Testing Automated Collision Avoidance Warning Systems for Public Transit Buses

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New Jersey Transit (retired)

2017 Fall Educational Forum - Baltimore, MD
Association of Governmental Risk Pools (AGRIP)
Tuesday, October 3, 2017
• 25 public transit members in Washington State
• A property and liability pool
• $14.5 million budget for 2017
• Miles travelled for 2017 is estimated to be 100 million
• $2.5 million of self-insurance / $20 million liability limits
Why?

• A technology may be considered *bleeding edge* where it contains a degree of risk, or, more generally, there is a significant downside to early adoption, such as:
  • Lack of consensus
  • Lack of testing
  • Industry resistance to change
Why Not?

Innovation

Early Adopters

Re-insurance Partnerships

Looking out for Members’ Horizon

Strategic Planning

Reality of Landscape
Innovations Deserving Exploratory Analysis (IDEA) Project Transit -82

Funding from

- Transportation Research Board
- Washington State Transit Insurance Pool
- Munich Re America
- Alliant Insurance Services, Inc.
- Government Entities Mutual, Inc.
Annual US Bus and Paratransit Injuries
2003-2015
Source: Federal Transit Administration
Annual US Bus, Paratransit and Vanpool Casualty & Liability Expense

Source: Federal Transit Administration National Transit Database
Collisions, Fatalities, Injuries, Casualty and Liability Expenses for Bus and Rail Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Reporting Period 2002-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Collisions</td>
</tr>
<tr>
<td>Total Bus, Demand Responsive and Van Pool</td>
<td>90,056</td>
</tr>
<tr>
<td>Total Rail</td>
<td>6,526</td>
</tr>
</tbody>
</table>
The Need to Improve Safety for Bus Transit Workers

Collisions, Employee Injuries, and Employee Fatalities by Transit Mode 2002-2014
Source: Federal Transit Administration (FTA) National Transit Database (NTD)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Employee Injuries</th>
<th>Employee Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Bus, Demand Responsive and Van Pool</td>
<td>16,312</td>
<td>56</td>
</tr>
<tr>
<td>Total Rail</td>
<td>1,462</td>
<td>36</td>
</tr>
</tbody>
</table>
National Transportation Safety Board (NTSB)

2015 - Special Investigation Report – The Use of Forward Collision Avoidance Systems to Prevent and Mitigate Rear End Crashes

- “currently available forward collision avoidance technologies for passenger and commercial vehicles ... could reduce rear-end crash fatalities.”

- Forward collisions reduced 71% for trucks with collision avoidance systems, (CAS) autonomous emergency braking, (AEB) and electronic stability control (ESC)
NTSB recommendations:

- Manufacturers - install forward collision avoidance systems on all newly manufactured passenger and commercial motor vehicles
- NHTSA - expand New Car Assessment Program to include graded performance rating of forward collision avoidance systems
- NHTSA - expand or develop protocols for assessment of forward collision avoidance systems
Transit May Be Left Behind

- Transit buses are a niche market – little incentive for OEM’s to invest in R&D
- Agencies required to retain buses for 12 + years
- Years before transit benefits from CAS and AEB on new buses
- Need to retrofit existing buses with CAS and AEB
- Need standards for CAS and AEB for retrofits and new buses
Driver killed, 18 injured after 2 NJ Transit buses crash in Newark

Newark bus crash victims to sue for at least $115M for 'catastrophic' injuries
Innovations Deserving Exploratory Analysis (IDEA)

TRB grant and funding from insurance companies

- Equipped 35 transit buses at seven member agencies and three buses at King County Metro with CAS
- Comprehensive examination of total costs for most severe and costly types of collisions
- Evaluate potential for CAS to reduce the frequency and severity of collisions, and reduce casualty and liability expenses
- Does not include autonomous braking in this phase
Participating Transit Agencies

• Ben Franklin Transit, Richland, WA
• Community Transit, Everett, WA
• C-Tran, Vancouver, WA
• InterCity Transit, Olympia, WA
• King County Metro, Seattle, WA
• Kitsap Transit, Bremerton, WA
• Pierce Transit, Tacoma, WA
• Spokane Transit, Spokane, WA
Rosco/Mobileye Shield+ system collision avoidance warning system (CAWS) specifically designed for transit buses

Provides alerts and warnings for events that could lead to a collision:

- changing lanes without activating a turn signal
- exceeding posted speed limit
- closing with vehicle in front of the bus
- closing with pedestrian or bicyclist in front of, or alongside the bus

Alerts and warnings

- visual indicators on windshield and front pillars
- Audible warnings issued when collisions are imminent
Shield+ system being installed on Gillig bus at C-TRAN in Vancouver, WA

