Program Progress Performance Report for University Transportation Center

Submitted to: U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology (OST-R)

Grant Number: DTRT13-G-UTC60

Project Title: University Transportation Centers
Transportation Research Center for Livable Communities (TRCLC)

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Submitting Official: Same as Program Director

Submission Date: April 30, 2016

DUNS and EIN: 622364479 / 386007327

Recipient Account Number: 25-7020240

Recipient Organization: Western Michigan University
1903 West Michigan Avenue
Kalamazoo, MI 49008

Project/Grant Period: September 30, 2013 – September 30, 2018

Reporting Period End Date: March 31, 2016

Report Term or Frequency: Semiannual

Signature of Submitting Official: [Signature]
1 ACCOMPLISHMENTS

1.1 What are the major goals and objectives of the program?

The TRCLC addresses five USDOT strategic goals through the prism of Livable Communities. The Center’s primary focus is to help developing communities that provide people with access to affordable and environmentally sustainable transportation through coordination between transportation, housing, and commercial development. In particular, the Center will concentrate on “bringing technological advances to aid the development of livable communities” by coordinating efforts among faculty in associated fields at five universities to collectively enable livable communities through transportation research.

Research
Livable communities are where people can enjoy their daily lives without having to drive their car. Toward this end, the TRCLC focuses on three research objectives:
- improving public transit systems and alternative transportation modes,
- providing better and safer pedestrian and bicycle networks, and
- enhancing transportation accessibility for children, people with disabilities, older adults, and lower income populations.

Education and Workforce Development
The TRCLC consortium will create opportunities for learning and knowledge sharing through a comprehensive education and workforce development program based on a lifecycle of occupational development approach that emphasizes K-12 outreach, career-oriented higher education and professional development. Our program goals are to:
1) Develop activities for teachers, counselors, administrators and students in K-12 schools to enhance awareness of the forms and functions of transportation systems.
2) Develop career-oriented higher educational programs that combine multidisciplinary course work, experiential education, participative research and industry-university partnerships
3) Create programs for professional development on a broad range of transportation topics geared to the needs of decision-makers, transportation officials, community members and professional staff.

Technology Transfer
The Center’s technology transfer program will leverage and extend our existing activities as well as build new capacity to achieve the following inter-related goals:
1) to formalize a widely distributed and multi-format knowledge-sharing infrastructure, and
2) to create opportunities for context-sensitive problem identification and participatory research.
**Collaboration**
Our primary collaborative goal is: *to develop capacities to identify, cultivate and sustain inter-disciplinary and inter-sectoral partnerships in order to meaningfully frame and address transportation problems that stifle the development of livable communities.*

**Diversity**
Our goal for diversity is to outreach to underrepresented groups, low income communities, and diverse disciplines and partners.

### 1.1 What was accomplished under these goals?

**Research**
- One research project was completed during the period.

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Title</th>
<th>Institution</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-8</td>
<td>Big Data Analytics to Aid Developing Livable Communities</td>
<td>WMU</td>
<td>Yang</td>
</tr>
</tbody>
</table>

- There are five on-going research projects funded during the 1st funding cycle. These projects are expected to be completed in this Summer.

