

Program Progress Performance Report

To US DOT/OST-R, University Transportation Centers

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1. Accomplishments

What are the major goals and objectives of the program?

Through a strategically focused program that is synergistic with U.S. DOT priorities and MAP-21 goals, the Midwest Transportation Center (MTC) addresses regional issues related to its theme of *Data Driven Performance Measures for Enhanced Infrastructure Condition, Safety, and Project Delivery*, focusing on the overall goal of **State of Good Repair**. Under this theme, the MTC's objectives are to

- Serve as a focal point within the region and nationally for research that develops data performance measures for infrastructure condition, safety, and project Delivery.
- Ensure efficient use of funds by building on existing programs, avoiding duplication, leveraging existing resources, and developing creative cooperative activities with industry.
- Develop products that are useful and relevant to stakeholders including national, state, regional, and local transportation agencies as well as industry and other researchers.
- Provide leadership in the next generation of technology transfer, beginning with the research itself—involving the user, innovative outreach, and new communications technology.
- Develop the next generation of transportation professionals and provide opportunities for current professionals.
- Provide leadership opportunities for students and young professionals.
- Recruit and retain a diverse workforce.

What was accomplished under these goals?

The MTC accomplishes these goals by focusing on the following five activities:

- A. Research (goals 1, 2, 3)
- B. Outreach/technology transfer (goals 3, 4)
- C. Education (goals 6, 7)
- D. Workforce development (goals 5, 6)
- E. Center management (all goals)

The following sections summarize MTC accomplishments under each of these activities during the reporting period.

Highlights include the following:

- MTC & IHRB combine funds for innovative research projects (page 7)
- 2017 Mid-Continent Transportation Research Symposium (page 7)
- Iowa Evening reception at 2017 TRB Annual Meeting (page 8)
- UHPC for Bridge Applications Workshop (page 8)
- Third Implementation Brief and Webinar (page 8)
- Study Abroad to Great Britain (page 8)
- 2016 MTC Outstanding Student of the Year (page 9)

A. Research

The MTC's lead organization, Iowa State University (ISU), is working with partners Wichita State University and Creighton University to help them develop transportation-focused research programs; partner organizations University of Missouri–Columbia (UMC) and the University of Missouri–St. Louis (UMSL) are working with partner Harris-Stowe State University.

The total number of projects funded under this grant to date is 118, with 57 being led by ISU and 61 being led by partner or other institutions. All MTC-funded research projects, completed and in-progress, are listed at intrans.iastate.edu/mtc/index.cfm/research.

Completed Research

During this reporting period, 12 final reports and 6 technology transfer documents were submitted for research projects funded under this UTC grant, bringing the total to 30 final reports to date (“Products” on page 14).

Current Projects

Following are highlights of a few projects representing the work of all the partner institutions during this reporting period:

Use of SHRP2 NDS Data to Evaluate Roadway Departure Characteristics

PIs: Omar Smadi and Shauna Hallmark, Iowa State University

The Second Strategic Highway Research Program (SHRP2) Naturalistic Driving Study (NDS) data provides a unique opportunity to evaluate the relationship between driver and roadway characteristics in a manner not previously possible. These data provide a detailed record of driver and roadway characteristics during actual crashes/near-crashes as well as a snapshot of normal driving behavior.

This study is using the SHRP2 NDS and accompanying Roadway Information Database (RID) with a focus on speed and distraction from the perspective of the driver and roadway geometry and countermeasures from the perspective of the roadway.

Evaluation of Work-Zone Safety Using SHRP2 Naturalistic Driving Study Data

PIs: Shauna Hallmark and Omar Smadi, Iowa State University

The Naturalistic Driving Study (NDS) data collected by the Second Strategic Highway Program (SHRP2) offers a rare opportunity for a first-hand view of work-zone safety-critical events. Using these data, actual driver behavior can be observed. Additionally, using forward roadway views, researchers can make a determination as to whether the events were actually work-zone related.

The goal of this research is to more fully investigate work-zone safety using the unique data available with the SHRP2 data. In particular, the analyses address the role of speed and distraction in work-zone crashes and near crashes.

Additionally, the goal is to also determine how drivers negotiate work-zones and determine the factors present when safety-critical situations arise as compared to normal work-zone driving. Results from earlier work suggest that the impact of speed, driver distraction, work-zone configuration, and roadway characteristics can successfully be included in the analyses.

Research Utilizing the SHRP2 Safety Data to Support Highway Safety

PIs: Shauna Hallmark, Omar Smadi, and Peter Savolainen, Iowa State University

Safe intersection negotiation depends on drivers being able to recognize the presence of an intersection and then respond appropriately to applicable traffic control devices and prevailing conditions. When drivers are required to yield right-of-way to on-coming traffic, they also need to be able to identify and select appropriate gaps. Consequently, the research for Phase I investigated the feasibility of answering the following research questions, which address the relationship between different stages of intersection negotiation and roadway and driver characteristics.

- What is the relationship between rural intersection crash risk and driver, roadway, and environmental characteristics?
- What is the relationship between intersection recognition and stopping behavior and intersection geometry and countermeasures?
- What are the primary influences for appropriate scanning behavior and gap acceptance at rural intersections?

Speed Limits, Geometry, and Driver Behavior

PI: Peter Savolainen, Iowa State University

Speed management has been an extensive focus of traffic safety research dating back to the 1960s. Research has generally shown crash risk to increase as the average speed of traffic increases and as the standard deviation of travel speeds increases within a traffic stream. However, research as to the effects of speed limits has been somewhat inconclusive.

