Safety and Health Impacts of Mobility Alternatives Technology Transfer

Final Report

by

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DISCLAIMER

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16. Abstract

Technology transfer is a vital component of the U.S. DOT University Transportation Center (UTC) program, ensuring that research findings are communicated to practitioners, policymakers, educators, and the general public. By translating technical insights into accessible and actionable information, technology transfer supports the implementation of innovative solutions that can improve out transportation systems. This report summarizes the outcomes of the "Safety and Health Impacts of Mobility Alternatives Technology Transfer" project, which aimed to broaden the dissemination of three completed C2M2 research efforts. These projects focus on automated vehicle safety, active transportation and bike share systems, and AI-enhanced truck platooning strategies. Through local, national and international presentations, educational integration, and the development of outreach materials, this project achieved its goals of sharing research finding with a broad audience.

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EXECUTIVE SUMMARY

The U.S. DOT UTC program emphasizes the importance of disseminating research through technology transfer. This initiative focused on expanding the outreach of three key Center for Connected Multimodal Mobility (C2M2) projects:

1. *Potential Reduction of Fatal Crashes in South Carolina due to Automated Vehicles*
2. *Assessing Potential of Bike Share Networks and Active Transportation to Improve Urban Mobility, Physical Activity and Public Health Outcomes in South Carolina*
3. *A Cloud-based Quantum Artificial Intelligence-supported Automated Truck Platooning Strategy to Reduce Energy Consumption and Enhance Mobility*

Major accomplishments include five presentations at local, national, and international venues, the development of one-page summaries and PowerPoint presentations for each project, and the creation of short lesson plans for curriculum use. These efforts helped translate technical findings into accessible formats, increased public and academic awareness, and encouraged dialogue among professionals and students.

CHAPTER 1

Introduction and Project Overview

One of the primary objectives of the U.S. DOT University Transportation Center (UTC) program is the dissemination of research findings through technology transfer. The goal of this initiative is to ensure that the results of transportation research are effectively communicated to professionals, policymakers, educators, and the general public to drive positive change in practice and policy.

In recent years, The Citadel, in collaboration with other Center for Connected Multimodal Mobility (C2M2) partner institutions, has undertaken several C2M2-funded research projects. This project focuses on expanding the outreach and technology transfer efforts of three previously completed initiatives.

The first project, “Potential Reduction of Fatal Crashes in South Carolina due to Automated Vehicles,” examined how automated vehicles (AVs) could impact the number of fatal crashes in South Carolina. Researchers conducted a comprehensive analysis of contributing factors for 919 fatal crashes that occurred in the state in 2019, along with a review of site-specific characteristics for each incident. A deterministic approach was used to estimate the effect of various AV automation levels on these crashes. Results showed a potential reduction in fatal crashes ranging from 10%–23% for Level 1 AVs, to nearly 95% for Level 5 AVs. These projections assumed that all vehicles operated at the same AV level and that users fully utilized the available technology and safety features. However, as illustrated in **Figure 1**, studies suggest that users do not consistently utilize AV capabilities. For instance, regardless of usage frequency, AV users are unlikely to activate autonomous features in snow or parking lots. Frequent users tend to embrace AV technologies more fully, while infrequent users are generally more hesitant. This project presented these findings at national and international venues, with the aim of encouraging the adoption and responsible use of AV technologies to enhance roadway safety.