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Title</th>
<th>Institution</th>
<th>PI</th>
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<tbody>
<tr>
<td>14-2</td>
<td>Developing Performances Measures to Capture the Effects of Transportation Facilities On Multiple Public Health Outcomes</td>
<td>UTA</td>
<td>Casey</td>
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<td>14-3</td>
<td>Developing Performances Measures to Capture the Effects of Transportation Facilities On Multiple Public Health Outcomes: A Case in Michigan</td>
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<td>14-5</td>
<td>Development of Decision Support Tools to Assess Pedestrian and Bicycle Safety: Development of Safety Performance Functions</td>
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<td>Kwigizile</td>
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<td>14-7</td>
<td>Development of Decision Support Tools to Assess Pedestrian and Bicycle Safety: Focus on Population, Demographic and Socio-economic Spectra</td>
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- There are thirteen on-going research projects funded during the 2nd funding cycle.
<table>
<thead>
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<td>15-1</td>
<td>Effect of Cycling Skills on Bicycle Safety and Comfort Associated with Bicycle Infrastructure and Environment</td>
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<td>Development and Assessment of Performance Measures for Evaluating and Improving Regional Transit Coordination Using GTFS Data</td>
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<td>15-3</td>
<td>Real Time Bicycle Simulation Study of Bicyclists’ Behaviors and Their Implication on Safety</td>
<td>WMU</td>
<td>Kwigizile</td>
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<td>15-4</td>
<td>Travel Behavior of Blind Individuals Before and After Receiving Orientation and Mobility Training</td>
<td>WMU</td>
<td>Kim</td>
</tr>
<tr>
<td>15-5</td>
<td>Infrastructure and Technology for Sustainable Livable Cities</td>
<td>WMU</td>
<td>Attanayake</td>
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<tr>
<td>15-6</td>
<td>Integrated Crowdsourcing Platform to Investigate Non-Motorized Behavior and Risk Factors on Walking, Running and Cycling Routes</td>
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<td>App-Based Crowd Sourcing of Bicycle and Pedestrian Conflict Data</td>
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<td>Community-Aware Charging Station Network Design for Electrified Vehicles in Urban Areas: Reducing Congestion, Emissions, Improving Accessibility and Promoting Walking, Bicycling and Use of Public Transportation</td>
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<td>Impact of Access Management Practices to Pedestrian and Bicycle Operations and Safety</td>
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<td>Development of Multi-Class, Multi-Criteria Bicycle Traffic Assignment Models and Solution Algorithms</td>
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<td>Development of a New Combined Modal Split and Traffic Assignment Model for Evaluating Transit Oriented Development Strategies</td>
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<td>Analysis of Walking Facility Performance Guidelines for Individuals with Disabilities</td>
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<td>15-13</td>
<td>Exploring Bicycle Route Choice Behavior with Space Syntax Analysis</td>
<td>USU</td>
<td>Song</td>
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</tbody>
</table>

Research Efforts at WMU

- Analyzed relationship between transportation data and health outcomes for Michigan counties using Structural Equation Model (TRCLC 14-3)
- Development of Decision Support Tools to Assess Pedestrian and Bicycle Safety (TRCLC 14-5)
  - Data analysis and development of Safety Performance Functions for intersections
- Built an instrumented bicycle to examine bicyclists’ dynamic movement associated with bicycle infrastructure (TRCLC 15-1)
- Development and Assessment of Performance Measures for Evaluating and Improving Regional Transit Coordination Using GTFS Data (TRCLC 15-2)
o Developed automated procedure for estimating time-averaged multimodal accessibility values for fine-scale geographies in two case study cities using open source software
  o Using existing GTFS data structure to examine accessibility outcomes for people with disabilities
• Real Time Bicycle Simulation Study of Bicyclists’ Behaviors and their Implication on Safety (TRCLC 15-3)
  o Continued building the bicycle simulator
  o Started designing the experiments
• Travel Behavior of Blind Individuals Before and After Receiving Orientation and Mobility Training (TRCLC 15-4)
  o Research protocol has been finalized and the equipment calibration has been fine tuned.
  o Data collection is currently in progress.
• Analyzed bike-sharing system for Kalamazoo (TRCLC 15-5)
• Developed a BikeableRoute app for testing (TRCLC 15-6)

Research Efforts at UTA
• Development of transportation infrastructure safety performance measures for pedestrians and cyclists, including
  o Pedestrian safety assessment index (PSAI) and bicyclist safety assessment index (BSAI)
  o Methodology for analyzing pedestrian, cyclist and vehicle conflicts
• Developed field based data collection tools to improve decision making
• Began work on “Public Health Performance Measures and Their Role in the Regional Metropolitan Transportation Planning Process” for the NCTCOG University Partnership Program.

Research Efforts at USU
• Conducted a review on existing studies, guidelines and regulations related to walking needs of individuals with disabilities and walking facility level of service analysis.
• Identified statistical approaches to analyze and empirically model qualitative perception data, observed pedestrian behaviors, and methods to compare these data sources.
• Coded survey data and developed a database to manage the pre-, mid-, and post-participation questionnaire data.
• Developed software to manage a large amount of pedestrian trajectory data and extract relevant macroscopic and microscopic information for different types of pedestrian necessary to develop time-space diagrams.
• Implemented statistical procedures to calibrate perceived pedestrian LOS and pedestrian satisfaction models for various walking facilities while considering different individuals with disability types.
• Analyzed the calibrated models inferring the role of different variables in pedestrian LOS thresholds while considering individuals with disabilities.
• Developed a method to convert a bicycle network to axial and segment maps that are compatible with GIS software.