This study investigated how speed limits affect driver speed selection, as well as the resultant crash risk, while controlling for various confounding factors such as traffic volumes and roadway geometry. Data are obtained at very high resolution from a Naturalistic Driving Study (NDS) conducted as a part of the Second Strategic Highway Research Program (SHRP2). These data are integrated with a Roadway Information Database (RID), which provided extensive details as to roadway characteristics in six state study areas (Florida, Indiana, New York, North Carolina, Pennsylvania, and Washington.) These sources are used to examine how driver speed selection varies among freeways with different posted speed limits and how the likelihood of crash/near-crash events change with respect to various speed metrics.

Development of Crash Modification Factors for Lane Departure Countermeasures

PI: Shauna Hallmark, Iowa State University

Lane departure crashes make up a large percentage of rural crashes for states in the Midwest. Since agencies have limited resources, they rely on studies that demonstrate the effectiveness of a particular countermeasure in order to make decisions about which countermeasures should be selected. Most agencies prefer countermeasure effectiveness to be stated in terms of crash modification factors (CMFs), since they are easily understood and commonly used by agencies. Developing data driven performance measures for safety is one of the main MTC themes, and robust CMFs have not been developed for a number of lane departure countermeasures.

The objective of this research was to develop CMFs for several lane departure countermeasures that have been used in Iowa. The research included selecting sites where the countermeasures have been installed, identifying control sites, extracting site characteristics, reducing crash data, conducting analyses, and summarizing results.



Flags placed on rural road traffic signs

Development of a Mix Formation and Pavement Design Using Asphalt-Rubber Binders and Biobased Additives

PI: Christopher Williams, Iowa State University

The evolution of renewable and sustainable specialty products from biomaterials has been ongoing for many years. Historically, the challenges have been being able to compete economically with crude petroleum analogues. ISU has developed block co-polymers that are both performance and cost advantaged over ones derived from crude petroleum. The ISU polymers are made from non-food source vegetable oils. Production of the monomers, used as the building blocks for polymers, has been under way at the ISU Bio-Polymers Processing Facility since March 22, 2017. The research teams anticipate producing polymers by June 2017 and conducting asphalt paving projects in late summer.

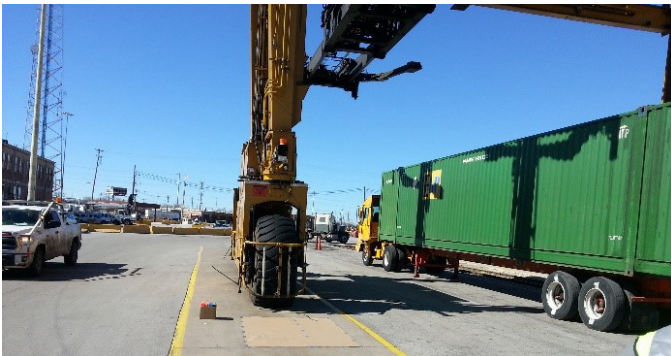


Bio-Polymers Processing Facility at ISU

Intermodal Gantry Crane Pavement and Foundation Design Improvement

PIs: Vern Schaefer, Chris Williams, and Jeramy Ashlock, Iowa State University

Gantry crane pavements and foundations represent a significant asset within intermodal facilities. Subjected to high variations in loading, they are critical to regulating safe operations, traffic interruptions, and costs associated with maintaining and rehabilitating distressed or failed pavements in these areas. ISU is investigating ways to improve the performance and increase the lifespan of gantry crane pavements and foundations by assessing the interactions between pavements, subgrades, operational loading conditions, and performance of these pavements and foundations. The current focus is on field efforts to measure the loads imparted to the pavements and subgrades. These data will aid in developing recommendations to improve performance of existing and newly constructed pavement systems.



Measuring loaded footprint of gantry crane tire

Keeping the Bottom Line

PIs: Carlton Basmajian and Biswa Das, Iowa State University

This project explored the transportation difficulties of rural Iowa households. Using a mixed methods approach, comprised of mail surveys and in-depth, in-person interviews, the research team examined self-reported travel experiences of households in four small Iowa counties: Wapello, Cerro Gordo, O'Brien, and Cass. The goal was to better understand how households define essential services, the barriers households face in accessing those services, and the techniques households use to overcome those barriers. In addition to better understanding rural travel and accessibility issues (an area with little extant literature), the research provides policy recommendations to local and state officials that could improve the lives of Iowa's rural households.

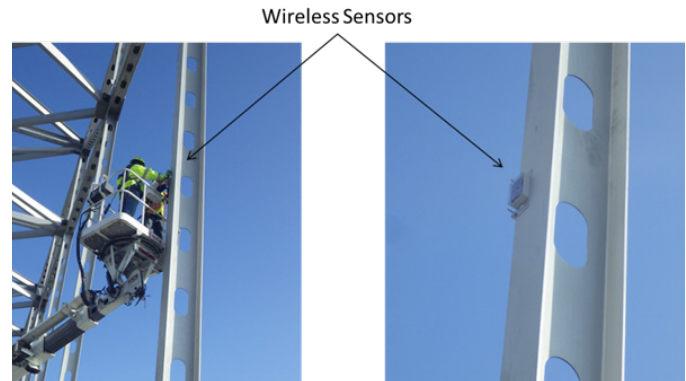
Monitoring Vibrations on the Jefferson City Truss Bridge

PI: Glenn Washer, University of Missouri–Columbia

The objective of the research was to determine the frequency and cause of resonant vibrations of vertical truss members on bridge A4497 over the Missouri River in Jefferson City, Missouri. Instrumentation to monitor the vibrations of four vertical members was installed on the bridge and monitored for 42 days. Weather data available from the weather

station at the Jefferson City Memorial Airport were used to analyze weather conditions causing resonant vibrations of the four vertical members.