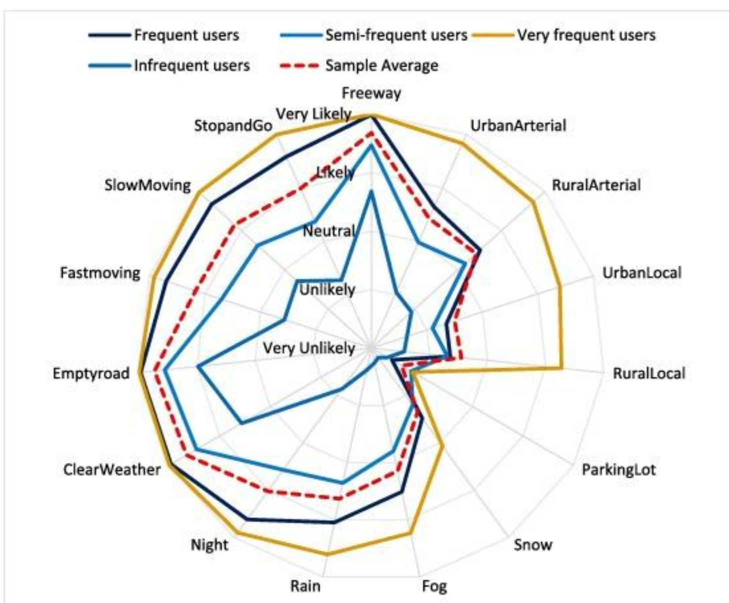


Figure 1: “Self-reported likelihood of using autopilot on various road types, weather conditions, and traffic conditions for the four latent classes of partially automated vehicle owners.” (2)

While this research focused on fatal crashes, future studies could broaden the scope to include crashes involving visible (non-incapacitating) injuries, severe injuries (incapacitating), or vulnerable road users. Follow-up studies may be pursued in partnership with NHTSA, SCDOT, SCDPS, and international collaborators. Long-term research could also validate the methodology using actual crash data as CAV penetration increases.

The second project, “Assessing the Potential of Bike Share Networks and Active Transportation to Improve Urban Mobility, Physical Activity, and Public Health Outcomes in South Carolina,” combined multiple data sources to evaluate how active transportation can address urban mobility needs. Findings from this research were disseminated to local stakeholders and shared with stakeholders implementing or expanding micromobility and bike share programs.

The third project, “A Cloud-based Quantum Artificial Intelligence-supported Truck Platooning Strategy for Safety and Operational Performance,” leveraged artificial intelligence to improve the efficiency and performance of truck platooning systems. The study evaluated both Long Short-Term Memory (LSTM) networks and a hybrid quantum-classical LSTM (QLSTM) for predicting the trajectory of leader vehicles in autonomous truck platoons. While both models produced comparable results, Quantum-AI offered greater efficiency in real-time applications, requiring significantly less computational power. Project outcomes communicated in accessible language for public understanding.

Technology transfer efforts included in-person presentations and incorporation of research outcomes into academic programs.

CHAPTER 2

Engagement

This project included several major dissemination and engagement activities in local, national, and international levels. Presentations conducted by the research team included:

- "Safety and Health Impacts of Mobility Alternatives" at the TU Delft Faculty Lunch Colloquium in the Netherlands on September 13, 2023.
- "Potential Reduction of Fatal Crashes in South Carolina due to Automated Vehicles" at the Southern District Institute of Transportation Engineers (SDITE) Annual Meeting in Wilmington, NC on April 4, 2024.
- "Safety and Health Impacts of Mobility Alternatives" at the International Conference on Transportation & Development (ICTD 2024) in Atlanta, GA on June 17, 2024.
- “Potential Reduction of Fatal Crashes in South Carolina due to Automated Vehicles” at the International Conference on Transportation & Development (ICTD 2024) in Atlanta, GA on June 17, 2024.
- "Safety and Health Impacts of Mobility Alternatives" at the C2M2 8th Annual Fall Conference in Columbia, SC on August 22, 2024.

An undergraduate student researcher also contributed to the dissemination efforts by presenting "Connected and Automated Vehicle Technologies and Related Legislation" during The Citadel’s Academic Excellence Day on April 5, 2024.

For each of those presentations, PowerPoint presentations and/ or posters were created. Figure 2 illustrates an example poster prepared for the presentation at the International Conference on Transportation & Development (ICTD 2024) in Atlanta, GA on June 17, 2024.