Research Efforts at WSU
• Developed framework for planning agency to evaluate network design for charging stations
• Created repository for transportation-related data on commute, walkability, state of charging station, and demand for arrival pattern of origin-destination pairs, station access coverage
• Developed stochastic mathematical models to optimize the network design of charging stations for a community based on the coverage and uncertainties in arrival patterns, state of charge, walkability, etc.
• Developed conceptual framework that will be used to create samples representing the uncertainties required for decision making
• Collected ped/bike/vehicle field data at 70+ crosswalk locations in Detroit, East Lansing, and Kalamazoo, including volume counts, yielding compliance rates, evasive maneuver rates and crash data. Prepared literature review, prepared data for analysis, analyzed data and began report writing

Research Efforts at TSU
• Two Masters students used the research as their masters dissertation topic
• Five graduate students supported fully or partially from the project funds
• Eight (8) technical papers extracted from TRCLC-related projects have been published, presented or submitted for review
• Final report production is underway

Education and Workforce Development
• Participated and shared research results via membership on TRB’s Bicycle Technical Committee and Research Committee of the National Committee on Traffic Control Devices
• New Master of Arts offered in Orientation and Mobility
• Participated in the American Concrete Institute (ACI) – Field Technician Grade I Certification program. Students are trained and prepared to take the exam by Dr. Upul Attanayake, P.E. Through this collaborative effort between WMU and the Michigan Concrete Association (MCA), 8 students from WMU will be taking the ACI field technician grade I exam in May 2016.
• Coordinated and facilitated focus groups with local governments and bicycle and pedestrian user groups
• Coordinated and funded student travel to TRB 2016 annual meeting
Technology Transfer

- Training on natural language processing and machine learning to civil and construction engineering students
- Presented research results from the “Comprehensive Evaluation of Pedestrian and Bicycle Crashes and Causes in Michigan” to MDOT’s Pedestrian and Bicycle Committees and to the Michigan Pedestrian and Bicycle Safety Action Team (PBSAT)
- Presented research results at the TRB annual meeting and ASEE-GSW Annual Conference
- Developed stochastic optimization model and data analysis tools for SEMCOG

Collaboration

- TRCLC agreed with the Center for Medical Humanities and Convergent Contents at Ajou University in South Korea to establish a formal linkage to foster international cooperation in education and research.
- Collaborated with the Regional TRC at the University of Minnesota on developing and providing pedestrian safety workshops in each region
- Collaborations between WMU and Purdue University, University of Nebraska Lincoln the City University of New York on transportation-related data science research
- Worked with DuPage Mayors and Managers Conference (a council of governments based in DuPage County, Illinois) via its Transportation and Policy Committee to identify key challenges to promoting active transportation among decision makers and transportation professionals
- Research team collaborated with the Center for Persons with Disabilities at Utah State University to analyze the role of the environment on pedestrian LOS thresholds relative to a heterogeneous population.
- Research team has collaborated with the Rocky Mountain ADA Center to assess and analyze the transportation access of individuals with disabilities in the intermountain west region VIII.
- Developed a collaborative research proposal between the UTA School of Social Work and Civil Engineering
- Collaborating with bicycling and pedestrian groups and local governments to develop a crowdsourcing application for safety data. We have conducted two focus groups to get their input on app development. Specifically, we have been working with pedestrian and bicyclist groups (e.g. Bike DFW) representing those that might use the app to determine how best to make the app user-friendly and to incentivize app usage. We are working with a group of local governments (e.g. Dallas County and City of Fort Worth), agencies (e.g. Dallas Rapid Transit), and the regional MPO (NCTCOG) in the DFW area to determine what data needs they have, and how the data collected by the app can be useful to them for improving safety within their municipality.
**Diversity**

- Four female graduate students are participated in WMU research projects; one of the students is Hispanic, and one of them is African American.
- Five African American graduate students are part of participating students including two female students participated for USU projects
- Female faculty members are PIs of four of the five TRCLC research proposals from UTA

1.2 **What opportunities for training and professional development has the program provided?**

- Delivered a keynote speech at the Rhode Island Transportation Forum, ”Developing Livable Communities with Sustainable Transportation Systems,” Jun Oh, October 30, 2015
- Delivered a talk during the following NSF sponsored workshop: The US/Morocco Workshop on Sensors and Wireless Networks for Smart Cities -- funded by the National Science Foundation (NSF), "Crowdsourcing Apps for More Livable Communities," Ala Al-Fuqaha, Jun Oh, Valerian Kwigizile, Rabat, Morocco, January 5-7, 2016.
- Shared project details and TRCLC research results with SEMCOG staff via several presentations