Eleven vibration “events” were found where vertical members vibrated with higher than normal acceleration. The researchers also analyzed historical weather data to determine how frequently the resonance vibrations were occurring. The research team concluded that the frequency of resonant vibration events was likely 0.25 or fewer events per day. The vibrations were caused by average winds from the west-northwest, northwest, or southwest of approximately 17 mph or greater, based on monitoring results.



Installation of wireless sensors to monitor vibrations

Implementation of Transportation Asset Management in Grandview, Missouri

PI: Henry Brown, University of Missouri–Columbia

The successful implementation of transportation asset management (TAM) by local governments facilitates the optimization of limited resources. The use of a data-driven TAM program helps to identify and prioritize needs, identify and dedicate resources for the preservation of infrastructure, and provide policy decision makers with the data to support good decisions.

In this project, a TAM program was implemented for the City of Grandview, Missouri. The implementation process included an examination of the current TAM practices, review of TAM software systems, deployment of a TAM system, analysis of existing pavement and service request data, inventory of existing pavement condition, formulation of a pavement preservation plan, and development of a framework for ensuring that the implemented TAM is sustainable.

Pavement preservation plans were developed for both the near term (2016 through 2020) and long term (2021 through 2040). A decision tree methodology was developed and utilized to select specific pavement treatments for the next five years. The long-term analysis assessed the possible impacts of a vote in 2021 to increase the sales tax to fund transportation projects. Recommendations for sustaining the TAM system were provided.

The flexible framework developed in this research can be used by other communities to help local governments maximize limited resources.

Strategic Design for Delivery with Linked Transportation Assets: Trucks and Drones

PIs: James Campbell and Donald Sweeney, University of Missouri–St. Louis

Home delivery by drones is being promoted and researched by a growing number of firms (Amazon, Walmart, Google, UPS, DHL, etc.) as an alternative or complement to traditional delivery by trucks. While widespread use of delivery drones requires overcoming a variety of regulatory and technological obstacles, there is also a need for strategic analyses of hybrid truck-drone delivery to identify promising system designs. We considered aerial drones that are launched from trucks or from fixed (or relocatable) facilities, where both drones and trucks can make deliveries.

The research team developed a series of continuous approximation models for the strategic design of drone and hybrid truck-drone delivery systems to analytically evaluate optimal system designs. In contrast to discrete VRP-based optimization models, the team treated demand for deliveries as a continuous spatial density over a region and formulate models for the expected distance and cost. Analytical results identified the best mix of drones and trucks, documented the benefits from using drones, and provided strategic managerial insights.

Emerging Freight Truck Technologies: Effects on Relative Freight Costs

PI: Ray Mundy, University of Missouri–St. Louis

New and emerging technology has changed the nature of many industries like the entertainment, news, and advertisement industries. The freight service industry is no exception. Platooning technology allows freight trucks to mimic the cost advantages of rail cars whereby cost savings increase with increases in the ton miles of a shipment. Combining this with emerging driverless technology gives a recipe for a major paradigm shift within the freight services industry. Intermodalism may lose its competitive edge in the long-haul freight market in favor of trucks, which can mirror the cost outcomes of intermodal options. Thus, government-subsidized intermodal infrastructure improvements could have a lower social return on investment than previously anticipated.

This study attempted to quantify the potential decrease in the cost per container mile of freight truck transportation and relate it to the cost per container mile of rail freight.



Freight trucks

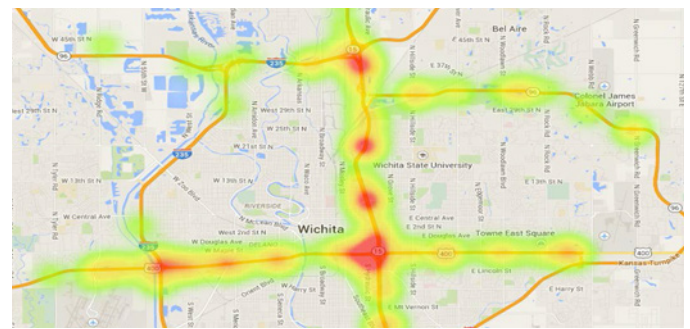
Particularly, the research team investigated the potential impact of this decrease in truck services on the demand for rail services using various methods.

Highway Incident Management System for the City of Wichita

PI: Pingfeng Wang, Wichita State University

The researchers at Wichita State University are collaborating with the Kansas Department of Transportation through the Traffic Management Center (TMC) in Wichita, Kansas, in developing a Highway Incident Management System (HIMS). The anticipated functions of the HIMS include an autonomous analysis of online traffic-related data for incident diagnosis/identification, an autonomous optimization that facilitates traffic control decision making to reduce average incident clearance and traffic recovery time, and conveniently extracting specific incident-relevant record data from high-dimensional and high-volume time series datasets.

In this research, a total of 182 actively logged incidents and traffic information from multiple online monitoring facility units during April 2015 in the City of Wichita will be used to facilitate model and technology development.



Distribution heat map of incidents for April 2015 in the City of Wichita

Economic Sustainability to Inner City Streets: A Collaborative Transportation and Safety Model

PIs: Fara Zakery and Joyce Eisel, Harris-Stowe State University

The faculty, students, and staff of Harris-Stowe State University continued their third phase of research on a sustainable asset management transportation system model. In this project, quantitative, qualitative, and observational research methods were employed and economic, social, and safety variables were identified. The research project was developed for an inner-city urban community within a 45-block area in downtown St. Louis, Missouri. This technology-driven economic, social, and safety model has been used for a designated St. Louis metropolitan area and can be replicated by similar municipalities. During the project, faculty and student researchers employed outreach activities engaging various constituents. These constituents included the City of St. Louis Department of Streets and Department of Sidewalks, the Missouri Department of Transportation, local government officials, aldermen, businesses, families, and other stakeholders affected by the project. Faculty and students have presented and published their research at several national and regional conferences.

