



# PIERCE TRANSIT AUTOMATED COLLISION AVOIDANCE AND MITIGATION SAFETY RESEARCH AND DEMONSTRATION PROJECT

## FINAL REPORT

### Background

From 2014 through 2019, bus transit modes experienced 32,327 collisions, 99,186 injuries, 583 fatalities, and reported casualty and liability (C&L) expenses of \$4,094,275,201. From 2003 through 2019, C&L expenses rose at twice the pace of inflation. Although the National Transportation Safety Board (NTSB) has strongly recommended the application of collision avoidance systems and automated emergency braking (CAWS/AEB), the transit industry has lagged behind autos and trucks.

### Objectives

The goal of this Federal Transit Administration project was to research and facilitate the development of CAWS/AEB for transit buses. The project scope included the following parallel research tracks assigned to research partners:

- Quantifying Contributing Factors to Transit Bus Casualty and Liability Expenses Using the National Transit Database (NTD) – University of Washington
- Commercialization Potential for Transit Bus Automated Collision Avoidance Warning and Emergency Braking Systems – Veritas Forensic Accounting and Economics
- Developing and Testing a 2D Flash Lidar Transit Bus Collision Avoidance Warning System – DCS Technologies, Inc.
- Evaluating the Accuracy of Transit Bus Collision Avoidance Warning Systems – University of Washington
- Analyzing Unrestrained Passenger Motion During Transit Bus Braking – Virginia Tech Transportation Institute (VTTI)

### Findings and Conclusions

*Although the project did not provide a conclusive evaluation of a CAWS/AEB system, it tested a 2D lidar sensor-based system, developed instrumentation and protocols to measure system accuracy and functionality, analyzed passenger motion during braking, and provided evidence for CAWS/AEB applicability and potential for return on investment.*

Statistical analysis of NTD data for 273 transit agencies showed that collisions with vehicles and persons predicted 67% of the variation in bus C&L expenses, a reduction of 100 collisions with motor vehicles could result in a decrease in C&L expenses of \$4.42 million, and a decrease of 100 collisions with persons could result in a decrease of \$16.7 million.

Veritas reviewed 12 years of Washington State Transit Insurance Pool transit agency member, fixed-route bus claims and found that 45% of \$59.9 million in liability claims and 38% of injuries could potentially be mitigated if a fully tested and operational CAWS/AEB system were to be implemented and adopted.

The potential return on investment was estimated by comparing the potential reductions in collision-related claims with estimated fully developed CAWS/AEB life-cycle costs on a per-vehicle-mile basis. Break-even costs for CAWS/AEB ranged from \$3,000 to \$17,000 per vehicle, depending on system effectiveness in preventing claims and system life expectancy.

DCS installed 30 Pedestrian Avoidance Safety System (PASS) CAWS/AEB units on Pierce Transit (PT) buses for a nine-month evaluation period. Based on a risk management assessment by PT staff, the AEB and driver feedback functionality was disabled. However, logging of system warning events were collected and logged. Data analysis showed that PASS recorded 1.2 warning events per bus operating hour. PASS units achieved a 200,000 mean distance between failure (MDBF) over a total of 930,091 project miles.

University of Washington video event detection instrumentation on four buses indicated that 93.5% of PASS detections were false positives and 2.6% were false negatives.

VTTI passenger motion instrumentation on 2 buses produced 649 passenger motion profiles (PMPs) among passengers who were seated, standing, in a wheelchair, and “seated unstable” if the passenger was holding a stroller, cane, or walker. Anonymized videos of head movements were measured and analyzed. Braking events did not exceed -0.3 g, and head movements did not vary significantly for different braking rates.

It is recommended that continued research and development funding for CAWS/AEB be provided by sponsoring agencies and that bus original equipment manufacturers (OEMs) and technology suppliers continue to research and develop the technology.

## Benefits

This research included development of new protocols and instrumentation for collection of data for CAWS/AEB testing and collection and archiving of datasets on CAWS/AEB events, CAWS accuracy testing, and passenger motion. Data loggers on 30 buses collected detailed data on 42,343 events during 930,091 miles of testing. Other systems developed for the project evaluated CAWS/AEB accuracy in terms of false positives and false negatives and the effects of braking on passenger motion. New models were developed to determine the relationship between collisions and casualty and liability expenses and to estimate the return on investment for CAWS/AEB.

## FTA Report No. 0220 Project Information

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