1.3 **How have the results been disseminated?**

- TRCLC news and information continue to be disseminated through e-mails, center website, and Facebook.
- TRCLC reports were electronically disseminated to related agencies
- TRCLC annual reports were mailed to related agencies, supporting partners, and other UTCs.
- The following documents were disseminated via DuPage Mayors and Managers Conference members (i.e., a total of 78 mayors and village managers) via email and the Conference website, www.dmmc-cog.org
  - Promoting Active Transportation in DuPage County: Trends, tools and strategies (October 2015)
  - Parking Management Strategies: A review of the state of the practice (February 2016)
  - Bicycle Parking: Recommended facility types and site planning best practices (April 2016)
- TRCLC research results were shared with transportation professionals at multiple meetings:
  - First Meeting Nov. 2nd 2015 with Rebekah Kik (Kalamazoo City Planner) and Kathy Schultz (Special Projects Coordinator, Kalamazoo Metro Transit)
  - Second Meeting Nov. 6th 2015 with Kathy Schultz and Bronson Hospital Committee on Parking Services
Third Meeting Feb 2nd 2016 with Rebekah Kik (Kalamazoo City Planner) and Kathy Schultz (Special Projects Coordinator, Kalamazoo Metro Transit)
Fourth Meeting April 1st 2016 with Kalamazoo Parking and Mobility Committee

1.4 What do you plan to do during the next period to accomplish the goals and objectives?

Research

- Begin a new line of research validating a training protocol for blind travelers
- Plan to carry out research aimed at changing the driving culture in the city of Ann Arbor to increase driver yielding to pedestrians in crosswalks
- Begin development of a risk factor and traffic volume mobile application
- An article will be written regarding the Travel Behavior of Blind Individuals Before and After Receiving Orientation and Mobility Training and submitted to an appropriate academic journal
- Begin examining lake-effect snow and traffic crashes in southwest Michigan in order to inform transportation planning and transportation safety measures in Michigan's small communities
- Extend the developed automated hazardous action classification method to other analysis of crash reports such as comparing the narrative with the crash scene diagram
- Develop virtual reality-based transportation accessibility evaluation method for the elderly and people with disabilities
- Develop assistive technologies for those with physical or cognitive disabilities, including but not limited to information and communication technologies, sensing technologies, machine learning technologies, automated reasoning technologies, natural language processing technologies, virtual reality technologies, robotics technologies, and knowledge modeling technologies
- Develop data modeling and analytical tools to optimize passenger and freight movements, using logic programming
- Develop a service system to help transportation professionals efficiently track the status of transportation infrastructure conditions, using advanced sensing technologies (e.g., laser scanning, image sensing) together with information modeling, GIS, and knowledge modeling
- Test and propose modifications to GTFS data structure to better assist trip planning for people with physical and cognitive disabilities
- Development of Decision Support Tools to Assess Pedestrian and Bicycle Safety (TRCLC 14-5)
  - Write the report and finalize the project
- Real Time Bicycle Simulation Study of Bicyclists’ Behaviors and their Implication on Safety (TRCLC 15-3)
  - Complete building the simulator
  - Conduct the experiments
  - Write the final report
• Association of Michigan’s Older Adult Crashes with Roadway Features
  o Conduct the survey on drivers and pedestrians
  o Analyze data to identify locations where older adults are overrepresented in crashes
• Current research has inspired a related project that focuses on assessing the impact of access management practices to pedestrian operations and safety. The related research will establish the relationship between access management and pedestrian crash frequency and severities. In addition, it will develop safety performance functions that can be used to evaluate the safety impacts of various access management practices to pedestrians.
• Develop a method to perform a statistical analysis to explore the relationships between space syntax and other bicycle-related attributes and aggregate bicycle counts.
• Finalize crowdsourcing bicycle and pedestrian conflict application and begin dissemination and identifying ways to maximize technology transfer.
• Application of public health performance measures to environmental justice and non-environmental justice communities.
• Synthesize strategic level public health performance measure for transportation planning.
• Begin work on up to five new multidisciplinary research projects
• Formalize network design framework for charging stations, integrate additional functionalities like risk factors, accessibility, multi-modal transportation, carry out sensitivity analysis to quantify the robustness of the model/tool and perform a pilot study using community-based data