An Assessment of the Models to Predict Pavement Performance

PIs: Ravi Nath and William Duckworth, Creighton University

This project examines and analyzes pavement performance datasets provided by the Iowa DOT. Models that predict pavement performance were developed and compared against each other to assess their relative efficacy and predictive ability. In addition, a “parsimonious” predictive modeling approach was employed to identify a simple, efficient, and effective predictive pavement performance model.

Plans include further exploring the data sets and developing additional predictive models in order to hone in on the most parsimonious approach for predicting pavement performance. This is likely to provide additional insights into the interrelationships among various predictor variables.

Other Research-Related Activities

Innovative Research Projects with Joint Funding: MTC and Iowa Highway Research Board

The Iowa Highway Research Board (IHRB) is an advisory group to the Iowa DOT and is responsible for assisting in the development and continuation of an effective research program for Iowa highway transportation. One of its goals is to encourage transportation innovation and long-range technological advances.

The Region VII MTC is one of 10 regional University Transportation Centers sponsored by the U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology and is led by the Iowa State University Institute for Transportation. The research focus area for the MTC is “State of Good Repair,” a key program under the 2012 Moving Ahead for Progress in the 21st Century Act (MAP-21).

To support innovation and advances, the IHRB and MTC provided seed funding for four projects that are innovative or explore long-range advances in highway transportation. These projects may be “high-risk, high-reward” in nature, or they may be basic research that can lead to new fundamental insights that, in due course, will result in substantive advances in the design, construction, instrumentation and monitoring, modeling, or management of highway-related projects. These projects are not necessarily expected to lead to results that are of immediate use in highway transportation, but produce results that hold promise for further useful development. These projects are just beginning.

B. Outreach/Technology Transfer

2016 Mid-Continent Transportation Research Symposium

The 2016 Mid-Continent Transportation Research Symposium was held in Madison, Wisconsin, on October 24–25. The theme for this event was “Where the Rubber Hits the Road: Moving from Research to Implementation.” ISU had several faculty, staff, and students attend this event along with a few serving as presenters, including Peter Savolainen,

Anuj Sharma, and graduate student Raha Hamzeie. This is a bi-annual event held opposite years at ISU. There were over 60 podium presentations and several poster sessions.



Symposium marketing material

2017 Mid-Continent Transportation Research Symposium, August 16–17, Ames, Iowa

Planning is under way for the 2017 Mid-Continent Transportation Research Symposium to be held in Ames, Iowa. This research event has been hosted by ISU since 1996 and is co-sponsored by the MTC, Iowa DOT, and FHWA, and will showcase several new research/outreach activities. The attendees are from local (county and city engineers), state, and federal agencies; industry; and universities from several states. MTC partner institutions are invited to attend this event, which is August 16–17, 2017.

Sandra Larson, recipient of Roy W. Crum Distinguished Service Award

Sandra Larson, the Systems Operations Bureau Director of the Highway Division at the Iowa DOT, was awarded the Crum Award on January 11, 2017, for her achievement and leadership contributions with the Transportation Research Board and the American Association of State Highway and Transportation Officials. In her role at the Iowa DOT, Larson collaborated on many ongoing research, educational, and implementation projects and programs with the faculty, staff, and students at ISU’s Institute for Transportation.



Sandra Larson

County Engineers Research Focus Group

Each year the Iowa DOT and the Iowa Local Technical Assistance Program co-sponsor the annual County Engineers Research Focus Group meeting in Ames, Iowa. The 7th annual event, February 15, 2017, hosted 44 county and city engineers. Participants heard about research updates and had the opportunity to share ideas, tools, and techniques that improved their operations or saved their department money. They also participated in a brainstorming session to identify priority research projects that will be presented to the Iowa Highway Research Board for consideration.



Engineers at County Engineers Research Focus Group meeting

InTrans, Iowa DOT Host Reception at TRB Meeting in Washington, DC

Transportation professionals from the United States and beyond enjoyed Iowa hospitality during the Iowa Evening reception at the 2017 Transportation Research Board Annual Meeting on January 10, 2017, in Washington, DC. ISU's Institute for Transportation and the Iowa DOT are the lead sponsors of this yearly event. The Iowans hosted individuals from the federal government, state DOTs, universities, other nations, and the private sector. Many graduate students also attended.

The Iowa Evening at TRB is our one chance each year to do what is most important...share, listen, learn, and celebrate at arm's length with the wonderful people in our profession! It is so important to share Iowa's accomplishments and challenges and to learn what others are doing across the US.
—Neal Hawkins, InTrans Associate Director

ISU Day at the State Capitol

The Institute for Transportation participated in ISU's Day at the Capitol on February 21, 2017, with a display. Iowa Governor Terry Branstad stopped to visit with InTrans transportation researcher Skylar Knickerbocker, who explained the work of the REACTOR (Real Time Analytics of Transportation Data) traffic operations lab at InTrans.



Skylar Knickerbocker, InTrans research engineer, and Governor Branstad

Ultra-High Performance Concrete (UHPC) for Bridge Applications Workshop

The Iowa DOT, FHWA, Local Technical Assistant Program, Institute for Transportation, and MTC will be holding a workshop on May 4, 2017, about ultra-high performance concrete (UHPC) bridge applications. The presentations have been finalized, and registration is open for this event. More details about this workshop will be included in the next report.



Bridge engineers

Third MTC Research Brief, Summer Webinar to Help Research Implementation

The MTC is again helping get new knowledge into the hands of transportation professionals. A research brief on a new bridge structural health monitoring system has been posted on the MTC website and a webinar on the topic is scheduled for July 19, 2017. The brief, titled "Bridge Structural Health Monitoring System Can Provide Immediate and Accessible Data," is the third in a series of MTC one-page documents that highlight research results. The previous two briefs were "Safety Benefits of Safety Edge" and "Evaluation of Low-Cost Traffic Calming." The webinar will explain how the system works and how it is being implemented in Iowa. Brent Phares, director of the ISU Bridge Engineering Center, and Ahmad Abu-Hawash, chief structural engineer in the Iowa DOT Office of Bridges and Structures, will present the webinar.

