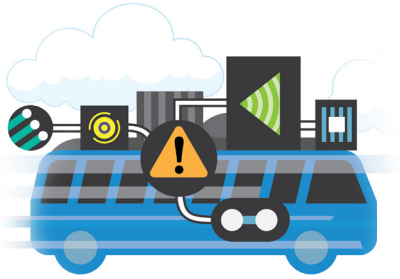
FTA RESEARCH
FEDERAL TRANSIT ADMINISTRATION

REPORT SUMMARY

U.S. Department of Transportation
Federal Transit Administration



Hazard and Safety Analysis of Automated Transit Bus Applications

Final Report

Background

The extension of driving automation systems to transit buses has the potential to alter the urban transportation landscape. However, public acceptance of these systems is dependent, in part, on their safe deployment. This study explored how unique aspects of transit bus operations and use cases could contribute to new hazards or safety challenges. The project builds upon a prior study that identified SAE Level 0 to Level 2 driving automation systems developed for light vehicles and commercial trucks that are potentially transferrable to 40-ft city transit buses.

Objectives

The objectives of this project were to identify potential vehicle-level hazards and top-level safety goals for a generic 40-ft transit bus system equipped with SAE Level 0 to Level 2 driving automation systems and derive generic top-level safety measures and safe states to support potential testing and evaluation of transit buses equipped with these systems and identification of driver warning needs.

Findings and Conclusions

Many vehicle-level hazards and functional safety measures for light vehicles and heavy trucks also apply to transit buses, but some transit bus operations can lead to unique vehicle-level hazards and additional safety measures that are specific to transit buses.

This study was based on a literature review and interviews with subject matter experts at suppliers, manufacturers, and transit agencies to gain insight into aspects of transit buses and their operation. Hazard analysis and risk assessment were tailored to transit buses by considering system interfaces with transit bus-specific systems not present on light or commercial vehicles as well as unique aspects of transit bus operations. Driving automation system technologies studied include adaptive cruise control with/without stop-and-go, automatic emergency braking, docking, full park assist/valet parking, lane keeping/lane centering/steering assist, object detection and collision avoidance, park assist/park out/yard park, reverse braking assist, and traffic jam assist with lane keeping/lane centering. The research identified potential vehicle-level hazards for these driving automation systems, with each assessed for risk in accordance with the ISO 26262 functional safety process that considers severity, exposure, and controllability.

The study found that many vehicle-level hazards and functional safety measures for light vehicles and heavy trucks also apply to transit buses, thus facilitating transfer of these driving automation system technologies to transit buses, as many would not require significant modification. However, it also was found that transit bus operations can lead to unique vehicle-level hazards and additional safety measures that are specific to transit buses.

Identified in the report are 21 safety goals for the driving automation systems studied, general safety strategy considerations for each, and example functional safety measures.

Benefits

As transit agencies and bus manufacturers consider integrating driving automation systems into transit buses, new approaches may be necessary to ensure the safety of these electronic systems. ISO 26262 is used extensively for light vehicles and has since been extended to cover transit buses, and this study may serve as an example of how ISO 26262 concepts may be applied to transit buses. The combination of safety goals and general safety strategy presented herein may be informative to transit agencies and manufacturers as they conduct pilot programs and other studies to transfer light vehicle driving automation system technologies to transit buses.

Project Information

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This research project was conducted by the John A. Volpe National Transportation Systems Center. For more information, contact FTA Project Managers Danyell Diggs at (202) 366-1077 or Danyell.Diggs@dot.gov or Steven Mortensen at (202) 493-0459 or Steven.Mortensen@dot.gov. All research reports can be found at **https://www.transit.dot.gov/about/research-innovation**.