**Education and Workforce Development**
• Plan to develop and implement the Second Livable Community Mobile App Challenge in 2016.
• An international workshop has been scheduled to host in July in Shanghai, China with international partners
• Provide field trip and field training opportunities to undergraduate and graduate students in CCE Department and other departments at Western Michigan University.
• Help establish a regular seminar at CCE Department where external professionals and experts are invited to present their work.
• Facilitate the upgrades of computing facilities in the computing labs at the College of Engineering and Applied Sciences, out of the need of running advanced simulation and analysis to support the education goals.
• Try to explore mentorship programs which allow external professionals and experts take selected student mentees to have conversation on a regular basis throughout a year.
• Conduct a training session to prepare students to take the American Concrete Institute (ACI) - Field Technician Grade I Certification.
• Present research findings from the Public Health Performance Measures Project to SRTS funding sources in Texas and Michigan
• Develop short-term training courses for planning agency on the concept of optimizing the siting of vehicle charging stations and integrate project knowledge into undergraduate and graduate courses

**Technology Transfer**
• Center research partners will present findings at 2016 Summer Conference of TRCLC in Kalamazoo
• Organize technological expos during the summer conferences to showcase the different technologies developed and seek collaborations in applying them.
• Plan to co-sponsor a Symposium on Safe Transportation in an Aging Society together with University of Michigan’s ALTAS
• Organize meetings with Kalamazoo and Portage City engineers and planners to educate them about the research being conducted as well as to understand their needs.
• Develop a workshop for using the new Public Health Performance Measures to make infrastructure funding decisions
• Work with SEMCOG and other planning agency to refine applied aspects of transportation research

**Collaboration**
• Collaboration with Tongji University, Hong Kong Polytechnic University, Ajou University in hosting an International Workshop on Sustainable Transportation Systems July 5th, 2016 at Tongji University in Shanghai, China.
• Collaboration with University of Michigan’s ATLAS and co-sponsor a Symposium on Safe Transportation in an Aging Society on September 14-15, 2016
• Seek collaboration with other public organizations and national labs such as the National Renewable Energy Laboratory, share resources (e.g., data, facility, equipment) as appropriate to amplify the impact of the research investment from the center
• Coordination with DuPage Mayors and Managers Conference (DMMC) on two forums to assist decision makers and transportation professionals:
  o *Paths to ADA Compliance* Forum (May 17 2016, 10am-noon) which includes presentations from leaders in the field regarding: (1) best practices for completing/updating Americans with Disabilities Act (ADA) transition plans; (2) best practices for managing self-evaluation inventory data; and (3) funding sources for remediation efforts. Presentations by TRCLC researcher Scott Smith, Mayor’s Office for People with Disabilities, Great Lakes ADA Center and Illinois Department of Transportation.
  o *Shaping the Future of Transit in DuPage County* (May 27 2016 8am-10am) focusing on current and planned transit levels of service and identifying strategies for improving transportation options and linkages in the County. Presentations by TRCLC researcher Scott Smith, Metropolitan Planning Council, County of DuPage Division of Transportation, Pace Suburban Bus and Metra commuter rail service provider.
• Partner with NCTCOG for further development and dissemination of the Conflict Data App throughout the region. We anticipate partnering with some of the other collaborators in Michigan for disseminating the App, too,
• Develop a strategy with the Michigan Fitness Foundation to use the Public Health Performance Measures Project to Evaluate SRTS Proposals

Diversity
• Recruit more female and minority students to work on TRCLC projects
• Encourage students affiliated with the center to apply to the Dwight David Eisenhower Transportation Fellowship Program (DDETFP) for the Hispanic Serving Institutions Fellowship

2 PRODUCTS

2.1 Publications, conference papers, and presentations

Publications.