- 6 different types of transit buses produced by three mfrs.
- high floor, low floor, Diesel, hybrid, and electric trolley buses
- 2-person team complete one bus installation in 8 hour period
Center indicator illuminates as pedestrian crosses in front of moving bus during testing
System Configuration
System Configuration - Alerts and Warning Displays

**MOBILEYE SHIELD+** OPERATOR REFERENCE GUIDE

LEFT SIDE DISPLAY
- Left Side Pedestrian Display
  - For detecting pedestrians and cyclists who are near left front corner of bus or left side of bus.
  - Yellow illumination with no sound
    - Alerts operator a pedestrian or cyclist has been detected near the left front or left side of bus.
    - Operator should exercise additional caution until verifying that the danger of collision has passed.
  - Red flashing with beeping sound
    - Alerts operator a pedestrian or cyclist has been detected in the left front or left side of bus and collision is imminent.
    - Operator should take action to carefully stop bus to avoid collision.

CENTER DISPLAY & EYEWATCH
- Center Display
  - Contains the Pedestrian Display and Eyewatch.
  - The Eyewatch readouts and explanations can be found below on this document.
  - Yellow illumination with no sound
    - Indicates a pedestrian or cyclist is in front of the moving bus or coming towards the moving bus.
    - Operator should exercise additional caution until verifying that the danger of collision has passed.

EYEWATCH READOUTS
- **Solid green dot**
  - System is operational with bus at 0 speed.
- **Solid yellow dot**
  - System is operational.
- **Lane Departure Warning (LDW)**
  - Occurs when crossing the lane markers without using turn signal.
  - Appears as a vertical white hash line on the Eyewatch.
  - A series of sharp warning beeps of short duration.
  - The hash line will be on the Eyewatch side corresponding to the lane marker crossed.
  - For pilots, this feature is not active.
- **Speed Limit Indicator (SLI)**
  - Appears when the bus is traveling at least 5 mph (adjustable) over the last posted speed limit sign.
  - Two vertical white hash lines on each side of the Eyewatch will appear with a white number indicating miles over the last posted speed limit.
  - Has a chime sound.
  - Operator should reduce speed to keep within the speed limit.
- **Headway Monitoring (HMW)**
  - Appears as green car.
  - Indicates detection of a vehicle in the path of the bus.
  - No number shown if bus is traveling a safe distance behind the vehicle in front or when bus is traveling below 10 MPH.
- **Headway Monitoring (HWM)**
  - Appears as green car and number.
  - Indicates how far the vehicle in front of the bus is in seconds.
  - The 2-3 indicates the seconds until a collision could occur if the front vehicle were to come to a stop.
  - Operator is advised to reduce speed if time to collision falls below preset seconds and car turns red.
  - Has a chime sound.
- **Headway Monitoring Warning (HMW)**
  - Appears as a red car with an available chime.
  - Indicates distance between bus and vehicle in front has fallen below a safe threshold.
  - Operator is advised to reduce speed to increase distance to a safe level.
- **Forward Collision Warning (FCW)**
  - Alerts operator a collision is imminent.
  - Operator must stop the bus immediately.

RIGHT SIDE DISPLAY
- Right Side Pedestrian Display
  - For detecting pedestrians and cyclists who are near right side of bus.
  - Yellow illumination with no sound
    - Alerts operator a pedestrian or cyclist has been detected near the right side of bus.
    - Operator should exercise additional caution until verifying that the danger of collision has passed.
  - Red flashing with beeping sound
    - Alerts operator a pedestrian or cyclist has been detected on the right side of bus and collision is imminent.
    - Operator should take action to carefully stop bus to avoid collision.

T: 718.526.2601  www.roscovision.com
System Configuration - Alerts and Warning Displays

**CENTER DISPLAY & EYEWATCH**

- **OFF**
  - Center Display
  - Contains the Pedestrian Display and EyeWatch.
  - The EyeWatch readouts and explanations can be found below on this document.

- **DETECTION**
  - Yellow illumination with no sound
  - Indicates a pedestrian or cyclist is in front of the moving bus or coming towards the moving bus.
  - Operator should exercise additional caution until verifying that the danger of collision has passed.

- **ALERT**
  - Red flashing with beeping sound
  - Indicates a pedestrian or cyclist is in front of the moving bus or coming towards the moving bus and collision is imminent.
  - Operator should take action to carefully stop bus to avoid collision.
Telematics - Monitoring System Performance

• The CAS does not record video
• Additional cameras record video of events
• Additional technology is used to generate data that can be used to evaluate the systems’ effectiveness
• Telematics unit captures and transmits data
Monitoring System Performance with Telematics and Video
Field Testing the CAS-Mapping Telematics Data
Field Testing the CAS

Checking System Performance in Revenue Service – comparing real time observations with telematics data
Field Testing the CAS- Logging Telematics Data

