

# UT Center for Transportation Research

ANNUAL REPORT

2017



The Center for Transportation Research has been operating for 45 years at the University of Tennessee. It is an internationally recognized center of innovation with more than \$10 million in sponsored research under contract. It plays a critical role in supporting the Tickle College of Engineering's continuing education of the state's future transportation professionals.



Since 1972, CTR has:

- Led 650 sponsored projects
- Been awarded \$150 million
- Worked with 182 sponsors

# Celebrating 45 Years— *and Revving Up for the Future*

In December of 1970, the University of Tennessee signed a Memorandum of Agreement with the Tennessee Department of Transportation (known at that time as the Department of Highways) to establish the Center for Transportation Research. The intent was for “the University, acting through the Transportation Center, to work in concert with appropriate agencies of State government to aid and assist in matters involving the total transportation needs of Tennessee.”

CTR was founded at the university because UT wanted to give the state a comprehensive transportation research and advisory service for all modes and aspects of transportation. For 45 years, this foundation has given CTR access to UT academic programs interested in conducting transportation research. Because of this access, we have been able to build enduring connections with the multitude of disciplines that inform transportation safety.

By 1972, CTR was in full operating mode and, in accordance with that MOU, improving the state of safe transportation in Tennessee. Our first tasks were to develop guides, manuals, and operating policies and procedures to ensure a modern and integrated highway network, both urban and rural, that can accommodate all highway travel in a safe,

efficient, and economical manner. We have been building on these ever since.

Early on, CTR aided in Tennessee’s adoption of the child passenger restraint laws. This led to many improved traffic safety laws.

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## *Mission, Vision, Values*

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Our center mirrors UTK’s land grant mission to provide education, research, and public service. In pursuit of these mandates, we created our values, mission, and vision statement:

CTR is dedicated to excellence and integrity in providing effective transportation solutions through research. Our mission is to harness the full resources of the University of Tennessee in the conduct of transportation research; develop and educate the transportation workforce; and assist and advise operators and users of the transportation system. Our vision is to be recognized for excellence in university-based transportation research, education, and service.

These principles will carry CTR far into the future. The next 45 years will be exciting!



# To CTR's Stakeholders

I am pleased and proud to present this annual report. It summarizes the activities and accomplishments of the Center for Transportation Research during our 45th Anniversary year at the University of Tennessee. In this span of five decades, CTR has become an internationally recognized center of innovation, with more than \$10 million in sponsored research under contract. CTR plays a critical role in the Tickle College of Engineering's training of Tennessee's future transportation professionals.

CTR's longevity has fostered many cooperative, cross-discipline, cross-institutional, and cross-cultural relationships that are essential to our productivity. The nature of transportation work requires us to combine expertise from engineering, economics and supply-chain management, geography, law, health care, and other related disciplines. This fundamental need is reflected in the interdisciplinary makeup of CTR's internal faculty and resources (engineers, geographers, planners, and economists) and is further addressed by our numerous interdisciplinary partnerships, such as our CTR Fellows Program.

The movement of people and things is an essential human activity. This can be as complex and modern as the simultaneous movement of 20 million shipping containers, or as simple and timeless as walking from

Point A to Point B. Moreover, the ubiquitous need for transport means that we are all stakeholders with interdependent transportation interests, and that very little of our inhabited environment can be isolated from ongoing transportation activity. In this way, transportation is the most public of all activities.

For 45 years, CTR has built its successes upon academic collaborations, delivered top-notch research results, furthered the careers of students and faculty, and improved how our state and nation moves people and goods safely and efficiently. We look forward to at least another 45 years of pushing the transportation boundaries.

That is why CTR exists.



David B. Clarke, Director



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## *CTR Leadership*

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*Dr. David B. Clarke*  
*Director*



*Dr. Jerry Everett*  
*Associate Director*



*DeAnna Flinchum*  
*Chief of Staff*



*Carol Hatmaker*  
*Business Manager*



*Dr. Mark Burton*  
*Director, Transportation*  
*Economics*



*Matt Cate*  
*Director, Tennessee*  
*Transportation Assistance*  
*Program (TTAP)*



*Dr. Airton Kohls*  
*Director, Traffic Signal*  
*Academy*



*Dr. Janet Hopson*  
*Fuel Economy Information*  
*Project Lead*

# Celebrating the Future of Transportation

“CTR should be recognized and celebrated because it is really the model of what is absolutely necessary in our nation and in our state to solve the problems of today.”

Dr. Robert Nobles, Interim Vice Chancellor  
for Research and Engagement

On November 1st, 2017 the Center for Transportation Research celebrated its 45th Anniversary. Staff members, students, friends, and associates from across Tennessee shared a comprehensive program led by CTR’s director, Dr. David Clarke. Dr. Clarke highlighted CTR’s commitment to multidisciplinary transportation research: By serving as the focal point for transportation research at the University of Tennessee, CTR brings experts from multiple engineering disciplines together with economists, planners, logisticians, environmental scientists, and other relevant specialists to provide timely information to federal, state, and local governments and the private sector.

Dr. Clarke was joined by two former CTR directors, Dr. Kenneth Heathington and Dr. Stephen H. Richards. Dr. Wayne Davis, Dean of UT’s Tickle College of Engineering (TCE), and Dr. William Dunne, Associate Dean for Research and Facilities at TCE, acknowledged CTR’s importance to the Tennessee transportation community.

Dr. Richards, who currently directs the Southeastern Transportation Center (STC), presented a history of CTR accomplishments ranging from its work to support pioneering legislation requiring the use of child safety seats in Tennessee to research on multimodal transportation and highway safety.

Dr. Robert Nobles, Interim Vice Chancellor of Research and Engagement at the University of Tennessee, Knoxville, spotlighted the importance of CTR’s research and partnerships. Since its formation in the early 1970s, more than 50 CTR principal investigators have led approximately 650 sponsored projects. These projects brought the university more than \$150,000,000 in awards from 182 unique sponsors. CTR’s top sponsors are the Tennessee Department of Transportation, the US Department of Transportation, and the US Department of Energy. Additionally, he recognized that three CTR staff members, Dr. Jerry Everett, Dr. Clarke, and Dr. Richards, are among UT’s largest recipients of funding.



Invited guest speakers included Commissioner David Purkey from the Tennessee Department of Safety and Homeland Security. Mr. Purkey discussed future concerns with cybersecurity for connected and automated vehicles. Deputy TDOT Commissioner Toks Omishakin cited CTR's research efforts on behalf of TDOT in all transportation spheres, including planning, design, operations, maintenance and economic impacts. Mr. Omishakin pointed to TDOT's increasing emphasis on Transportation Systems Management and Operations (TSMO) as multimodal strategies to maximize the efficiency, safety, and utility of existing and planned transportation infrastructure.

Finally, Ms. Leslie Meehan, Director of Primary Prevention at the Tennessee Department of Health, discussed the department's efforts to create livable, prosperous, and healthy communities across Tennessee by focusing on the built environment and opportunities for active transportation.

To conclude the program, Dr. Clarke presented the 2017-18 CTR Fellows. The CTR Fellows Program recognizes existing partners and stimulates new connections with researchers across UT's Knoxville campus. The latest fellows with their research interests are listed on page 10.

A reception followed the technical program where attendees mingled and conversed with the UT students who presented their research in a poster session.

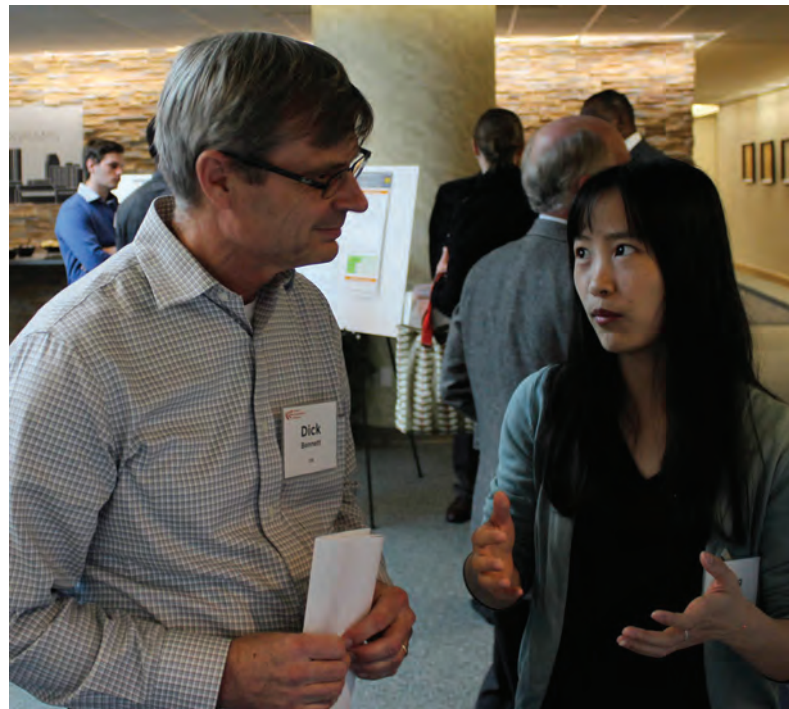
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*“Since CTR’s beginning, we understood that its mission was not just about the College of Engineering; it was about the University of Tennessee and the State of Tennessee.”*

*Dr. Wayne Davis, Dean,  
College of Engineering*

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*Above: Dean Davis and doctoral student Mojdeh Azad;  
center: CTR Fellow Rachel Chen and Dr. Clarke; bottom: CTR  
Fellow Dick Bennett and doctoral student Meng Zhang.*



# Points of Pride

In a year filled with notable accomplishments, the following achievements stood out for their impacts on transportation safety, scholarly publishing, and the communities we serve.

## Tax Policy Brief - CTR Supports Governor's Highway Proposal



In a January 2017 presentation to Tennessee Legislators, Dr. Mark Burton, CTR Director of Transportation Economics, laid out the options Tennessee has for funding its highway infrastructure. As Tennessee's governor sought a workable solution to this issue,

CTR provided historical data, compared Tennessee's performance to other states, and created forward-looking alternatives for maintaining and improving safety and quality.

