “intent to proceed” to decrease nuisance alerts when no real collision threat

• Other
  ▪ Minor adjustments to the Driver Vehicle Interface, including longer alert display times and verbal alerts instead of beeps
Lessons Learned

• On-bus software implementation was effective at providing alerts to transit drivers
• Transit drivers expressed acceptance of the TRP concept
• DSRC radios performed well – no TRP problems traced to DSRC performance
• Significant rate of false alerts for the PCW application due to combination of GPS limitations and pedestrian detector limitations
Lessons Learned (cont.)

• WAAS-enabled GPS accuracy is insufficient for PCW application
  ▪ Typical lane width is 3.35 meters, thus accuracy within 1.675 meters is required, which cannot reliably be achieved with WAAS-enabled GPS
  ▪ Significant improvements could be achieved with more accurate technology, such as Differential GPS for specific localized TRP implementations
Lessons Learned (cont.)

• Doppler microwave-based detector technology is insufficient for the PCW application
  - Cannot adequately distinguish between pedestrians and slow moving vehicles in the crosswalks
  - Significant improvements could be achieved with more discerning technology, such as high-speed imaging (computer vision)