[UTA] Hamidi, S., Kittrell, K., and Ewing, R. (2016) Transit's value as reflected in U.S. single family home premiums: A meta-study summarizing 40 years of research. Transportation Research Record: Journal of the Transportation Research Board 2543 (DOI: 10.3141/2543-12)


Conference Papers


[UTA] Li, J. & Casey, C. (2015). Integration of public health in transportation planning through knowledge sharing. Poster accepted for presentation at the Association for Collegiate


2.2 Website or other Internet sites

- TRCLC disseminates information and relevant news via TRCLC website and the TRCLC Facebook page
  - Website – www.wmich.edu/transportationcenter
  - Facebook – www.facebook.com/TRCLC
- Lake Michigan Water Trail Website – Michigan Section (www.lmwt.org)
- SafeITS (http://www.safeits.org) shares TRCLC research on Intelligent Transport Systems (ITS), Connected Vehicles or Vehicular Networks (VANET), and other enabling technologies to improve road safety and traffic efficiency

2.3 Technologies and techniques

- TRCLC researchers are carrying out research via a range of novel technologies and techniques including mobile applications, cloud computing and IEEE 802.11p (WAVE)
- Drafted mobile application for collecting bicycle and pedestrian conflict data
- Develop and share on TRCLC website Python scripts used for data development, processing and equity-based analysis of bike share systems using OpenTripPlanner, Open Street Map, ACS data and TIGER shapefiles
- Develop and share Q(uantum)GIS add-on for development of animated maps on TRCLC website
- Develop and share Python scripts used for batch processing of time-averaged job accessibility using OpenTripPlanner, Open Street Map, Lodes data and TIGER shapefiles on TRCLC website
- Develop and share tools for modifying GTFS data to assist with trip planning for people with physical and cognitive disabilities.
- Novel two-stage stochastic programming methods for EV charging network design
- Risk-averse two-stage stochastic programming model with application in EV charging network design
- Developed method for pedestrian data extraction

2.4 Inventions, patent applications, and/or licenses
- Nothing to report.

2.5 Other products
- Nothing to report.

3 PARTICIPANT & COLLABORATING ORGANIZATIONS

3.1 What organizations have been involved as partners?

<table>
<thead>
<tr>
<th>Organization Name</th>
<th>Type / Location</th>
<th>Financial support</th>
<th>In-kind support</th>
<th>Facilities/ Data</th>
<th>Collaborative research</th>
<th>Personnel exchanges</th>
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- List of Research Projects from Other Partners

[WMU] Evaluating the impacts of speed limit changes on identified case studies, Michigan Department of Transportation (MDOT), $136,930, March 2016 - Dec 2017
[WMU] 2014-2015 NHTSA The Effects of High Visibility enforcement on Driver Compliance to Pedestrian Yield Right of Way Laws Follow-up. $73,759
[WMU] 2013-Present Contract MDOT Comparison of Pedestrian Crosswalk Treatments. $218,513
[WMU] Better long cane design and biomechanics for blind cane users" NIH, February 2014-January 2017, $421,125


[UTA] Feasibility Study of Using Freeway Shoulders as Travel Lanes, University Partnership Program, North Central Texas Council of Governments, 1/15/14-9/15/14, $12,000.


[UTA] Walkup Wakeup: Indenting the regionally significant walkable urban places in Dallas Fort Worth Metropolitan area in partnership with George Washington University, 2016-2017; $120,000

[UTA] Walkability study in Downtown Dallas, City of Dallas, TX, 2016, $30,000
3.2 Have other collaborators or contacts been involved?
- Center for Medical Humanities and Convergent Contents at Ajou University, South Korea
- Tongji University
- DuPage Mayors and Managers Conference (DMMC)
- Dona Sauerburger, private contract O&M instructor
- Professor Sujit K. Ghosh at Department of Statistics, North Carolina State University

4 IMPACT

4.1 What is the impact on the development of the principal discipline of the program?
- A better knowledge of the abilities of blind pedestrians to positively influence their travel environment.
- By jointly modeling the number of crash and the presence of severity and accommodating the nature of correlated data, TRCLC researchers expect to develop a more accurate prediction model.
- Gateway sign treatment is being employed in a number of jurisdiction in Michigan and in other areas of the United States. The Regulatory and Warning Committee of the NCUTCD is drafting changes for the use of the in-street sign.
- Work on Count Down signals is being considered by FHWA for changes to the MUTCD.
- Development of new algorithms and communications protocols and solutions that are tailored for transportation applications.
- Research findings will both add to the knowledge base in the discipline of Orientation and Mobility and transportation engineering and shed light on travel behaviors of blind pedestrians in their communities.
- Bring in knowledge and expertise about various computing technologies to help with transportation related issues, example technologies are natural language processing and machine learning.
• Implementation of TRCLC funds have effectively expanded transportation-related research at TSU
• Planning tools for network design which can be easily integrated within state or national planning programs
• Quantitative framework considering qualitative factors for a charging station network design while considering the uncertainties in the inputs
• Short term courses
• Linkage between driver behavior when approaching pedestrians and crash occurrence