Burton joined forces with Dr. Matthew Murray and Jilleah Welch of the Howard H. Baker Jr. Center for Public Policy, and Emily Pratt of the Boyd Center for Business and Economic Research to produce *Policy Brief 5.16, Tax Policies and Alternative Revenue Sources: State Responses to Declining Purchasing Power of Roadway Funding*. This report details insights into how other states are responding to funding challenges through tax policies and alternative revenue sources, including the strengths and weaknesses of these revenue mechanisms.

## ADA compliance - Tennessee Transportation Assistance Program (TTAP)

A major success for TTAP this year concerns the Americans with Disabilities Act (ADA). In the past, local agencies have been required to provide ADA-compliant facilities and services only when using state or Federal funds. Now TDOT requires all local governments receiving these funds to appoint an ADA coordinator and publish an ADA grievance procedure.

Most agencies are willing to perform self-evaluations and create or update transition plans, but they need guidance and detailed information. In response, TTAP helped local agencies conduct self-evaluations and develop transition plans. TTAP offered the ADA workshop, *ADA Self-Evaluations/Transition Plans and Overview of Elements of Public Right-of-Way Accessibility*, taught by Dr. Ron Eck from the West Virginia LTAP center.

## #GetConvinced Teen Outreach Program

*Not buckled up? What's holding you back?*

# #GET CONVINCED

With the end of the CDC Night-time Seatbelt pilot study drawing near, Associate Director Dr. Jerry Everett

wanted to sustain the grant's focus of increasing seatbelt use by young people. His solution was to request and obtain funding from Tennessee Highway Safety Office, whose primary mission is reducing fatalities on our roads. Dr. Everett and



his team developed the #GetConvinced outreach program, aimed at teens aged 15-19. Studies show that car crashes are the leading cause of death for this age group. This grant allows CTR to bring the Arrive Alive with The Seatbelt Convincer program to area schools and events at no cost.

#### *Seatbelt Convincer reaches thousands of youth*

The #GetConvinced program has brought the UTK Seatbelt Convincer to more than 5,000 young people. The convincer simulates a 5-7 mph crash, demonstrating just how jolting even a low-speed impact is and how effective seatbelts can be. In 2016-17, CTR staff brought the convincer to area events attended by 16-32 year olds in Blount, Knox, Loudon, Roane, and Sevier counties. The Convincer made appearances at the Luke Bryan Farm Tour Concert at Maple Lane Farms in Greenback; UT Police Department's Blue Light Special awareness campaign; local high school driving classes; law enforcement community events such as Blount and Alcoa's law enforcement National Nights Out; and the press conference for Tennessee Highway Safety Office's Seatbelts Are for Everyone launch.

#### **Cross-cutting Continuing Education: Rail Safety Workshop for Transit Workers**

Dr. David Clarke delivered a workshop on Railroad Track Inspection and Safety Standards that was customized for the Washington DC Metrorail Transit System (WMATA). Because federal track safety standards do not usually apply to transit



systems, this version of the workshop was customized to meet specialized requirements to train transit system track inspectors and track supervisors. Dr. Clarke delivered individualized versions of this workshop for the Memphis Area Transit Authority and the San Francisco Bay Area Rapid Transit.

Railroad Track Inspection and Safety Standards is CTR's most popular railroad workshop; it addresses the basic principles of track inspection. Under new Federal training rule requirements, this workshop is the first in the nation to be FRA Part 243 certified.

#### **Journal of Transportation Safety & Security (JTSS) Indexed in Web of Science**

Founded in 2009, JTSS was indexed in Web of Science in 2016. Prior to the inception of JTSS, there were limited outlets for publishing research in the areas of comprehensive transportation safety or transportation security. JTSS fills that gap by emphasizing safety issues of multimodal transportation, including highway, transit, ride-sharing, pedestrian and bicycle modes as well as rail, water and aviation. The journal's aim is to disseminate advanced research results and engineering experience to educators, researchers, practitioners, and policy makers to enhance transportation safety with comprehensive and integrated solutions. JTSS is an official journal of the Southeastern Transportation Center in partnership with the University of Tennessee and Beijing Jiaotong University.

#### **Visiting Scholars Program**

CTR established the Visiting Scholars Program in 2010, with one scholar, Dr. Binmin Liu, coming from Beijing Jiaotong University (BJTU). The second scholar was Dr. Chunjiao Dong, pictured right, also from BJTU. Dr. Dong now oversees this growing program, and she has increased the number of



visiting scholars to 12 this year and increased our partner institutions by 80 percent. Through this program, CTR connects with different universities in China, and participants gain broader perspectives on both transportation and culture. CTR and UTK are gaining name recognition throughout China, especially with researchers, students, and officials. This increases the opportunities to develop new programs such as student exchanges, international summer schools, and professional training programs.

### Fuel Economy Guide

CTR staff at the National Transportation Research Center produce the nationally recognized Annual Fuel Economy Guide and the fueleconomy.gov website for the Department of Energy and the Environmental Protection Agency. The Fuel Economy Information Program meets the DOE's statutory requirements to provide fuel economy information to the public. The program goal is to promote clean energy alternatives.



Fueleconomy.gov provides comprehensive information about vehicle fuel economy. The official U.S. government site for fuel economy information, it is operated by the Department of Energy and the Environmental Protection Agency. The site provides access to general information, widgets to help car buyers, Top Ten lists of fuel-efficient cars, a trip calculator, and fuel economy datasets. Fueleconomy.gov is considered to be one of the most useful consumer sites on the internet.

The program's objective is to recognize and improve collaboration among faculty across the university who focus on transportation-related research. CTR Fellows play an active role in our center by providing new ideas and initiatives. CTR fosters a cross-disciplinary atmosphere because working together across departments is often the key to our success.

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## 2017-18 CTR Fellows

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2017 marks the fourth year of the CTR Fellows Program. The 2017-18 class, pictured from left to right, includes **Dr. Qing “Charles” Cao**, Associate Professor in TCE's Department of Electrical Engineering and Computer Science; **Dr. Rachel Chen**, Director of the Center for Sustainable Business and Development in the Institute for a Secure and Sustainable Environment; **Dr. Brad Collett**, Associate Professor of Plant Sciences in the UT Institute of Agriculture; **Dr. David “Butch” Irick**, Research Associate Professor in TCE's Department of Mechanical, Aerospace, and Biomedical Engineering; and **Dr. Lance Saunders**, Assistant Professor of Marketing and Supply Chain Management in the Haslam College of Business.



# Research & Supporting Programs

CTR provides research expertise in three major areas: transportation safety, transportation planning, and intermodal transportation and freight. This work benefits the region, the state, and the nation through our programs of education, workforce development, service, and community outreach.

Our work touches many lives by improving safety on our highways and neighborhood streets. We help state and local agencies craft good transportation policy. We strive to understand the attitudes our citizens have toward transportation issues, and we educate drivers on safe practices. CTR brings transportation options to underserved populations. Our work promotes environmentally sound ways to move freight, and our workshops improve personnel safety in roadway work zones. CTR has expertise maintaining and improving transportation infrastructure, and assisting public and private transportation agencies to keep their staffs up-to-date in industry methods, practices, and regulations.

As an interdisciplinary research center, CTR brings together experts in civil, environmental, and industrial engineering; transportation and urban planning; logistics and supply chain management; economics; geography; and education. Through collaborative efforts, center researchers address technical and policy-related issues through traditional sponsored research.

CTR conducts its activities with a combination of internal staff, faculty and staff from other

University of Tennessee departments, faculty and staff from other universities, and private-sector partners. CTR frequently partners with faculty and staff members and graduate students from the University of Tennessee's Departments of Civil and Environmental Engineering, Industrial and Information Engineering, Geography, and Economics; research centers such as the Institute for a Secure and Sustainable Environment; and outreach and service programs, including the Municipal Technical Advisory Service, the County Technical Assistance Service, and the Center for Industrial Services. External university partners include Tennessee Tech University, the University of Memphis, and Vanderbilt University.

This research and program activity is vital to the development of tomorrow's transportation workforce. Our students fill positions in public transportation agencies and the organizations that serve these agencies. Sponsored research gives students exposure to real-world data and problem solving, providing valuable experience for the workplace and improving the effectiveness and appeal of the University's academic programs.



## Transportation Safety Research

Three large-scale projects related to transportation safety were underway at CTR in 2017. Two of these began wrapping up this year: the \$5.5 million Southeastern Transportation Center and the \$1.2 million Centers for Disease Control and Prevention Nighttime Seatbelt Use pilot study. Also, CTR transitioned from a regional to a national transportation safety research focus this year by joining the Collaborative Sciences Center for Road Safety (CSCRS), funded by US DOT. CSCRS's transportation safety focus aligns with CTR's principles.

### Southeastern Transportation Center (STC)

STC is a consortium of nine universities in US DOT



Region 4. It is led by the Center for Transportation Research at the University of Tennessee. Under the theme of *Comprehensive Transportation Safety*, STC conducts and funds research that improves public safety and health

by reducing transportation-related fatalities and injuries. Several STC projects were completed during this year, and others were recently funded.

### Major Research Initiatives wrapping up in 2017

STC determined the scope of its Major Research Initiatives through a safety research needs assessment in our region. TDOT and the SASHTO research subcommittee assisted with this assessment. Based on this input, STC designed the following four projects to address common and high-priority regional needs, coordinating topics that were identified by US DOT modal administrators.