<table>
<thead>
<tr>
<th>Report Name :</th>
<th>Vehicle name</th>
<th>Heading</th>
<th>Distance In Miles</th>
<th>Driver name</th>
<th>Address</th>
<th>Speed</th>
<th>Status Name</th>
<th>Rule name</th>
<th>POI Original</th>
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<tbody>
<tr>
<td>28/03/2016 21:57:25</td>
<td>KCM #4346</td>
<td>NE</td>
<td>3.29</td>
<td></td>
<td>1333-1367 Madison St, Seattle, WA 98104, USA</td>
<td>14</td>
<td>ME - Pedestrian In Range</td>
<td>ME4 - Pedestrian In Range</td>
<td>Warning</td>
</tr>
<tr>
<td>28/03/2016 21:57:29</td>
<td>KCM #4346</td>
<td>NE</td>
<td>3.29</td>
<td></td>
<td>1368-1398 Madison St, Seattle, WA 98104, USA</td>
<td>14</td>
<td>PDZ-R</td>
<td>ME4 - PDZ - Right</td>
<td></td>
</tr>
<tr>
<td>28/03/2016 22:00:06</td>
<td>KCM #4346</td>
<td>NE</td>
<td>3.73</td>
<td></td>
<td>1349-1397 E Madison St, Seattle, WA 98122, USA</td>
<td>14</td>
<td>ME - Pedestrian In Range</td>
<td>ME4 - Pedestrian In Range</td>
<td>Warning</td>
</tr>
<tr>
<td>28/03/2016 22:00:07</td>
<td>KCM #4346</td>
<td>NE</td>
<td>3.73</td>
<td></td>
<td>1349-1397 E Madison St, Seattle, WA 98122, USA</td>
<td>12</td>
<td>ME-PCW</td>
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<td></td>
</tr>
<tr>
<td>28/03/2016 22:00:07</td>
<td>KCM #4346</td>
<td>NE</td>
<td>3.73</td>
<td></td>
<td>1350-1398 E Madison St, Seattle, WA 98122, USA</td>
<td>11</td>
<td>ME -</td>
<td>ME4 -</td>
<td></td>
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</table>
Data Collection
April 1, 2016 – June 30, 2016

• 352,129 operating miles
• 23,798 operating hours
• 250 driver surveys returned
• 178 comments received
• 16,600 hours of video
• 10,000 events logged
• 19 TB of video storage
• No pedestrian or forward collisions
Comparing Frequency of Alerts and Warnings with Spokane Transit Control Group

<table>
<thead>
<tr>
<th>Warning Type</th>
<th>Warnings per 1000 miles</th>
<th>Active Fleet</th>
<th>Active Fleet Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control Group</td>
<td>Active Fleet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2 buses 17K mi)</td>
<td>(33 buses, 344K mi)</td>
<td></td>
</tr>
<tr>
<td>Forward Collision</td>
<td>327.76</td>
<td>93.24</td>
<td>-71.55</td>
</tr>
<tr>
<td>Pedestrian Collision</td>
<td>61.66</td>
<td>34.95</td>
<td>-43.32</td>
</tr>
</tbody>
</table>
Video Analyses by UW
Testing for False Positives and False Negatives
<table>
<thead>
<tr>
<th>WSTIP Fixed Route Liability Claims History</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2004-2016 – Claims &gt;$2,900</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>$53,159,668</td>
</tr>
<tr>
<td><strong>Claims not Impacted by CAWS</strong></td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>$18,585,081</td>
</tr>
<tr>
<td><strong>Claims Impacted by Forward Vehicle CAWS</strong></td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>$18,593,035</td>
</tr>
<tr>
<td><strong>Claims Impacted by Pedestrian CAWS</strong></td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>$15,981,552</td>
</tr>
<tr>
<td><strong>Total Claims Impacted by Forward Vehicle and Pedestrian CAWS</strong></td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>$34,574,587</td>
</tr>
</tbody>
</table>
## Research Implications – The Business Case for CAS/AEB

<table>
<thead>
<tr>
<th>Bus Type</th>
<th>2015 Casualty &amp; Liability Expense per Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commuter Bus</td>
<td>$6,229</td>
</tr>
<tr>
<td>Motor Bus</td>
<td>$7,986</td>
</tr>
<tr>
<td>Rapid Bus (BRT)</td>
<td>$4,116</td>
</tr>
<tr>
<td>Trolley Bus</td>
<td>$11,796</td>
</tr>
</tbody>
</table>
What Next - Autonomous Braking

- The curved line shows velocity of the bus when braking
Pierce Transit - Continuing Research in Collision Avoidance

• Pierce Transit received $1.66 million grant from Federal Transit Administration (FTA) to install bus safety technology
• 176 buses will be equipped with Shield+ CAWS
• Buses will be operated and data recorded for a full year
• Some buses will also be equipped with Automated Emergency Deceleration (AED) for testing
Thank You!

Questions?

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jerome.lutin@verizon.net