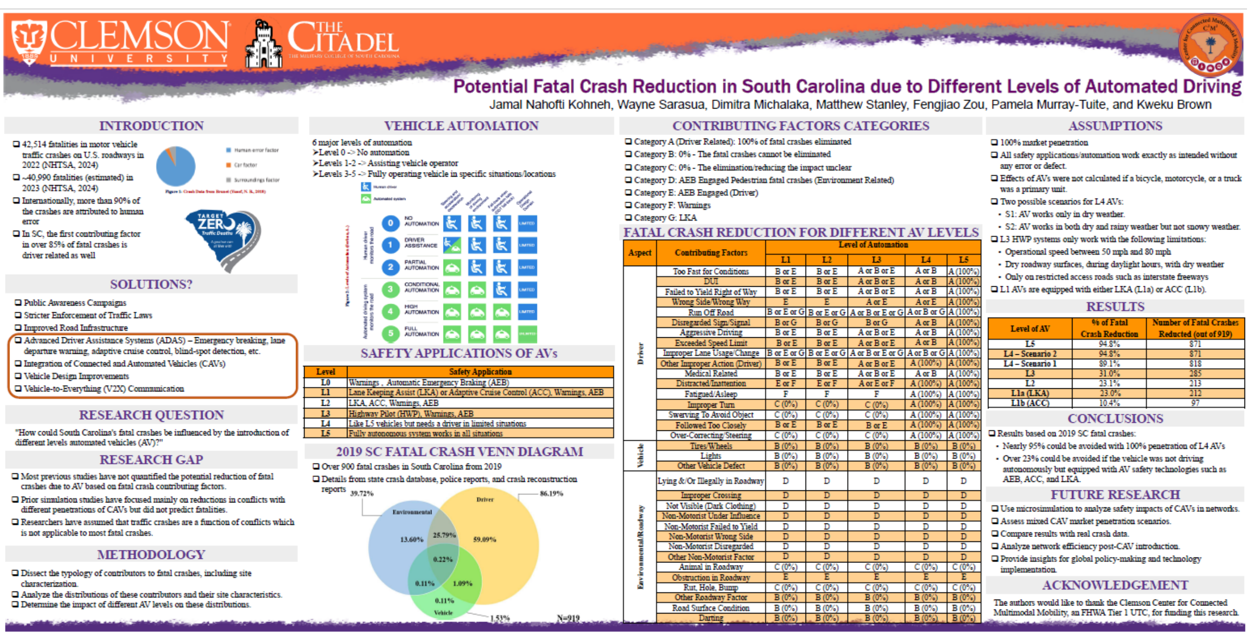


Figure 2: “Potential Reduction of Fatal Crashes in South Carolina due to Automated Vehicles” poster presented at the International Conference on Transportation & Development (ICTD 2024) in Atlanta, GA on June 17, 2024.

The presentations are available upon request. Complementing these presentations, the team developed one-page summaries for each project in order to communicate key findings in an accessible format for non-engineering audiences. Figures 3-5 present the summaries.

Potential Reduction of Fatal Crashes in South Carolina due to Automated Vehicles

Introduction

In 2023 alone, 40,901people died in roadway crashes across the U.S. This study investigates how automated vehicle (AV) technologies could reduce fatal crashes in South Carolina by evaluating how these technologies might have prevented real-world accidents.

How It Works?

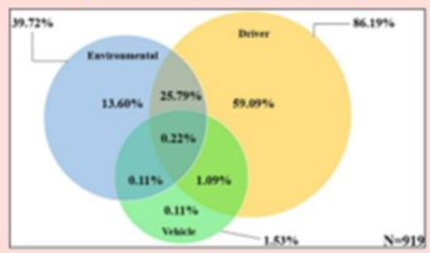
Researchers analyzed actual crash reports using data from police records, insurance documents, and other sources and applied various levels of vehicle automation to assess whether those crashes could have been avoided.

Levels of Automation

There are basically six levels of automation. Refer to image on the right.

Study Approach

1. Identify cause of each crash: weather (e.g., rain), mechanical failure, or driver behavior
2. Determine whether AV technologies could have prevented the crash
3. Apply potential reduction where automation may have had an effect



Examples of Impact

- Automated Braking: Could prevent rear-end collisions
- Speed Control: AVs can eliminate excessive speeding
- Driver Error Reduction: AVs don't get distracted or impaired

Why It Matters

This study provides data-driven evidence to support investments in vehicle automation as a public safety strategy. Results can guide policy, funding, and further research to help save lives and make roadways safer for everyone. In the Table below, you can see the potential % reduction with respect to the automation level.