- MRI 1. Crash Modification Factors and the Highway Safety Manual, Raghavan Srinivasan, Highway Safety Research Center, Coordinator

- MRI 2. Integrated Simulation and Safety, Essam Radwan, University of Central Florida & Nikiforos Stamatiadis, University of Kentucky; Co-Coordinators
- MRI 3. Exploring Socio-Demographic Characteristics and Culture Factors in Differential Safety Performance across Geography, Shashi Nambisan, University of Alabama & Steve Polzin, University of South Florida; Co-Coordinators
- MRI 4. Big Data for Safety Monitoring, Assessment, and Improvement, Asad Khattak, University of Tennessee, Coordinator

### Opportunity and Exploratory Grants initiated in 2017

O&E Grants provide individuals or small groups of faculty and students the opportunity to engage in safety-related research within their areas of interest and expertise. These projects have transferred a significant amount of technology to the field of transportation safety. The 2017 O&E Grants are:

- Connected and Automated Vehicles: What are the implications of partial adoption? Asad Khattak, University of Tennessee
- Technology based risk mitigation strategies to improve older driver safety. Adam Kirk, University of Kentucky
- Electric bikes in bikeshare systems and big data: opportunities to assess widespread safety and health. Chris Cherry, University of Tennessee
- Development of a connected vehicle test bed on UT campus. Lee Han, University of Tennessee
- Can you hear it now? A study of personal listening devices and pedestrian safety. Maranda McBride, North Carolina A&T State University
- Disaster analytics: Disaster preparedness and management through online social media. Samiul Hasan, University of Central Florida
- A scalable augmented reality testbed for automated and human-driven vehicle coordination experiments. Subhadeep Chakraborty, University of Tennessee

## Centers for Disease Control & Prevention Nighttime Seatbelt Use Pilot Study



CTR embarked on the third and final year of this study for the CDC. The study has been investigating nighttime seatbelt use by drivers and passengers on Tennessee's highways. Whereas previous seatbelt awareness programs have helped the Tennessee Highway Patrol and other law enforcement agencies raise overall seatbelt use, this pilot has focused specifically on increasing nighttime seat belt use through outreach and marketing campaigns. Before-and-after-campaign surveys and roadside observations were conducted to gauge the campaign's effectiveness.

Surprisingly, many people who buckle up for daytime driving do not use seatbelts at night, especially younger drivers. To address this trend, CTR designed and implemented the *Buckle Up Tonight to See Tomorrow* media campaign aimed at young drivers. CTR staff flooded the area with radio and Pandora spots, social media, 30 second movie theater ads, billboards, yard signs, banners in high schools, T-shirts, and in-restaurants promotion via cups, coasters, and table tents. Driver Service Centers Surveys measured the before-and-after levels of awareness of saturation patrols and media campaigns.

### *CrossFit Friday Night Lights: Why Wear Your Seatbelt? It's What the Tough Guys Do!*

According to data gathered through surveys in Tennessee, the people least likely to use seat belts are men aged 18 to 32, especially those who drive pickup trucks. To expose this population to the Buckle Up message, CTR partnered with 14 local CrossFit gyms to sponsor Friday Night Lights competitions that are part of the Reebok CrossFit Games Open qualifier. A large segment of CrossFit athletes fall into the campaign's target demographic. Knoxville native and Professional CrossFit Games Athlete Alex Anderson agreed to be the face of the seatbelt campaign. As the *11<sup>th</sup> Fittest Man*

**BUCKLE  
UP  
TONIGHT  
TO SEE  
TOMORROW**

*in the World for 2016*, he knows the importance of buckling up. "I used to not wear my seatbelt, but one day it just clicked and I thought, 'What am I doing? Why wouldn't I take the time for something so simple when I spend so much time making other choices to better myself?'"

### **Collaborative Sciences Center for Road Safety (CSCRS) National Safety Center**

In December of 2016, CTR joined this new National University Transportation Center. Led by the UNC Highway Safety Research Center, CSCRS unites leading transportation research, planning, public health, data science, and engineering programs at Duke, Florida Atlantic University, Cal Berkeley, UNC Chapel Hill, and UTK.

CSCRS kicked off its research program with the funding of eight "Quick Start Programs." Two CTR researchers, Drs. Asad Khattak and Chris Cherry, are principal investigators on two of these projects: *Completing the Picture of Traffic Injuries: Understanding Data Needs and Opportunities for Road Safety* (Cherry) and *Advanced Analytics for Vulnerable Road User Scenarios* (Khattak, co-PI with Noreen McDonald).

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## *Transportation Planning*

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CTR has the research experience and technical competency to forecast demographic and land use changes that indicate major growth corridors. We develop long-range plans for capital improvement; estimate the effects of proposed transportation system improvements; and develop financial plans to fund implementation and operation of transportation improvements.

Our expertise lies in these areas of transportation planning:

- Travel Demand Forecasting and Modeling
- Traffic Operations
- Geographic Information Systems
- Infrastructure Finance
- Land-Use Planning
- Air Quality and Emissions Modeling
- Community Level Planning
- Active Transportation Planning and Outreach

CTR Planning personnel created Access Management Design Guidelines for TDOT. These guidelines help TDOT personnel during the approval process of projects that require access to State Routes. The guidelines also describe best practices for corner clearances and median openings for TDOT projects.

Planning researchers also conducted a Truck Ramp Parking Project for TDOT. Trucks parking on the shoulders of ramps pose a safety risk to drivers. This safety issue is weighed against the need for efficient freight movement and federal requirements for rest periods.

Research for the Green Generates Green project supports TDOT's Long Range Transportation Plan by looking at less costly transportation investments that will maximize TDOT's financial investment.

### **Tennessee Model Users Group (TNMUG)**

The Tennessee Travel Demand User's Group provides a forum for practitioners to exchange information about travel demand modeling and forecasting. The goal is to improve modeling and forecasting capabilities in Tennessee. The group's

training efforts focus on a much smaller but more technically advanced audience of transportation modelers within TDOT's Long Range Planning Division and the state's 11 Metropolitan Planning Organizations. The group is a collaboration among Tennessee universities, TDOT, FHWA, MPOs, consultants, and other interested parties. The modeling group promotes standard statewide guidelines and validation standards, helps coordinate systematic data collection and processing, organizes and promotes staff member training, and conducts research on selected areas of interest to the group.

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## *Freight and Intermodal Transportation Research*

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### **National University Rail Center (NURail)**

The National University Rail (NURail) Center is a consortium of seven partner colleges and universities dedicated to the advancement of North American rail transportation. The Center is headquartered at the University of Illinois at Urbana-Champaign and includes researchers and educators who are experts and national leaders in railway infrastructure, systems, and vehicles.

The center's overarching objective is to sustain and expand US freight railroad transportation safety, capacity, efficiency, and reliability, while also developing commuter and intercity passenger rail systems. The divergent needs of freight and passenger trains on shared corridors present complex infrastructure, rolling stock, operational, and institutional problems. NURail Center research investigates issues affecting railroad infrastructure, railroad vehicles, and railroad systems.

CTR manages these NURail projects:

- *Laboratory Investigation of Steel Tie Performance*, David Clarke and Baoshan Huang
- *Seismic Performance of Stone Masonry and Unreinforced Concrete Railroad Bridge Substructures*, David Clarke and Z. John Ma
- *Assessment of Existing Railroad Bridges to*



*Accommodate a Higher Speed Considering Chinese Practices*, David Clarke and Z. John Ma

- *Lateral Impact of Railroad Bridges with Hybrid-Composite Beams*, Richard Bennett and Z. John Ma
- *Development of New Damping Materials for Ballastless Trackbed and their Behavior under Mixed Traffic*, David Clarke and Baoshan Huang
- *Evaluation of Terminal Capacity Models for Rail Freight Flow Analysis*, David Clarke and Mingzhou Jin
- *Integrated Network Capacity Analysis for Freight Railroads*, David Clarke and Mingzhou Jin
- *What is the Extent of Harm in Rail-Pedestrian Crashes?* David Clarke and Asad J. Khattak
- *The Impact of Reduced Coal Consumption on the Southeastern Railroad Network*, David Clarke and Mark Burton

## Freight Planning and Operations

Goods are moved best when moved cleanly, cheaply, safely, and unobtrusively, causing as little interruption as possible to communities. Preserving and improving freight mobility in an era of increasing population densities, congested transportation networks, and uncompromising environmental standards is an immense challenge. CTR is rooted in the university's enduring commitment to understanding freight transportation and educating new generations of freight industry professionals.

## Inland Waterways

This past year, CTR partnered with Vanderbilt and the former CEO of Ingram Barge to complete an analysis of the effects of unanticipated lock closures, funded by the National Waterways Foundation. CTR economists completed waterway traffic forecasting on the Kentucky Lock and Chickamauga Lock for the US Army Corps of Engineers. They also completed a study for the Appalachian Regional Commission on the effects that decreasing reliance on coal has on freight transportation. These are lasting, structural changes that deeply

affect the region.

CTR is one of the few university-based transportation research organizations with a strong focus on inland waterway freight transport via barge. Key staff members have decades of experience supporting federal policy makers, the U.S. Army Corps of Engineers, the Tennessee Valley Authority, and the barge industry.

This navigation work involves waterway system components throughout the United States, primarily the Mississippi, Tennessee, and Cumberland Rivers. CTR helps communities throughout the state evaluate barge terminal opportunities, and works jointly with TDOT and the U.S. Army Corps of Engineers' Nashville District to identify truck movements that could be diverted to waterways.

CTR's waterway research ranges from operational issues to national policy. CTR's staff has the expertise to resolve issues tied to vessel type, fleeting activities and cargo transfer techniques. America's inland waterways are among our oldest and most reliable means of moving both people and freight, accommodating roughly 560 million tons of freight annually.

## Intermodal Freight Systems

Improving the ability to combine individual transport modes is at the forefront of state and federal policy and infrastructure discussions. Intermodal transportation is routinely cited as a key strategy for addressing roadway congestion, improving environmental outcomes, enhancing global connectivity, and spurring localized economic development. However, evaluating the desirability of individual intermodal projects requires a great deal of additional information.

CTR experience in intermodal transportation includes terminal design, operations studies, demand forecasting, and benefit-cost analysis. Our project experience includes marine-rail, marine-highway, waterway-rail, waterway-highway, and rail-highway systems. These systems include both bulk and containerized cargos.



*Above: TTAP Director Matt Cate tests a PowerMoon light, which is used in nighttime seat belt observations for the CDC project.*

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## *Workforce Development*

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Over our 45 years, CTR has developed three continuing education programs to improve the capabilities of the staff and professionals who work in transportation. Through customized workshops and courses, CTR reached more than 2,460 people this year alone.