C. Education

Study Abroad Students to Visit Great Britain

The MTC will conduct its third study abroad program in May 2017, taking students to various sites in Great Britain including Edinburgh, Scotland and London, England for the two-week course Global Perspectives in Transportation. Twenty-five students, led by five MTC-affiliated faculty, will gain a global perspective of transportation systems and how they vary from the U.S. The students will begin to gain a better international understanding of the impact of different historical, cultural, social, environmental, and political factors on transportation and infrastructure projects.

MTC Transportation Scholars Program Enhances Student Experience

The MTC continues to sponsor and manage the Transportation Scholars program at ISU, University of Missouri-Columbia, and the University of Missouri-St. Louis. The program requires students to demonstrate excellence in coursework, research, leadership, and community outreach.

2016 MTC Outstanding Student of the Year

Ken Bao attended the University of Missouri–St. Louis as an undergraduate finance major and, after graduation, decided to stay and pursue a master’s degree in economics. He was chosen as MTC Outstanding Student of the Year for 2016 because he exemplifies integrity and commitment along with the team leadership abilities necessary for a successful student researcher. Primarily interested in air and ground transportation, Bao’s main undergraduate research project explored the cost comparison of restructuring the Essential Air Services (EAS) program, which was presented at the Transportation Research Board annual meeting in January 2017 in Washington, DC.



Ken Bao with UMSL Professor Ray Mundy

Seminar in Transportation

Led by MTC Director Shauna Hallmark, the Tom Maze Transportation Seminar presents weekly lectures during the spring semester by nationally and internationally recognized speakers who discuss timely transportation-related topics with the students. The seminar is broadcast online in real-time to students at MTC partner institutions. The broadcast location rotates among ISU, University of Missouri–Columbia, and University of Missouri–St. Louis. Presentations are recorded and made available via the MTC website. During this reporting period, 10 presentations were made and averaged 57 participants. Presenters participating were from the Accelerated Bridge Construction-University Transportation Center (ABC-UTC) in Florida, Hallmark Cards, University of Iowa, University of Minnesota, Purdue University, and Iowa State University.

Fall Transportation Graduate Student Research Seminar

The second year of ISU’s weekly Transportation Graduate Student Research Seminar took place in fall 2016. This series, led by ISU’s Peter Savolainen, was developed by the transportation division of the Department of Civil, Construction, and Environmental Engineering. Graduate students in transportation, including MTC Transportation Scholars, present their research results, allowing them to develop their presentation skills and receive feedback on their research from other students and faculty. Each transportation student must participate in this seminar at least once. Nine student presentations were made during the current reporting period with an average of 41 attendees.

Ellen Nightingale receives Trinect Fellowship Award

Each year Iowa State University’s Trinect program recruits 10 ISU graduate students associated with the College of Engineering to work collaboratively with a selected elementary school teacher and ISU pre-service teachers to leverage their expertise in science and mathematics. For fall 2016 through spring 2017, InTrans graduate student Ellen Nightingale participated as one of the program’s Fellows. Nightingale and other Fellows developed innovative and engaging STEM activities for elementary school students. They spent one day a week throughout the school year in an elementary classroom in Des Moines, Iowa, performing the duties of a “resident engineer” as they interacted with their partner teachers and students.



Ellen Nightingale

MTC Beginning Third Year of Undergraduate Research Program

The MTC is starting the third year of its Undergraduate Research Program at ISU. Seed funding is allocated to faculty who engage undergraduate students in research projects under the thematic focus of the MTC. Faculty provide matching funds and this project is oriented toward facilitating broader opportunities for undergraduate research and encouraging students to consider graduate school opportunities. Funding is available for up to 10 projects per year.

AASHTO Bridge Competition Teams

As part of a pilot program, the MTC partnered with the Iowa DOT to fund three ISU graduate students to work with teachers and mentor students in order to encourage participation in this transportation opportunity. The AASHTO National Bridge and Structure Competition is held annually for students from participating TRAC & RIDES states. Guidelines for the competition were posted on the TRAC website in October 2016, entries were submitted in February 2017, and teams selected to participate in the final competition were notified in March 2017. Five groups from this new program completed the required digital design, model, and proposal for submission. Of the 18 teams chosen to compete, one of ISU’s Science Bound teams was selected as a finalist for the competition to be held in Portland, Maine, during the Annual AASHTO meeting May 23–24, 2017.

The Missouri Traffic Safety and Blueprint Conference

From October 18–20, 2016, the annual Traffic and Safety Conference, which is typically held in May on the University of Missouri–Columbia campus, was expanded to also include Missouri’s Blueprint Conference (a biannual event). This new format brought in an expanded audience of 500 to allow more opportunities for networking. Additionally, a number of University of Missouri transportation scholars showcased their research.