Level of AV	% of Fatal Crash Reduction	Number of Fatal Crash Reduction (out of 919)
Level 5	94.8%	871
Level 4 – Scenario 2 (S2)	94.8%	871
Level 4 – Scenario 1 (S1)	89.1%	818
Level 3	31.0%	285
Level 2	23.1%	213
Level 1a (LKA)	23.0%	212
Level 1b (ACC)	10.4%	97

Figure 3: Potential Reduction of Fatal Crashes in South Carolina due to Automated Vehicles Brief Summary

Assessing Potential of Bike Share Networks and Active Transportation to Improve Urban Mobility, Physical Activity and Public Health Outcomes in South Carolina

Goal

This study explores the health benefits of bicycle travel in downtown areas. By focusing on shared bike usage, it highlights the convenience of a system that eliminates the need for personal bike storage and maintenance. A key component of the study is the evaluation of the usability and safety of existing bike routes through the Bicycle Level of Service (BLOS) metric, which assesses how smooth, accessible, and safe the infrastructure is for cyclists.

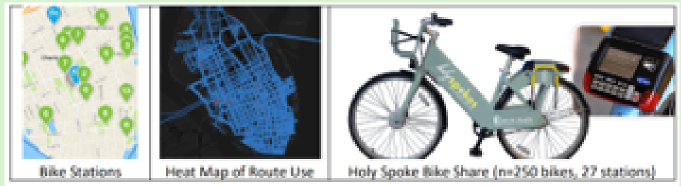


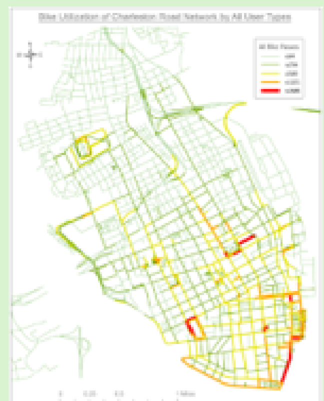
Figure 1 Holy Spokes Bike Share System, Charleston, SC, 2017-2022

How was it done?

Using detailed trip data from the Holy Spokes Bike Share system, researchers analyzed trip times, routes, time of day, and second-by-second GPS coordinates to reconstruct travel patterns for April 2018.

The Bicycle Level of Service (BLOS) was, then, determined by assessing factors such as the number of traffic lanes, speed limits, percentage of heavy vehicles, pavement conditions, and the width of the usable space for cyclists outside of vehicle lanes.

In addition, the physical activity benefits were estimated using the speed data recorded for each trip.



Why it Matters

Understanding the Level of Service helps city planners and stakeholders maintain and develop bike infrastructure in areas where people are more likely to replace car trips with bicycle trips. The health analysis suggests that current usage patterns are already contributing to a reduction in premature deaths, which are estimated between 0.099 and 0.3 annually. Expanding the system could amplify these health benefits, promoting a healthier and more sustainable urban environment.

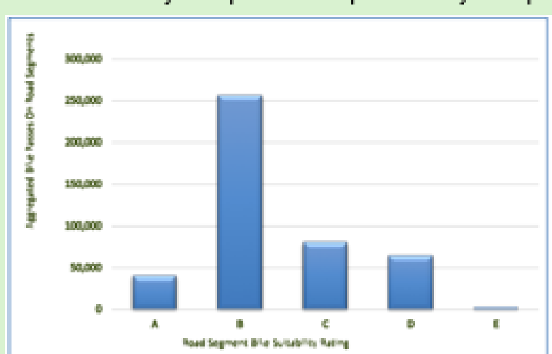


Figure 10 Cumulative Bike Share Segment Usage vs. Bike Suitability Level of Service

Figure 4: Assessing the Potential of Bike Share Networks and Active Transportation to Improve Urban Mobility, Physical Activity, and Public Health Outcomes in South Carolina Brief Summary

A Cloud-based Quantum Artificial Intelligence-supported Truck Platooning Strategy for Safety and Operational Performance

Introduction

Transporting goods across the U.S. is expensive and places heavy demand on infrastructure. Implementing automated truck platooning, a system where trucks travel in closely spaced groups, could save the trucking industry an estimated $868 million, while reducing roadway improvement costs by $4.8 billion. These savings benefit both private companies and public agencies. Reducing the computing demands on each truck through a centralized, cloud-based solution could further support widespread adoption.