The Tennessee Transportation Assistance Program (TTAP) provides direct technical assistance to Tennessee cities and counties on highway and traffic engineering issues. Their training workshops and short courses address the ever-changing needs of transportation agency staff and professionals. TTAP offers a certificate program

through the Tennessee Academy of Transportation Engineering (TATE) that is designed to fill the knowledge gaps of new graduates as they enter the workforce. The Traffic Signal Academy promotes best practices in signal timing procedures to help transportation agencies improve benefit-to-cost ratios by operating new or existing systems with greater efficiency. Rail courses provide education and training to the railroad industry in track inspection and safety standards, railroad security and vulnerability assessment, and advanced railroad track geometry, among other topics.

### **TTAP**

The Tennessee Transportation Assistance Program is part of a nationwide Local Technical Assistance





*Above: CTR Director Dr. David Clarke demonstrates how to measure track gage and rail elevation in a Railroad Track Inspection and Safety Standards workshop.*

Program (LTAP) financed jointly by the Federal Highway Administration (FHWA), Tennessee Department of Transportation (TDOT), and the University of Tennessee. TTAP moves innovative transportation technologies and practices into the hands of the men and women charged with maintaining Tennessee's local roads and bridges. TTAP assists city and county staff in solving transportation related problems and strives to be the prime resource in developing and transfer-

ring technologies, proven solutions, and reliable services to resolve the transportation challenges facing local governments. TTAP improves the state of Tennessee's workforce through continuing education, workshops, and technical assistance. We maintain a library of videos, publications, and reference materials to lend to transportation agencies in Tennessee.

### **Traffic Signal Academy**

As they face limited fiscal resources, agencies at all levels must find ways to optimize available technology while applying innovative concepts to systems already in place. To aid in solving this problem, the Traffic Signal Academy courses present academic research findings and established best practices in signal timing procedures and policies. This reliable information can help improve benefit-to-cost ratios by operating new or existing systems with greater efficiency.

### **Rail Courses**

CTR's expertise in railway transportation is nationally recognized. We are a member of the National University Rail Transportation Center (NURail) consortium, led by the University of Illinois at Urbana-Champaign. NURail is the only federally funded rail oriented university transportation center. In conjunction with the University of Tennessee's Department of Civil and Environmental Engineering, CTR provides college courses in railway engineering. CTR also has one of the few university-based continuing education programs oriented to professionals in the rail industry and related public sector agencies. Course attendees come from throughout North America.

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## *Education*

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CTR supports and advances transportation education at all levels. Over the years CTR has funded more than 1,800 graduate and undergraduate students at UT, involving these students in research to prepare them to enter the transporta-



tion workforce and address transportation's most critical and emerging needs.

K–12 efforts use transportation concepts in math and science curriculum development, teacher training, and interactive content development for iBooks. The Federal Transit Administration funded CTR's project, Transit: Your Ride to the Future. This program targeted young people and introduced them to public transit in our region. Outreach included Transit Days, held at Knox County public elementary schools, and a calendar art competition for K–12 students.

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## *Service & Community Outreach*

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### **Tennessee Vans (TN Vans)**

Tennessee Vans is a unique social business enterprise. The Tennessee Vans program was initiated in 1990 as a continuation of TDOT's supportive role in the development of van transportation services in Tennessee. Tennessee Vans is a human mobility system designed to address the changing nature of

mobility needs and the growing demands for transportation resources among a diverse population in Tennessee. Tennessee Vans works in partnership with community agencies that provide services to persons with disabilities, recovery program participants, youth, seniors, and many others. The program provides vehicles and associated services to community agencies. The characteristics that distinguish Tennessee Vans from other mobility approaches are its flexibility to meet diverse mobility needs and to fill mobility gaps that exist across the state.

### **Judicial Outreach Liaison (JOL) program**

Through the National Highway Transportation Safety Administration (NHTSA) and the Tennessee Highway Safety Office (THSO), Tennessee has added the **Judicial Outreach Liaison (JOL)** program. CTR's Associate Director, Dr. Jerry Everett, is the principal investigator for the program. Judge Leon Burns, formerly the Criminal Court Judge for the Thirteenth Judicial District, is the Liaison for Tennessee. In this role, he provides education, training, and technical assistance to judges and court staff throughout the state. Judge Burns supports both judges and court personnel to improve community outreach, provide quality education, and promote confidence and trust in the judiciary. The program goal is to assist NHTSA in reducing the annual highway traffic fatality rate to no more than 1.0 deaths per 100 million vehicle miles of travel.

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## *Technical Assistance*

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### **Assisting State and Local Agencies**

CTR gives technical assistance and training in transportation planning for the TDOT Long Range Planning Division's Office of Community Transportation in these areas: major thoroughfare planning in Tennessee's counties; state-aid programs for locally maintained roads in Tennessee; revising urban and urbanized area boundaries; and evaluating roadway efficiency software to determine the



existing and future capacity of any roadway in the state.

In 2017, TTAP offered three workshops, addressing the Americans with Disabilities Act (ADA) Self-Evaluations/Transition Plans and Overview of Elements of Public Right-of-Way Accessibility. The classes provided guidance through the self-evaluation process, outlined elements of a successful, compliant transition plan, and gave examples of the types of infrastructure issues that agencies must address in this process.

Working with the City of Knoxville, TTAP created the Education Toolbox for a Neighborhood Traffic Safety Program. This toolbox supports a neighborhood-led, neighborhood-centric education campaign. The goal of this outreach campaign is to slow traffic through residential areas. Neighbors use the toolbox to create and manage a neighborhood outreach effort to make residents and pass-through drivers aware of the need for slower speeds.

TTAP aided in planning the Knoxville Neighborhood Traffic Safety Program Education Plan (NTSP). Developed jointly with the City of Knoxville Engineering Department, Police Department, and Office of Neighborhoods, NTSP is a comprehensive approach to neighborhood concerns about speeding. The program includes enforcement, education and traffic calming measures such as speed humps and traffic circles.

The City of Morristown worked with TTAP to assess more than 60 miles of municipal sidewalks. Together, they developed a web-based GIS tool that allows inspectors to record ADA compliance and sidewalk condition information.

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## *Technology Transfer*

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### **Advanced Transportation Technologies Symposium**

On May 9, 2017 CTR's Traffic Signal Academy and Rhythm Engineering presented the Advanced Technologies in Transportation Symposium at the National Transportation Research Center. This

symposium brought together transportation professionals to highlight FHWA's Every Day Counts efforts on Automated Traffic Signal Performance Measures and recent advancements and challenges in Connected and Automated Vehicle technology.

Top experts in the transportation industry, including Carl Andersen (FHWA Connected Vehicle Program Manager), Randy Iwasaki (former director of CALTRANS and current director of Contra Costa Transportation Authority), Jesse Manning (Rhythm Engineering) and Dr. Jeff Price (GRIDSMAST) shared their insights on the future of traffic technology and how these technologies may affect the industry.

A group of 50 attendees representing FHWA, TDOT, and transportation agencies in Tennessee, California, Colorado, Massachusetts, Kansas, and Florida participated in the meeting. Dr. Airton Kohls leads Traffic Signal Academy for CTR.





## O&E Grants Deliver New Technologies

### CAV - *What are the implications of partial adoption?*

*Asad Khattak, PI*

In 2017, Dr. Khattak made substantial progress in developing an ad-hoc, behaviorally-based vehicle simulator using Matlab. However, this task has implicit limitations to simulate and visualize high density traffic for extended periods of time. After a deep search for alternatives, the SUMO simulator was selected for its flexibility in changing the car-following models and to account for vehicle crashes. The work focuses on adapting the SUMO car-following models to represent vehicles with different levels of automation.



### *New technologies and bicycle safety,* *Chris Cherry, PI*

The main objective of Dr. Cherry's research has been to assess travel behavior of bicycle users: travel speeds, use of bicycle routes, wrong-way riding, and route choice preferences. This project characterized routes chosen by cyclists as deter-

mined by speed limit, traffic volume, and type of bicycle facilities. These inputs were used to assess user safety. Additionally, the research project provided an enormous array of data from the users about their travel choices and characteristics.

This project led to an article in *Journal of Transport & Health* (Volume 7, Part A, December 2017, Pages 54-63), titled *Factors influencing single-bicycle crashes at skewed railroad grade crossings*. Video from the study showing biker wrecking along a section of bike path that crosses rail tracks went viral last summer.





# Collaborators

During our 45-year history, CTR has built upon on collaborations with UT's academic programs, government and industry partners, and project sponsors. Our partnerships include state and federal agencies, individual communities, other universities, private-sector firms, and transportation leaders worldwide.

## University of Tennessee

### *Colleges*

Tickle College of Engineering  
College of Art and Architecture  
College of Business Administration  
College of Education, Health, and Human Sciences  
School of Communication Studies

### *Offices & Departments*

Office of the Provost  
Office of Communications and Marketing  
Civil & Environmental Engineering  
Industrial & Systems Engineering  
Materials Sciences & Engineering  
Mechanical, Aerospace & Biomedical Engineering  
Earth and Planetary Sciences  
Food Science & Technology  
Forestry, Wildlife & Fisheries  
Geography  
Kinesiology, Recreation and Sport Studies  
Marketing & Supply Chain Management  
Parking and Transit Services  
Social Work Office of Research & Public Service  
Tennessee Hospitality and Tourism Association  
UT Athletics  
UT-Battelle  
UT Libraries  
UT Transportation Services

### *Centers & Institutes*

Institute of Agriculture  
Institute for Assessment and Evaluation

Institute for Public Service  
County Technical Assistance Service  
Municipal Technical Advisory Service  
Center for Business and Economic Research  
Center for Sustainable Business and Tourism  
Construction Industry Research and Policy Center  
Howard Baker Center for Public Policy  
Institute for a Secure and Sustainable Environment  
Southeastern SunGrant Center  
UT Medical Center Cole Neuroscience Center  
***Student Organizations***  
Office of Sorority and Fraternity Life  
Student Chapter, Institute of Transportation Engineers  
Society of Women Engineers  
UT Rail Society  
UT Outdoor Program

## National Partners

Appalachian Regional Commission  
Centers for Disease Control and Prevention  
Collaborative Sciences Center for Road Safety  
Council of University Transportation Centers  
National University Rail Center  
Oak Ridge National Laboratory  
Tennessee Valley Authority  
US Army Corps of Engineers  
US Department of Energy  
US Department of Transportation  
Federal Highway Administration  
Federal Motor Carriers Administration