Yohan Chang receives first place for poster presentation

MTC Students Win Awards, Gain Valuable Experience

MTC students are actively participating in competitions and presenting their research. During the current reporting period, MTC students had several major accomplishments:

- ISU graduate student Ilker Karaca was accepted into the Airport Cooperative Research Program’s (ACRP’s) Graduate Research Award Program, which encourages applied research on airport and related aviation system issues while fostering the next generation of aviation community leaders.
- On November 12, 2016, during the Ready, Set, Build!: Bridge-Building Challenge, members of ISU’s Transportation Student Association (TSA) hosted an informational booth and activity, which focused on roundabout education.
- The 6th annual Graduate Student Research Showcase and Poster Competition was held on November 30, 2016, at ISU. TSA members represented 15 out of 60 posters in the competition. ISU graduate student and TSA member Emira Rista placed first in the transportation category.
- ISU graduate student Georges Bou-Saab was accepted into the IRF Road Scholar Program as an Executive Fellow. The program took place in January 2017 in Washington, DC, and was held in conjunction with the Transportation Research Board Annual Meeting.
- The ISU Transportation Student Association funded 35 students to attend the Transportation Research Board Annual Meeting in Washington, DC, in January 2017. Students were able to network, especially during evening events like the Institute for Transportation Engineers (ITE) Student Reception and the Iowa Night reception, where local professionals and stakeholders conducting engineering research mingled with Iowans.
- The University of Missouri sponsored six students to attend and present posters at the National Transportation Research Board Conference in Washington, DC, in January 2017.

- ISU graduate students Ellen Nightingale and Anjana Avr attended the Transportation Expo in Minneapolis, Minnesota, in March 2017.
- In March 2017, ISU graduate student Raha Hamzeie attended the 10th International Symposium on Managing Fatigue in San Diego, California.
- ISU graduate students Ashirwad Barnwal, Georges Bou-Saab, and Niloo Parvin attended the Lifesavers Conference in Charlotte, North Carolina, in March 2017.

D. Workforce Development

Ready, Set, Build!: Bridge-Building Challenge Held November 2016

Expanded in 2016 to a two-day event, the Ready, Set, Build!: Bridge-Building Challenge was held November 11–12 at the Science Center of Iowa (SCI). On November 11, school groups from across Iowa (18 teams and 71 participants) participated in a stand-alone session. Then, on November 12, families and after-school groups (25 teams and 87 participants) took part in their own session. Participants were divided into four categories: 1st–3rd grades, 4th–6th grades, 7th–8th grades, and family. Each team had three hours to build a bridge out of provided materials (e.g., Popsicle sticks, wooden dowels, masking tape, glue, string, and poster board).

“I have heard nothing but amazing feedback about the Ready, Set, Build!: Bridge-Building Challenge this last weekend. I just wanted to send our sincere thanks for this partnership and collaboration! Your dedication to K-12 audiences and beyond is clear and we couldn’t be more grateful for your support and interest to inspire Iowans in STEM literacy!”
–Renee Shull Harmon, Vice President of Science Learning at SCI

Participants had the opportunity to interact with engineering professionals from the Iowa DOT and the Institute for Transportation and learn more about bridges and other transportation-related topics. ISU engineering graduate students also volunteered for the day to assist the young designers and builders.

Through hands-on learning booths at the main entrance, the Iowa DOT, InTrans, ISU Transportation Student Association, and the ISU Women in Science and Engineering (WiSE) provided over 1,200 SCI attendees with learning opportunities about transportation and bridges.

This event was sponsored in-part by the Iowa DOT and supported by ISU 4U Promise, which helps prepare students



Student and family teams await bridge results during judging

for college who come from communities with historically lower attendance or academic success in higher education.

MTC Teams with Program for Women in Science and Engineering

The MTC teamed with the ISU Program for Women in Science and Engineering (WiSE) to offer the Ready, Set, Build! Bridge-Building Challenge. The event was held on October 27, 2016, at ISU during the WiSE-sponsored Taking the Road Less Traveled (TRLT) Career Conference, which hosted 350 9th and 10th graders, 45 of whom participated in the bridge challenge. WiSE collaborates with other groups to increase the participation of women in STEM fields. One of the goals of the conference (held multiple times in spring and fall) is to expand awareness of STEM careers. This was the second time the Institute for Transportation conducted this activity as part of the TRLT Career Conference.



InTrans engineer Katelyn Freeseaman tests bridges

ASCE Engineering Day for Kids

The University of Missouri student chapter of the American Society of Civil Engineers (ASCE), with support from the MTC, held its fall Engineering Day for Kids on December 3, 2016. There were over 60 3rd- to 5th-grade participants. ASCE student members assisted the students as they learned about what civil engineers do. They built bridges and structures out of toothpicks and gumdrops, set-up and ran cars on a simulated highway, built retaining walls with sand and paper, and measured and calculated material properties.



Students and volunteers at Engineering Day for Kids

SCI Engineering Week

The Science Center of Iowa (SCI) celebrated Engineering Week 2017 from February 20–24. The Institute for Transportation sponsored the full week and hosted a booth activity (balloon cars) on February 24. The event had the following outcomes:

- Celebrated and expanded the public's knowledge of how engineers make a difference
- Increased visibility for engineering and SCI engineering experiences
- Brought engineering to life for children, educators, and parents
- Provided opportunities for women and students of color to connect with diverse voices in engineering
- Connected Next Generation Science Standards to experiences for better understanding of engineering
- Communicated a clear alignment between engineering with creativity and compassion

Transportation Institute: Summer Workshop for High School Educators

The Summer Workshop for High School Educators is being sponsored by the MTC and the Iowa DOT for its third summer in 2017. The program gives teachers from across Iowa the opportunity to explore a range of educational activities relating to transportation and suitable for use in high school physics curricula and afterschool STEM programs. The teachers will gain a better understanding of transportation concepts associated with physics, supplemented with presentations from Iowa DOT and ISU staff and faculty. All of the 2016 participants received a \$500 grant to help bring transportation concepts into their classrooms. One teacher purchased a dynamics system for experiments with motion, collisions, velocity, and acceleration. Another bought a radio-controlled car to help students better understand the laws of motion and engineering mechanics.

"The workshop was fantastic! I'm able to teach this year with confidence and the students are much more engaged using the modeling method. The grant was used to add another lab station consisting of a dynamics cart and track, pulleys, springs, and photogates. These are a great addition, allowing for smaller lab groups, giving each student greater access to the lab equipment."