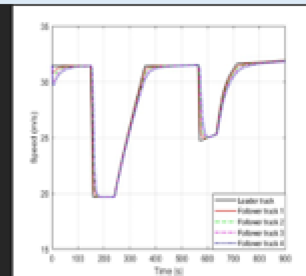


Figure 10: Speed profiles of autonomous trucks using LSTM trajectory prediction

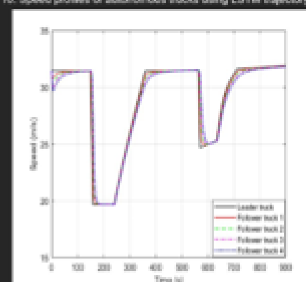


Figure 11: Speed profiles of autonomous trucks using QLSTM trajectory prediction

How It Works

Traditionally, each truck in a platoon must independently compute path and speed adjustments, placing a high computational burden on the system. This study explores a centralized cloud computing approach in which a program predicts the lead vehicle's behavior and transmits instructions to following trucks. Two methods were evaluated:

- **LSTM (Long Short-Term Memory Network)**
- **QLSTM (Quantum Long Short-Term Memory Network)**

Study Methodology

A simulation environment was developed to fairly test both LSTM and QLSTM models under identical conditions. Each method was used to predict vehicle trajectories and control platoon behavior. The study evaluated whether the new quantum-based method would maintain safety while offering computational advantages.

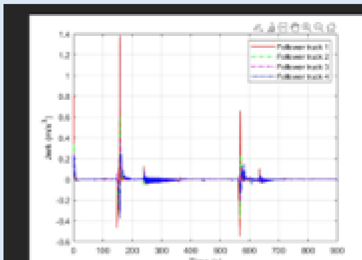


Figure 16: Jerk profiles of autonomous trucks using LSTM trajectory prediction

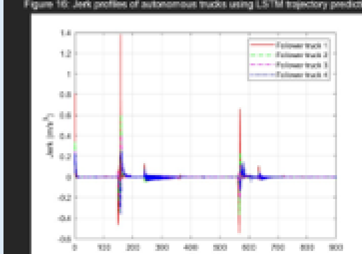


Figure 17: Jerk profiles of autonomous trucks using QLSTM trajectory prediction

Key Findings

"The analysis found that both the LSTM and QLSTM gave comparable results. It can be inferred that Quantum-AI will be more efficient in real-time management and require less computational burden for an Automated Truck Platoon."

This means that QLSTM maintains the same level of safety and control as LSTM but does so more efficiently, making it the preferred method for implementation. The graphs above show that shifting computation to a central system does not negatively impact platoon speed or stability.

Overall, QLSTM offers a reliable, scalable way to implement truck platooning using fewer resources supporting cost savings, infrastructure longevity, and safer highways.

Figure 5: A Cloud-based Quantum Artificial Intelligence-supported Truck Platooning Strategy for Safety and Operational Performance Brief Summary

CHAPTER 3

Conclusions

The dissemination and engagement efforts led to meaningful outcomes. Several students and professionals engaged directly with the research topics through presentations, class discussions, and events. One-page project summaries were developed to simplify complex research concepts for the general public, as presented in Chapter 2, while integration of project findings into lesson plans in transportation and highway engineering courses enhanced engineering education. PowerPoint materials were also utilized effectively in both classroom and conference settings, providing accessible communication tools for various audiences.

This project significantly enhanced the visibility and accessibility of key C2M2 research findings. Presenting these findings to diverse audiences, that included academics, students, professionals, and international researchers, increased awareness of the potential safety benefits of automated vehicles, the public health and mobility advantages of bike share and active transportation, and the energy efficiency and operational gains of AI-supported truck platooning. The project fostered new partnerships with engineers in the Netherlands. Materials developed through this effort remain available for future use, supporting ongoing and future initiatives. Looking ahead, continued research could explore the application of findings to injury crashes, vulnerable users, and predictive simulation modeling, particularly through collaborations with national and international partners.

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