National Highway Institute  
National Highway Transportation Safety Admin.  
Pipeline and Hazardous Materials Safety Admin.  
Secretary of Transportation—Research

### University Partners

National University Rail Center (NURail)  
University of Illinois at Urbana-Champaign  
University of Illinois at Chicago  
Massachusetts Institute of Technology  
Michigan Technological University  
University of Kentucky  
University of Tennessee  
Rose-Hulman Institute of Technology  
Southeastern Transportation Center  
University of Tennessee, Knoxville  
Clemson University  
North Carolina A&T State University  
University of Alabama  
University of Alabama at Birmingham  
University of Central Florida  
University of Kentucky  
University of North Carolina, Chapel Hill  
University of South Florida

### State & Local Agencies

American Public Works Association, TN Chapter  
City of Knoxville  
Fayette County Commission on Aging  
Institute of Transportation Engineers, TN Section  
Knox Area Transit  
Knox County Engineering  
Knox County Recovery Court  
Knox County Schools  
Knoxville Transportation Planning Organization  
McGhee Tyson Airport  
Metropolitan Nashville Health Department  
Metropolitan Nashville Transportation Planning Organization  
TN County Highway Officials Association  
TN County Services Association  
TN Department of Safety and Homeland Security  
TN Department of Transportation  
TN Highway Safety Office

### International Partners

Beijing Jiaotong University  
Chang'an University  
China Academy of Railway Sciences  
Nanchang Hangkong University  
Southwest Jiaotong University  
Shijiazhuang Tiedao University  
Tongji University  
Yanshan University  
Zhejiang Institute of Communications

### Private & Nonprofit Organizations

Cambridge Systematics  
National Waterways Foundation  
Nisus Corporation  
Norfolk Southern Railway  
TN Municipal League

### Community Partners

Blue Knights International  
BMW Riders Association  
Continuum Courtyards  
Easter Seals  
Emerald Youth Foundation  
Great Smoky Mountains Institute at Tremont  
Honda Goldwing Association  
Karat Place  
Knoxville Anti-Drug Coalition  
Knoxville CrossFit  
Manchester Anti-Drug Coalition  
Motor Cycle Riders Education Program  
Memphis Leadership Foundation  
Pacesetters  
Sertoma Center  
Skills Development Services  
Synergy Foundation  
United Methodist Neighborhood Centers  
Youth Encouragement Center  
Wesley House

# Publications, Presentations, Dissertations

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## *Selected Recent Publications*

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Burton, Mark. (2016). A Sanguine Assessment of North American Freight Railroads. *Center for Business & Public Policy, Georgetown University, Economic Policy Vignette*.

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- Zeng, Jin, Jin Xiaonan, Dong, Chunjiao, & Clarke, D.B. (2016). A Transfer Routes Choice Model of Railway Passenger Based on the Maximum Utility. *International Conference on Transportation & Development, American Society of Civil Engineers, Houston, TX*.
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- Wali B., A. Khattak, & T. Karnowski, How Driving Volatility in Time to Collision Relates to Crash Severity in a Naturalistic Driving Environment? 18-00060, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Zhang M. & A. Khattak, Identifying and Analyzing Extreme Lane Change Events Using Basic Safety Messages in a Connected Vehicle Environment, 18-04734, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Hoque A., M. Ahmed, J. Rios-Torres, A. Khattak, & R. Arvin, Impact of Vehicle-to-Vehicle Communication Reliability on Safety Applications: An Experimental Study, 18-05532, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Kamrani M., A. Khattak, & T. Li, A Framework to Process and Analyze Driver, Vehicle and Road Infrastructure Volatilities in Real-time, 18-00979, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Ahmed M., A. Hoque, & A. Khattak, Intersection Approach Advisory Through V2X Technology Using Signal Phase and Timing (SPaT) Information at Fixed-Time Signalized Intersection, 18-05804, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Arvin R., M. Kamrani, & A. Khattak, & J. Rios-Torres, Safety Impacts of Automated Vehicles in Mixed Traffic, 18-00088, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Ahmed M., M. Hoque, J. Rios-Torres, & A. Khattak, A Cooperative Freeway Merge Assistance System using Connected Vehicles, 18-05614, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Arvin R., M. Kamrani, & A. Khattak, & J. Rios-Torres, Safety Impacts of Automated Vehicles in Mixed Traffic, 18-00088, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- McCubbin, J. A., Switzer, F. S., LaDue, M. N., Ogle, J. H., & Bendigeri, V. (2016). Cardiovascular Emotional Appraisal and Risk Behavior: Resting Blood Pressure Predicts Risky Driving in Women. *Psychometric Medicine*, Vol. 78, No. 3, pp. A150-A150, Philadelphia, PA: Lippincott Williams and Wilkins.
- McBride, M., Carter, L., and Phillips, B.; Integrating the Theory of Planned Behavior and Behavioral Attitudes to Explore Texting among Adolescent Drivers in the US; submitted; acknowledgement of federal support (yes).
- Sandt\*, A., AL-DEEK+, H., and Rogers\*, J., "Identifying Wrong-Way Driving Hotspots by Modeling Crash Risk and Assessing Durations of Wrong-Way Driving Events," *Journal of the Transportation Research Board*, February 2017.
- Rogers\*, J., Sandt\*, A., AL-DEEK+, H., Alomari\*, A., Gordin, E., and Carrick, G. "Modeling the Risk of Wrong-Way Driving on Freeways and Toll Roads," *Journal of the Transportation Research Board*, No. 2554, pp. 166-176, DOI: 10.3141/2554-18, November 2016.
- Wu, J., Radwan, E, & Abou-Senna, H. Use of a Driving Simulator to Evaluate Pedestrian-vehicle Conflicts with Different Potential Risk Factors at Signalized Intersections. 17th COTA conference International Conference of Trans-



portation Professionals, 8 July 2017.

Wu, J., Radwan, E., & Abou-Senna, H. (2017). Determine if VISSIM and SSAM could estimate pedestrian-vehicle conflicts at signalized intersections. *Journal of Transportation Safety & Security*, (accepted).

Wang, L., Abdel-Aty, M., Lee, J., & Shi, Q. (2017). Analysis of real-time crash risk for expressway ramps using traffic, geometric, trip generation, and socio-demographic predictors. *Accident Analysis & Prevention*, accepted; acknowledgement of federal support (yes).

Amiridis, K., Stamatiadis, N., and Kirk, A. "Safety Based Signalized Intersection Left-Turn Phasing Decisions," *Journal of the Transportation Research Board*, 2619, 2016 (accepted)

Amiridis, K. \*, Stamatiadis, N., and Kirk, A. 2017 "Safety-Based Decisions for Left-Turn Phasing," *Proceedings of the Road Safety and Simulation 2017 Conference*, Deft, Netherlands, October 2017.

Stamatiadis, N., Sallee, T. and Kirk, A. 2016 "Left turn guidance based on crossing conflict analysis," *Advances in Transportation Studies*, Vol. 2, pp. 17-26.

Liu J. & A. Khattak. Delivering improved alerts, warnings, and control assistance using basic safety messages transmitted between connected vehicles, *Transportation Research, Part C, Volume 68*, pp. 83–100, 2016.

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Liu J., X. Wang, & A. Khattak, Customizing driving cycles to support vehicle purchase and use decisions: Fuel economy estimation for alternative fuel vehicle users, *Transportation Research, Part C, Vol. 67*, 2016, pp. 280–298.

Bandeira J., D. Carvalho, A. Khattak, N. Roupail, P. Fernandes, T. Fontes, S. Pereira, & M. Coelho, Empirical assessment of route choice impact on emissions over different road types, traffic demands, and driving scenarios. *International Journal of Sustainable Transportation*, 10:3, 2016, pp. 271-283.

Wang X., A. Khattak, J. Liu, & D. Clarke, Non-crossing rail-trespassing crashes in the past decade: a spatial approach to analysis of injury severity, *Safety Science*, Volume 82, February 2016, Pages 44–55.

Liu, J., A. Khattak, S. Richards, & S. Nambisan, What are the differences in driver injury outcomes at highway-rail grade crossings? Untangling the role of pre-crash behaviors, *Accident Analysis & Prevention*, Volume 85, December 2015, pp. 157–169.

Wang X., A. Khattak, J. Liu, G. Amoli, & S. Son, What is the level of volatility in instantaneous driving decisions? *Transportation Research Part C, Volume 58, Part B*, September 2015, pp. 413-427.

Liu J., A. Khattak, X. Wang, The role of alternative fuel vehicles: Using behavioral and sensor data to model hierarchies in travel, *Transportation Research Part C*, 55, 2015, pp. 379-392.

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- Ling, Z. C. Cherry, Y. Ni, K. Li (2015) Pedestrian Level of Service at Signalized Intersections in China. *Transportation Research Record: Journal of the Transportation Research Board*. 2519 pg 75-81. Doi: 10.3141/2519-09
- Fishman, E., C. Cherry (2015) E-bikes in the mainstream: Reviewing a decade of research. *Transport Reviews* doi: 10.1080/01441647.2015.1069907
- Langford, B.C., Chen, J. C. Cherry (2015) Risky riding: naturalistic methods comparing safety behavior from conventional bicycle riders and electric bike riders. *Accident Analysis and Prevention*, 82, 220-226.
- McBride, M., Carter, L., and Phillips, B. Integrating the Theory of Planned Behavior and Psychosocial Factors to Explore Texting among Adolescent Drivers in the US. Under review by the *Journal of the Association for Information Systems*.
- Shi, Q., & Abdel-Aty, M., 2016. Evaluation of the Impact of Travel Time Reliability on Urban Expressway Traffic Safety. Accepted by *Transportation Research Record: Journal of the Transportation Research Board*, Accepted.
- Modeling the Risk of Wrong-Way Driving on Freeways and Toll Roads. Authors: John H. Rogers P.E., Haitham Al-Deek, Ph.D., P.E., Ahmad Alomari, Nizam Uliin, Ph.D., Eric Gordin, and Grady Carrick, Ph.D., accepted for publication in the *Transportation Research Record: Journal of the Transportation Research Board*, February 2016.
- David L. Greene, Jun Liu, Asad J. Khattak, Behram Wali, Janet L. Hopson, Richard Goeltz, 2017, How does on-road fuel economy vary with vehicle cumulative mileage and daily use? *Transportation Research Part D* 55 (2017) 142–161
- David L. Greene, Asad J. Khattak, Jun Liu, Xin Wang, Janet L. Hopson, Richard Goeltz, 2017, What is the evidence concerning the gap between on-road and Environmental Protection Agency fuel economy ratings? *Transport Policy* 53 (2017) 146–160