—Patty Green, Wahlert Catholic High School, Dubuque, Iowa



2016 Transportation Institute teachers brainstorming

High Schoolers Do Research in Young Engineers and Scientists Program

The MTC and ISU's Center for Biorenewable Chemicals will collaborate again in summer 2017 on the YES (Young Engineers and Scientists) program. In this partnership with Iowa high schools, the program offers six-week research internships to participating students who can work up to 40 hours a week under the supervision of a mentor. At the session's end, each student will present a poster outlining his or her research. Four high school students have been selected for placement with ISU's Institute for Transportation for summer 2017. Also, a 2016 YES program participant, Logan Peters, has continued to work at InTrans as a student employee. He is the second program participant who has been asked to stay on with InTrans following the completion of the YES program.

Three STEM Educators in Research Experience for Teachers program

For the fourth year, the MTC will participate in the Research for Teachers program offered in summer 2017 by ISU's Center for Biorenewable Chemicals and funded by the National Science Foundation. Three Iowa public high school math and science teachers worked on active research projects while building their science and engineering knowledge base for use in their classrooms. MTC and ISU Institute for Transportation Director Shauna Hallmark, MTC affiliate researcher Basak Aldemir-Bektas, and ISU Bridge Engineering Center Director Brent Phares will host the teachers for six weeks at InTrans.

Teaching in the Fast Lane: Summer Workshop for Elementary School Teachers

Twenty-four elementary teachers have been selected to participate in the MTC-sponsored Teaching in the Fast Lane: Summer Workshop for Elementary School Teachers from July 10–14, 2017. The workshop, now in its third year, introduces teachers to engineering concepts and engineering professions with the goal of equipping them to enrich their classrooms and raise awareness and enthusiasm among young students about engineering. Hands-on activities come from the AASHTO Roadways in Developing Elementary Students (AASHTO RIDES) kit. Each participant will receive a modified version of the AASHTO RIDES kit, which includes ready-to-use supplies for implementation of newly learned activities. Each kit includes items such as a set of engineering process flash cards, Hot Wheels cars, spring scales, stopwatches, and other items.



2016 Teaching in the Fast Lane teachers on ISU campus

GO! Further: Workshop for High School Students Develops Leadership Skills

The MTC will offer two weeklong GO! Further workshop sessions at ISU during summer 2017 in partnership with the Office of Precollegiate Program for Talented and Gifted (OPPTAG) at ISU. Each session provides a leadership and learning experience for high school students. Students learn about the world of engineering and take part in hands-on activities to develop leadership and teamwork skills. To ensure diversity, the MTC is collaborating with ISU's Science Bound program, which partners with schools to increase the number of ethnically diverse Iowa students pursuing STEM careers and with ISU's Program for Women in Science and Engineering (WiSE) to appeal to young women across Iowa.



2016 GO! Further students visit InTrans REACTOR Lab

Science Bound Saturday

As a part of Science Bound, a weekend event hosted annually at ISU, Bob Steffes, a research engineer for the Institute for Transportation's National Concrete Pavement Technology Center, hosted an activity for a visiting 9th grade student group.

His "Introduction to Concrete" activity included a tour of the PCC Pavement and Materials Research Laboratory, which is located on the ISU campus.

"I feel it went over very well, and I hope through these efforts the ISU InTrans PCC Lab left a memorable impression, in concrete, on our young future leaders."
—Bob Steffes, PCC Research Engineer



9th grade students in ISU's PCC Lab

Go! Online Magazine

Go! online magazine has become the MTC's premier tool for informing young people about careers in transportation. Through articles, activities, and resources, Go! provides information about a variety of transportation-related careers and academic programs. Go! is financially and academically

supported by the MTC, initiative partners at MTC consortium universities, ISU's Department of World Languages and Cultures, Iowa DOT, OCTA Youth Programs (in Orange County, California), and representatives from OnlineMaster-Programs.org, AffordableCollegeFoundation.org, College-affordabilityguide.org., OnlineColleges.net, and ChickTech, a national nonprofit whose mission is to retain women in the technology workforce. *Go!* also partners with the accelerated bridge construction-themed UTC at Florida International University, which provides one ABC-related article every quarter.

During this reporting period,

- At least three new articles were published, disseminated, and marketed to potential users monthly.
- *Go!* reached 1,379 teachers and transportation professionals monthly.
- The web comic “Dot’s Adventures with Transportation,” written by *Go!* program coordinator Brandy Haenlein and illustrated by Stephen Post, was routinely published, often monthly.
- On social media, the *Go!* Facebook page has 309 followers and the Twitter page has tweeted 1,303 times and has 354 followers.
- The *Go!* website was accessed by 3,732 unique users who viewed 9,819 pages.

E. Center Management

Quarterly Partner Meetings

MTC leadership at ISU and its partner institutions have regular teleconference team meetings. The goal is to identify commonalities among institutions, leverage funding for similar activities, and identify opportunities to collaborate. These conversations have been productive.

New Website to Better Showcase MTC’s Impacts/Products

A new, mobile-friendly MTC website with improved user features is under development by ISU’s Institute for Transportation. The rebuilt site will enable the MTC to better highlight its products, programs, and information to its diverse audiences. The planning phase is under way, and the website will be constructed in the latter half of 2017. The site is expected to be fully functional by early 2018.