4.2 What is the impact on other disciplines?
• Greater understanding on the part of city planners and transportation engineers regarding the needs and abilities of blind pedestrians
• Facilitate the collaboration of scholars between different disciplines on projects targeting at the common good, including engineering disciplines such as construction engineering and other disciplines such as psychology and education
• Provide test ground for scientific and technological development in other disciplines by adapting/adopting those developments to solve transportation problems
• Department of Social Work is able to collaborate with Civil Engineering and assess the impact that transportation gaps may have on their client populations.
• Methodology for two-stage stochastic programming model with 0-1 variables in second stage
• Methodology for Risk-averse two-stage stochastic programming model with 0-1 variables in second stage

4.3 What is the impact on the development of transportation workforce development
• Many graduate students are being trained on the use of technology to develop transportation solutions.
• Provide technical training opportunities for transportation engineers and future transportation engineers
• Provide access to state-of-the-art technologies for transportation engineers and future transportation engineers
• Provide advising support from world-class faculties in multiple disciplines to transportation engineers and future transportation engineers
• Instill the excitement of transportation engineering to students by educating students all different aspects of transportation engineering especially how important it is to human life and society
• 38 undergraduate students are introduced to active transportation modes through project-based learning. Previously, another 40 students participated in the same project-based learning activity.
• Graduate students have received notice to proceed on their mini-grants
• In both cases, students are receiving an opportunity to experience transportation research, which may increase his or interest in pursuing additional education.
• Numerous undergraduate and graduate students are exposed to transportation-related project objectives and research methods.

4.4 **What is the impact on physical, institutional, and information resources at the university or other partner institutions?**

- Through developing applications of advanced technologies in transportation engineering, it not only contributes to the domain of transportation engineering, but also provides opportunities to further develop, adapt, or customize the state-of-the-art technologies to better satisfy the need for real world engineering applications in the transportation sector.
- It provides equipment, facilities, and financial resources to Western Michigan University and all partner institutions to allow the faculty there to conduct research using state-of-the-art knowledge and techniques, while at the same time allow students in these institutions to learn about state-of-the-art research and development first-hand.
- TRCLC funds have improved recruitment of graduate students interested in transportation engineering and planning field and given participating faculties and students opportunities to pursue and publish transportation research.

4.5 **What is the impact on technology transfer?**

- Findings may influence the MUTCD.
- Mobile applications that are currently under development have patent and commercialization potential.
- Clear the barriers between state-of-the-art technologies and transportation workforce to make the technology transfer feasible and smoother.
- Provide a platform for industry, government, and academia to communicate and transfer state-of-the-art technologies in transportation domain with each other.
- Provide guidelines to drafting DOT policies to better support the development and transfer of state-of-the-art technologies in transportation domain.
- Charging station model/tool can be integrated into existing toolkits at one or more transportation planning agencies. The modular designs of the tools developed so can be seamlessly integrated within an organization’s existing technology infrastructure.

4.6 **What is the impact on society beyond science and technology?**

- Research results are likely to make walking safer which will have a positive impact on the likelihood that people choose walking as a mode choice.
- Mobile applications current under development utilize crowdsourcing which allows participants to report and be notified about potential risk factors on public infrastructure (biking routes, parks, trails, etc.)
- Increase people’s awareness of transportation issues.
- Make suggestions to government to help with resource allocation decision makings.
• Provide a center of transportation knowledge base outside of DOT
• Promote a more sustainable transportation mode consisted of more frequent use of walking and cycling
• In part due to TRCLC technology transfer, communities in DuPage County, Illinois are increasingly interested in expanding opportunities for non-motorized modes of transportation, especially bicycling and walking. This is evidenced by the growing number of communities and their residents: seeking out and receiving Bicycle Friendly Community designations; adopting Complete Streets policies; and developing and implementing active transportation plans
• Analytical approaches and data structures under development are designed to improve mobility among people with physical and cognitive disabilities

5  CHANGES/PROBLEMS

5.1  Changes in approach and reasons for change
• Nothing to report.

5.2  Actual or anticipated problems or delays and actions or plans to resolve them
• Nothing to report

5.3  Changes that have a significant impact on expenditures
• Nothing to report

5.4  Significant changes in use or care of animals, human subjects, and/or biohazards
• Nothing to report.

6  SPECIAL REPORTING REQUIREMENTS
• Nothing to report.