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### *Selected Recent Presentations*

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- Burton, Mark (2017, January 9). *The Limited Usefulness of Revenue Adequacy Determinations in the Ongoing Regulation of Railroad Rates*. Presented at the 97<sup>th</sup> Annual Transportation Research Board Meeting (AR-040), Washington DC.
- Burton, Mark & Robert Gallamore (2016, June). *Sunk Costs and Railroad Capital Costs: Improving Policy Applications*. Presented at the Georgetown Colloquium on Railroad Research, Washington DC.
- Clarke, David. (2016, July 12). *Train Performance Simulation Tutorial*. Invited Lecture at The Railway Academic Conference/Railroad Engineering Education Symposium, University of Illinois at Urbana-Champaign, Champaign, IL.
- Clarke, David (2016, July 22). *U.S. Railways-Selected Topics*. Invited Presentation, China Academy of Railway Sciences, Beijing, PRC.
- Clarke, David (2016, August 10). *U.S, Railways-A Turning Point?* Invited Presentation, TRB Summerail, Council Bluffs, IA.
- Everett, Jerry (2016, April). *Another "T" in STEM part of GAMTTEP Workshop*. National NSTA Conference, Nashville, TN.
- Everett, Jerry & Enix, Tammy. (2016, May). *FTA's Innovative Public Transportation Workforce Development Program, Transit-Your Ride to the Future*. Federal Transit Administration, Washington DC.
- Everett, Jerry. (2016, June). *Highway Traffic Safety Culture, A Tennessee Perspective*. Texas Traffic Safety Conference. College Station, TX.

Everett, Jerry. (2017, February). *Buckle Up Tonight to See Tomorrow Results To-Date and More*. ADTSEA SERA Conference, Myrtle Beach, SC.

Everett, Jerry. (2017, March). *iBOOKS-A Cool Tool for Teaching Transportation to K-12 Students*. INTED (Session Moderator and Presenter).

Everett, Jerry, Cates, Matt, & Waxstein, Christine. (2017, September). *Buckle Up Tonight to See Tomorrow*. TN Lifesavers Conference.

Everett, Jerry (2017, October). Tennessee Model User's Group (TNMUG)-Exchanging Travel Model Information for More Than a Decade. AMPO Conference.

Kohls, Airton, (2017). *Yellow Change Intervals and Red Clearance Intervals*. TDOT 2017 Traffic Engineering Workshop-Chattanooga, TN.

Kohls, Airton. (2017). Improving Operations with Automated Traffic Signal Performance Measures. Tennessee Section of ITE Meeting, Franklin, TN.

Kohls, Airton. (2017). *Traffic Signal Safety*. TN Highway Safety and Operations Conference, Franklin, TN.

Lovett, A.H., C.T. Dick and C.P.L. Barkan, 2016. Evaluating Track Maintenance Aggregation in Extended Work Windows on Freight Railroad Lines. Presented at the 2016 Joint Rail Conference, Columbia, SC, April 2016.

Shih, M-C, C.T. Dick and P-Y Liao. 2016. A Decision Support Screening Tool for Infrastructure Capacity Planning on Single-track Lines. Presented at the 2016 Joint Rail Conference, Columbia, SC, April 2016.

Heywood, R and J. Sussman, "Regional Governance and Hub Stations: The Impact of Development and Transport Connections," ASCE 2016 International Conference on Transportation and Development, Houston, TX, June 2016.

Kalluri, S., Lautala, P., Handler, R., Comparative Life Cycle Assessment of Road and Multimodal Transportation Options – A Case Study of Copperwood Mine, Transportation Research Board 95th Annual Meeting of the National Academies, Washington, DC, January 12-16, 2016.

Lautala P., Dick T., Railway Engineering Education Symposium: Evolving to Rebuild a Growing Rail Academic Community, Transportation Research Board 96th Annual Meeting of the National Academies, Washington, DC

Kalluri, S., Lautala, P., Handler, R., Comparative Life Cycle Assessment of Road and Multimodal Transportation Options – A Case Study of Copperwood Mine, ASME/ASCE/IEEE 2016 Joint Rail Conference, Columbia, SC, April 12-15, 2016

Addison, P., Lautala P., Oommen T., Vallos, Z., Embankment Stabilization Techniques for Railroads on Permafrost, ASME/ASCE/IEEE 2016 Joint Rail Conference, Columbia, SC, April 12-15, 2016

Deilamsalehy, H. Havens, T., Lautala P., Detection of Sliding Wheels and Hot Bearings Using Wayside Thermal Cameras, ASME/ASCE/IEEE 2016 Joint Rail Conference, Columbia, SC, April 12-15, 2016

Landry, S., Jeon, M., Lautala P., Nelson, D., Getting Active with Passive Crossings: Investigating the Use of In-Vehicle Auditory Alerts for Highway-Rail Grade Crossing, ASME/ASCE/IEEE 2016 Joint Rail Conference, Columbia, SC, April 12-15, 2016

Pouryousef, H., Lautala, P., Hybrid Optimization of Train Schedules (HOTS) for Stop Pattern and Dwell Time Analysis, 11th World Congress in Railway Research, Milan, Italy, May 29 – June 2, 2016

Lautala, P., Jeon, M., Landry, S., Nelson, D., Design and Evaluation of In-Vehicle Auditory Alerts for Railroad Crossings, Global Level Crossing Safety & Trespass Prevention Symposium 2016, Helsinki, Finland, June 12-16, 2016

Lautala, P., Jeon, M., Nelson, D., Driver Behavior at Level Crossings Using Naturalistic Driving Study Data, Global Level Crossing Safety & Trespass Prevention Symposium 2016, Helsinki, Finland, June 12-16, 2016



Wali, B., Khattak, A. J., Liu, J. Heterogeneity Assessment of Incidents Durations: Estimation of Random Parameter and Quantile Regressions. Presented and Awarded with the “Distinguished Scientific Paper – Americas Award” by the 23rd ITS World Congress, Melbourne, Australia (2016).

Khattak, A. J., Wali, B. Dynamics of Driving Regimes Extracted from Basic Safety Messages Transmitted Between Connected Vehicles. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA. (2017). TRB PAPER # 17-00234.

Khattak, A. J., Wali, B. Exploring Non-Linear Dependencies in Correlates of Rural Two-Way Two-Lane Roadway Crashes. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-00239.

Greene, D. L., Khattak, A. J., & Wali, B. (2017). Planning Tools for Deployment of Alternative Energy Refueling Infrastructure. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA. TRB PAPER # 17-03416.

Kamrani, M., Wali, B., & Khattak, A. J. Can Data Generated by Connected Vehicles Enhance Safety? Proactive Approach to Intersection Safety Management. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-00238.

Wali, B., Khattak, A. J., Liu, J. Heterogeneity Assessment of Incidents Durations: Estimation of Random Parameter and Quantile Regressions. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-00236.

Liu, J., Khattak, A. J., & Wali, B. Do Safety Performance Functions Vary Across Space? Application of Geographically Weighted Regressions. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-00237.

Xu, J., Khattak, A. J., & Wali, B. Injury Severity Analysis of Passenger Vehicle-Truck Collisions and Contributory Unsafe Pre-Crash Behaviors. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-00241.

Li, X., Khattak, A. J., & Wali, B. Large-Scale Traffic Incident Duration Analysis: The Role of Multi-agency Response and On-Scene Times. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-01049.

Boakye K., A. Khattak, J. Liu. How Do Smartphone and Non-Smartphone Users Access and Use Travel Information? Evidence from 2014 Puget Sound Regional Household Travel Survey. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-00698

Boakye, K., S. Nambisan, and M. Shelley. The Impacts of Click It-Or-Ticket Campaign and Saturation Patrol Interventions on Nighttime Seat Belt Usage. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-04622

Boakye, K., S. Nambisan, and M. Shelley. Influence of Passenger Presence on Driver’s Seatbelt Use at Nighttime. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-04622

Boakye, K., S. Nambisan, and M. Shelley. Nighttime Seatbelt Use of Front-Seat Passengers Based on Their Corresponding Drivers’ Seatbelt Use. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-04802

Lee, H., and Y. Zhang. Enhancing Relative Positioning Accuracy in V2V Safety Applications Using Multivehicle Kinematics and Nonlinear Filtering. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-03709

Lee, H., and Y. Zhang. Dijkstra-DBSCAN: A Network Based Clustering Algorithm to Support Incident Hotspots Detection and Management in Connected Managed Lane Networks. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-05918

Lee, H., Y. Liu, and Y. Zhang. Real-Time Piecewise Regression and Its Application in Effective and Economical GPS Trajectory Data Collection. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-03680

Lee, H., Lim, H., S. Chin, and H. Hwang. A Gravity Model Using Spatial Correlation of Time Series Data For Freight Distribution Estimation: A Case Study of the County-Level Coal Distribution Estimation in the United States. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-06189

Lee, H., Lim, H., S. Chin, and H. Hwang. Incorporating Information Complexity into Regression-Based Freight Generation Model Selection. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-06162

Bae, B., B. Whetsel, and L. Han. A Gray Zone in Isolated Intersection Control Type Selection. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-02609

Cherry, C., H. Yang, and X. Lu. Application of Geographically Weighted Regression to Predicting Bicycle and Pedestrian Volume at Intersections. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-02391

Nambisan, S., Z. Ling, N. Franceschetti, C. Cherry, and A. Boggs. Truck Parking Facilities and Ramp Parking: Role of Supply, Demand, and Ramp Characteristics. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-06604

Weinert, J., J. Macarthur, Z. Ling, and C. Cherry. Differences Between Cycling Experiences and Perceptions Between E-bike and Bicycle Users in the United States. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, USA (2017). TRB PAPER # 17-06462

Khattak, A.J. (Host), Wali, B (Presenter). The Role of Connected & Automated Vehicles: How Can Urban Areas Use the Data They Create? U.S. DOT ITS Professional Capacity Building Program, Talking Technology and Transportation in Education (T3e) Webinars Series, October 11, 2017. [https://www.pcb.its.dot.gov/t3/s171011\\_Role\\_of\\_Connected\\_and\\_Automated\\_Vehicles.asp](https://www.pcb.its.dot.gov/t3/s171011_Role_of_Connected_and_Automated_Vehicles.asp)

Khattak, A.J., Wali, B. Analysis of Volatility in Driving Regimes Extracted from Basic Safety Messages Transmitted Between Connected Vehicles. Presented at the Intelligent Transportation Systems World Congress (October 29 – November 2, 2017), Montreal, Canada.

Kamrani M., R. Arvin, & A. Khattak, What measures of driving volatilities best explain crash frequency at intersections? 18-00089, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.

Khattak A., B. Wali, & H. Bozdogan, How is Driving Volatility Related to Intersection Safety in a Connected Vehicles Environment? 18-00058, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.

Boakye K., A. Khattak, & S. Nambisan, Correlates of Front-Seat Passengers' Non-Use of Seatbelts at Night, 18-00405, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.

Wali B., A. Khattak, & T. Karnowski, How Driving Volatility in Time to Collision Relates to Crash Severity in a Naturalistic Driving Environment? 18-00060, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.

- Wali B., A. Khattak, & X. Li, Exploring Non-Linear Dependencies in Correlates of Roadway Crashes: Application of Generalized Additive and Piecewise Linear Count Data Models, 18-00064, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Wali B., A. Khattak, D. Chimba, J. Waters, & X. Li, Development of Safety Performance Functions for Tennessee: Unobserved Heterogeneity & Functional Form Analysis, 18-00065, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Zhang M., A. Khattak, & E. Shay, Analysis of Crashes Involving Pedestrians across the United States: Implications for Connected and Automated Vehicles, 18-04721, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Zhang M. & A. Khattak, Identifying and Analyzing Extreme Lane Change Events Using Basic Safety Messages in a Connected Vehicle Environment, 18-04734, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Hoque A., M. Ahmed, J. Rios-Torres, A. Khattak, & R. Arvin, Impact of Vehicle-to-Vehicle Communication Reliability on Safety Applications: An Experimental Study, 18-05532, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Kamrani M., A. Khattak, & T. Li, A Framework to Process and Analyze Driver, Vehicle and Road Infrastructure Volatilities in Real-time, 18-00979, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Wali B., A. Khattak, & M. Zhang, Injury Severity Analysis of Pedestrian and Bicyclist Trespassing Crashes at Non-Crossings: Application of Predictive Text Analytics, 18-00209, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Ahmed M., A. Hoque, & A. Khattak, Intersection Approach Advisory Through V2X Technology Using Signal Phase and Timing (SPaT) Information at Fixed-Time Signalized Intersection, 18-05804, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Arvin R., M. Kamrani, & A. Khattak, & J. Rios-Torres, Safety Impacts of Automated Vehicles in Mixed Traffic, 18-00088, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Ahmed M., M. Hoque, J. Rios-Torres, & A. Khattak, A Cooperative Freeway Merge Assistance System using Connected Vehicles, 18-05614, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Boakye K., A. Khattak, B. Wali, S. Nambisan, Are Education and Enforcement Strategies Effective in Increasing Night-Time Seat Belt Use? Evidence from a Large-Scale Before-After Observational Study, 18-06451, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Weber, J., Azad, M., Riggs, W., and Cherry, C., The Convergence of Smartphone Apps and Competition to Increase Cycling, 18-02631, presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Hezaveh, A., Azad, M., and Cherry, C., Pedestrian Crashes in Tennessee; A Data Mining Approach, 18-01507, Presented at Transportation Research Board annual meeting, National Academies, Washington, D.C., 2018.
- Boayke, K. Some Impacts of Enforcement and Community-based Outreach & Education Programs on Nighttime Seatbelt Use, Presentation at the 2017 Lifesavers conference held March 26-28 in Charlotte, NC.
- Boggs A., Truck Parking Facilities and Ramp Parking: Role of Supply, Demand, and Ramp Characteristics, Presentation at the 2017 Lifesavers conference held March 26-28 in Charlotte, NC.



Boggs, A. Shortage of Commercial Vehicle Parking Influence on Interstate Ramp Crashes in Tennessee, Presentation at the TSITE Summer Meeting held July 29-31 in Gatlinburg, TN.

Wali, B. Exploring Non-Linear Dependencies in Correlates of Rural Two-Way Two-Lane Road Crashes: A Hybrid Statistical-Machine Learning Approach, Presentation at the TSITE Summer Meeting held July 29-31 in Gatlinburg, TN.

Bae B., Gray Areas in Isolated Intersection Control Type Selection: A Complementary Decision Support Tool, Presentation at the TSITE Summer Meeting held July 29-31 in Gatlinburg, TN.

Carter, L.; Texting While Driving: The Role of Personality, Protection Motivation and General Deterrence Theory; presented to the School of Information Systems and Technology Management in the University of New South Wales in Sydney, Australia; September 26, 2017; acknowledgement of federal support (yes).

McBride, M.; Exploring Adolescent Texting While Driving Behaviors using the Theory of Planned Behavior and Psychosocial Factors; Applied Human Factors and Ergonomics Conference; Los Angeles, California, July 19, 2017; acknowledgement of federal support (yes).

Sandt, A., AL-DEEK+, H., and Rogers, J., "Identifying Wrong-Way Driving Hotspots by Modeling Crash Risk and Assessing Durations of Wrong-Way Driving Events," published in the Transportation Research Board 96th Annual Meeting Compendium of Papers CD-ROM, Washington D.C., January 8-12, 2017.

Wu, J., Radwan, E. and Abou-Senna, H. Assessment of pedestrian-vehicle conflicts with different potential risk factors at midblock crossings: A driving simulator study Transportation Research Board 96th Annual Meeting.

Radwan, E., Darius, B., Wu, J., & Abou-Senna, H. (2016, November). Simulation of pedestrian safety surrogate measures. In ARRB Conference, 27th, 2016, Melbourne, Victoria, Australia.

Wu, J., Radwan, E., Abou-Senna, H. Assessment of pedestrian-vehicle conflicts with different potential risk factors at midblock crossings: A driving simulator study Transportation Research Board 96th Annual Meeting.

Radwan, E., Darius, B., Wu, J., & Abou-Senna, H. (2016, November). Simulation of pedestrian safety surrogate measures. In ARRB Conference, 27th, 2016, Melbourne, Victoria, Australia.

Wu, J., Radwan, E., Abou-Senna, H. Analysis of driver's avoidance behavior at mid-block crossings based on driving simulation experiment. Roadway Safety and Simulation, Netherlands, 2017. (Accepted).

Lee, J., Abdel-Aty, M., Cai, Q., Wang, L., & Huang, H. (2017). Integrated Modeling Approach for Non-Motorized Mode Trips and Crashes in the Framework of Transportation Safety Planning. Submitted to the 97th Transportation Research Board Annual Meeting.

E.R. Green, C. Blackden, M.A. Fields. "Spatial Database For Intersections", 95th Annual TRB, Washington, DC; Transportation Research Board: Washington, DC, 2016. Published in conference proceedings.

E.R. Green, N. Stamatiadis, R. R. Souleyrette. "Segment Length and Highway Safety Analysis: Does It Matter?", 96th Annual TRB, Washington, DC; Transportation Research Board: Washington, DC, 2017. Published in conference proceedings.

E.R. Green, K.R. Agent, E. Lammers. "Development of an Improved Method for Determining Advisory Speeds on Horizontal Curves", 96th Annual TRB, Washington, DC; Transportation Research Board: Washington, DC, 2017. Published in conference proceedings.

Zhang, X. and M. Chen. Quantifying Effects from Weather on Travel Time and Reliability, Presented at the 96th Annual Meeting of the Transportation Research Board, Washington, DC, 2017.

Agarwal, N. and A. Kirk. Application of VISSIM Basic Tools to Simulate Emergency Preemption. Road Safety & Simulation International Conference Paper.

- “Safety Based Signalized Intersection Left-Turn Phasing Decisions,” 96th Annual Meeting of the Transportation Research Board, Washington, DC, January 8-12, 2017 (Amiridis, A.).
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- Stamatiadis, N. and Kirk, A. 2016. “Operational Efficiency and Left Turn Phasing,” Proceedings of the Transport Research Arena, Warsaw, Poland, 18-21 April 2016.
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- What Role Do Pre-Crash Driver Actions Play in Work Zone Crashes? Application of Hierarchical Models to Crash Data – 16-1587 by Jun Liu, Asad Khattak, Meng Zhang.
- Migrating Toward Using Electric Vehicle on Campus-Proposed Method for Fleet Optimization – 16-1703, Taekwan Yoon, Christopher Cherry, Megan Ryerson, John Bell.
- Modeling Traffic Incident Duration Using Quantile Regression – 16-4235, Asad Khattak, Jun Liu, Behram Wali, Xiaobing Li, ManWo Ng.
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- Wrong Way Driving Multifactor Risk-Based Analysis for Florida Limited Access and Toll Facilities. Authors: John H. Rogers P.E., Adrian Sanli , Haitham Al-Deek, Ph.D., P.E., Ahmad Alomari, Nizam Uliin, Ph.D., Eric Gordin, P.E., Cristina Dos Santos, and Grady Carrick, Ph.D., presented at the Transportation Research Board, January 2015. This won the best paper award in freeway operations for the 2015.
- Modeling Driver Responses to Wrong-Way Driving Countermeasures through a Driver Survey and Countermeasure Implementation in Florida. Authors: Adrian Sanli, Haitham Al-Deek, Ph.D., P.E., John Rogers, P.E., Presented at the Transportation Research Board in January 2016.
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### *Dissertations & Theses*

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Liu, Jun, Driving Volatility in Instantaneous Driving Behaviors: Studies Using Large-Scale Trajectory Data, PhD Dissertation (supervisor: Dr. Asad Khattak).

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Yang, Jianjiang, Spatio-Temporal Dynamics of Short-Term Traffic, PhD Dissertation (Supervisor: Dr. Lee Han).

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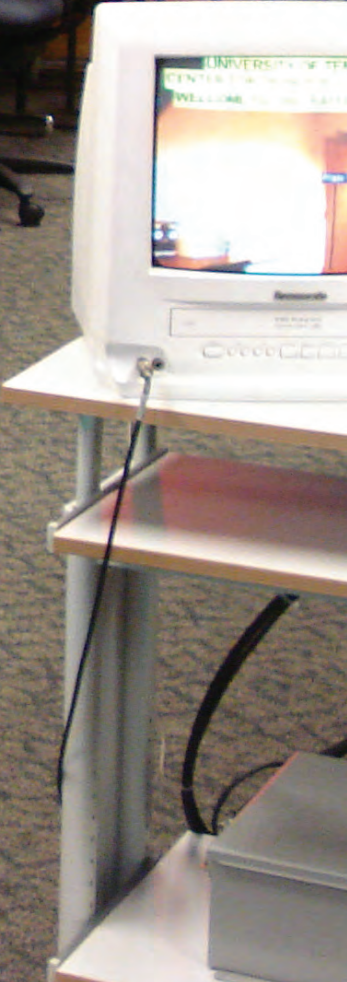
Hunter McCracken, University of Tennessee, Master of Science, The Economic Implications of Evolving Aviation Funding Policy in Tennessee

Luis Taboada, University of Tennessee, Master of Science, Non-residential Pedestrian Access to Transit Systems: A GIS Modeling Application.

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# Looking Ahead to 21st Century Transportation: Safe, Autonomous, Connected

Imagine a time when driverless vehicles are the norm, accidents are rare, traffic flows freely, and integrated systems connect vehicles, buildings, and the grid. The technological breakthroughs that will get us there are in development through TennSMART—and CTR will play a large role in making this vision a reality.



TennSMART is a public-private partnership of Oak Ridge National Laboratory, Tennessee Technological University, The University of Tennessee, and a growing number of private companies working together to develop scientific knowledge and new technologies that could change how America transports people and goods.

Working with smart cities, vehicle manufacturers and suppliers, fleet operators, software developers, utilities, and regulators, TennSMART will shape America's mobility future.

These areas are the focus for TennSMART's research and development:

**Connected and automated vehicles:** Leveraging high performance computing, data science, and advanced sensors and communications protocols to develop technologies and algorithms for vehicle-to-vehicle and vehicle-to-grid interactions that enable smart routing, alleviate congestion, improve safety, and increase the efficiency of the entire transportation system.

**Electrification infrastructure for electric vehicles:** Advancing wireless charging technologies for vehicles to charge on the go, automate the charging process, and share energy back and forth between vehicles, buildings, and the grid for maximum energy savings and convenience.

**Cybersecurity:** Developing systems and technologies that validate the trustworthiness of messages from vehicles and the infrastructure, address identity and privacy needs, and explore best paths to provide the computing power necessary in a connected world.

**Freight efficiency:** Exploring new paradigms in freight transport including the development of hybrid electric heavy-duty powertrains, truck platooning technologies, automated multimodal freight delivery, and unmanned aerial systems.

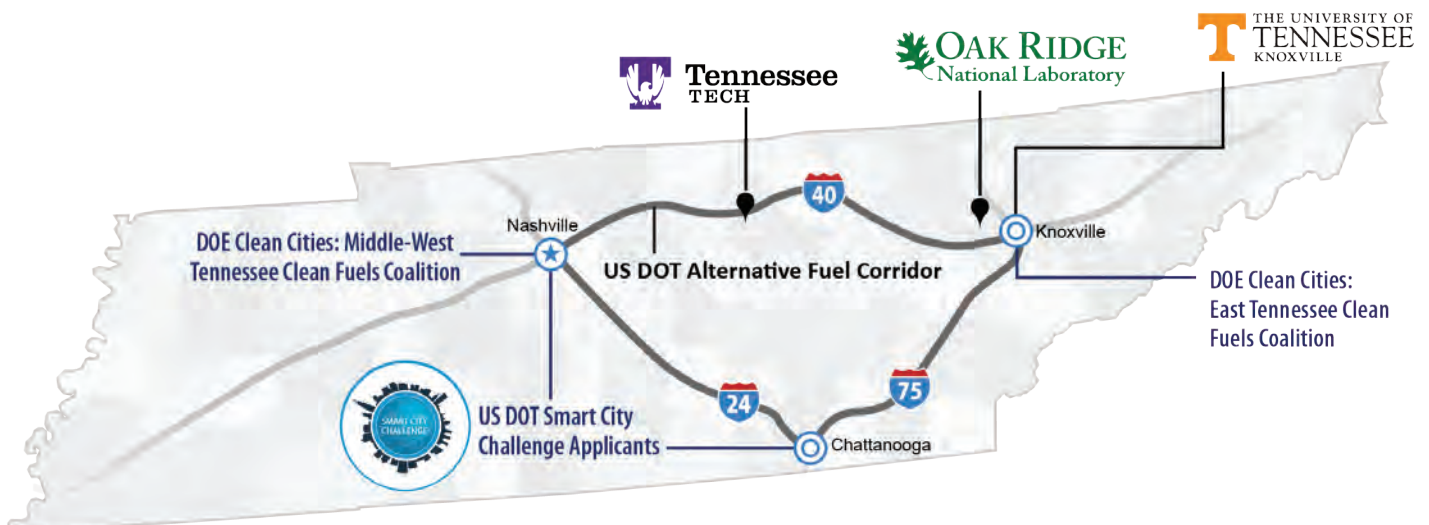
**Multimodal commuting:** Facilitating mode shifting to optimize energy efficiency and convenience in passenger commutes through the development of smart technologies that increase connectivity between various forms of transportation.

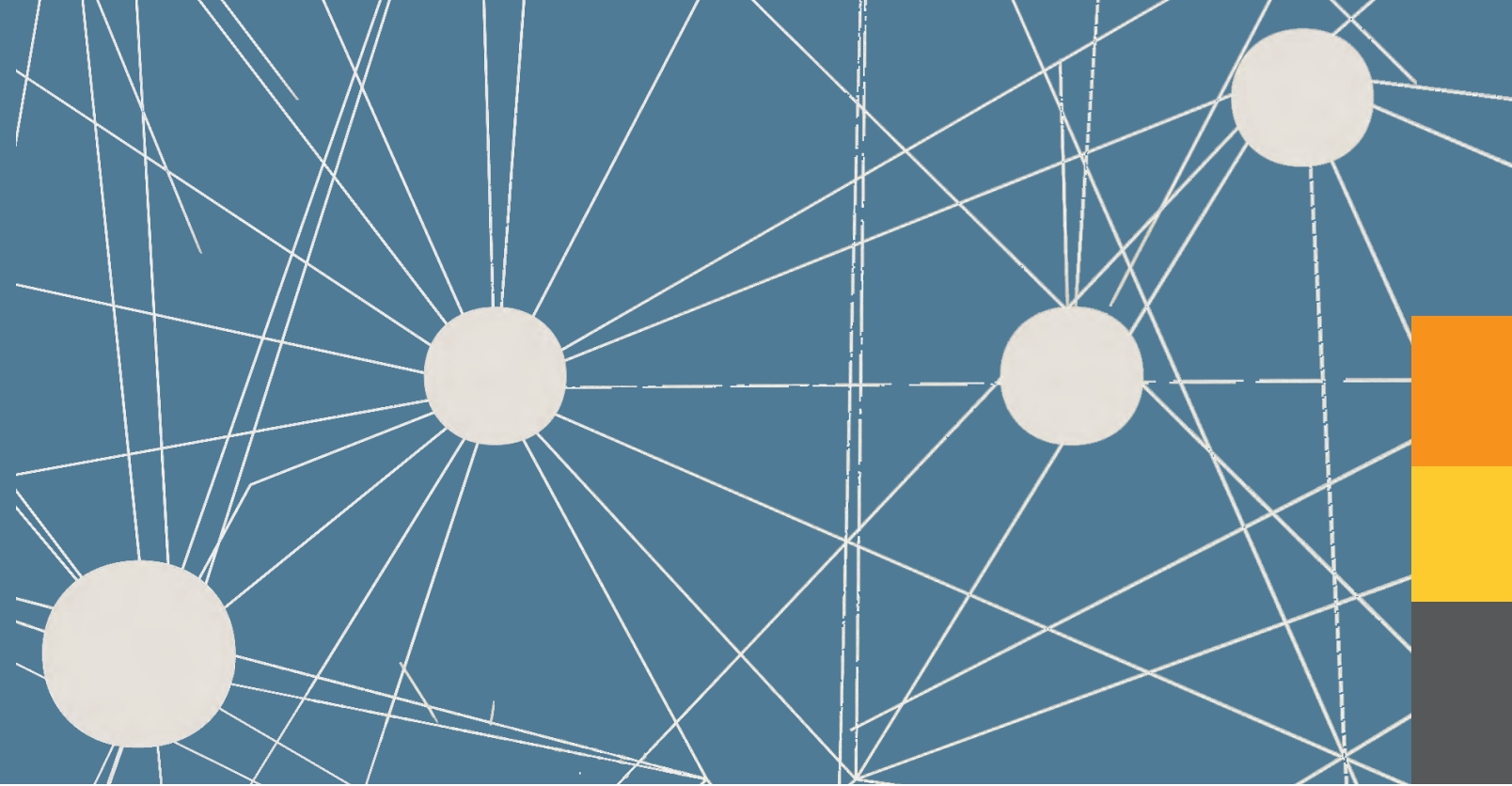
The TennSMART multimodal smart mobility park is a test bed facility for research, development, and deployment of connected and automated vehicle (CAV) technologies. The activities undertaken by the partners create new knowledge about the performance of technologies and their impact on safety, mobility, and environmental sustainability. The initial network of collaborators includes Oak Ridge National Laboratory, Tennessee Technological University, and The University of Tennessee, Knoxville. It is receiving strong support from all entities owning roads or having jurisdiction over infrastructure, especially the State of Tennessee.

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*TennSMART is a high impact, transformational facility that is testing new CAV technologies.*

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