Efforts to showcase MTC products on the current MTC website continue, with an emphasis to reflect research progress, educational and workforce development activities, and outreach initiatives. Some examples of new or updated content in the current reporting period include the following:

- New editions of *Go!* e-magazine, which feature Dot’s Adventures in Transportation comic
- Latest issues of MTC/InTrans Enroute e-news
- News stories on MTC summer programs/workshops and Central Iowa Bridge-Building Challenge
- Feature story on 2016 MTC student of the year
- Promotional information for the 2017 Mid-Continent Transportation Research Symposium, August 16–17, 2017

October	
Articles	‘Green’ transportation innovations: Solar bike paths ‘Green’ transportation innovations: Autonomous pods ‘Green’ transportation innovations: ‘NextGen’ air traffic control
ABC-UTC article	The ABC advantage: Time, safety, and quality make ABC a bridge construction hero
Blog	<i>Doctor Who’s ‘Gridlock’: A vision of the future of transportation</i>
Dot comic strip	Claymation
November	
Articles	Steampunk transportation: The Victorian era and the Steampunk craze Steampunk transportation: A pirate’s life for me Steampunk transportation: Dystopian features
Review	<i>Wild Wild West</i> review: A Steampunk Western
Dot comic strip	All about Trains!
December	
Articles	Breaking Point: Traversing a winter wonderland Breaking Point: Transportation and tornadoes Breaking Point: Planning a hurricane exodus
Interview	5 Questions with...an air traffic controller
Dot comic strip	The Career Fair
January	
Articles	Before we were here: BCE transportation Before we were here: CE transportation Before we were here: The New World
February	
Articles	Final frontiers: Space odyssey Final frontiers: Under the sea Final frontiers: The Oregon Trail
March	
Articles	Driving the future: What is virtual reality Driving the future: The pros of virtual reality Driving the future: The cons of virtual reality



A panel from *Dot’s Adventures with Transportation*

- Transportation Safety Webinar Series Moving Research into Implementation
- Promotional information for the 2017 Study Abroad to Great Britain, May 8–20, 2017
- Tom Maze Transportation Seminars for students, named after the MTC founder

How were results disseminated?

In general, information about the MTC and its activities, particularly for the purposes of enhancing public understanding, increasing interest in transportation careers, and advancing technology transfer, was disseminated via the following channels:

- *Go!* online magazine for teens
- MTC e-newsletter/InTrans Enroute Newsletter
- Website
- Research reports
- Most of the activities described under Outreach/Technology Transfer (beginning on page 7) and Workforce Development (beginning on page 10)

Detailed, itemized information about many of the above activities is provided in the annual performance metrics report to OST-R, U.S. DOT.

What activities are planned for the next reporting period?

The following activities are planned for the next reporting period:

Center Management

- Continue showcasing MTC products/activities

Research

- Continue to monitor progress of the research program

Education

- Hold the summer 2017 Study Abroad program to Great Britain (May 2017)
- Track Transportation Scholar participation in required and recommended activities

Workforce Development/Diversity

- Continue producing content for *Go!* magazine
- Hold summer 2017 workforce development activities: Research Experience for Teachers (RET), Young Engineers & Scientists (YES), Transportation Institute, GO! Further, Teaching in the Fast Lane, etc.

Outreach

- Hold webinar to highlight the impact of bridge research project results (July 2017)
- Hold Mid-Continent Transportation Research Symposium (August 2017)
- Host Ultra-High Performance Concrete (UHPC) for Bridge Applications Workshop (May 2017)

2. Products

In addition to products and activities discussed in the previous section, the MTC has generated and/or funded the following products:

Presentations (in chronological order)

- Hu - “Data-Driven Prognostics of Li-Ion Rechargeable Battery using Bilinear Kernel Regression,” Annual Conference of the Prognostics and Health Management Society, Denver, Colorado, October 3–6, 2016
- Hamzeie - “The Interrelationship between Speed Limits, Geometry, and Driver Behavior,” Annual MOVITE/OTEA Meeting, Oklahoma City, Oklahoma, October 5–7, 2016
- Boeckman - “Implementation Evaluation of Rustic Road Geosynthetic Reinforced Soil Integrated Bridge System,” Deep Foundations Institute, New York, New York, October 12–14, 2016
- Hamzeie - “The Interrelationship between Speed Limits, Geometry, and Driver Behavior,” Mid-Continent Transportation Research Symposium, Madison, Wisconsin, October 24–25, 2016
- Campbell - “Strategic Design for Delivery with Linked Transportation Assets: Trucks and Drones,” INFORMS Annual Meeting, Nashville, Tennessee, November 13–16, 2016
- Zu, Dai, and Dong - “Convex Optimization for Energy-Efficient Traffic Control,” 55th IEEE Conference on Decision and Control, Las Vegas, Nevada, December 12–14, 2016
- Jeong - “Guide to Life-cycle Data and Information Sharing Workflow for Transportation Assets One,” Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Alipour - “Climate Change Impact on Highway Bridges: Flood-Induced Bridge Scour,” Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Edara - “Safety Effect of Diverging Diamond Interchanges on Adjacent Roadway Facilities,” Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Sun - “Design Guidance for J-Turns on Rural High-Speed Expressways,” Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Sun - “Driving Simulator Study of J-Turn Acceleration/Deceleration Lane and U-Turn Spacing Configurations,” Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Brown - “Development of a Safety Assessment Tool for Work Zones,” Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Brown - “Investigation of Alternative Bicycle Pavement Markings Using a Bicycle Simulator,” Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017

- Hamzeie, Roy, and Thompson - "State-Level Comparison of Fatality Data in Consideration of Marijuana Laws," Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Rista - "Examining the Impact of Median Turnaround Type and Spatial Proximity Relative to Access Points on Crash Type and Frequency," Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Rista - "Work Zone Safety Performance: Comparison of Alternative Traffic Control Strategies," Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Thompson - "Development of an Economic Framework for the Proactive Identification of Traffic Safety Countermeasures," Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017
- Ashlock - "Update on ISU Drilled Shaft Calibration Study," 41st Annual ASCE Iowa Section Geotechnical Conference, Ames, Iowa, March 8–9, 2017
- Goswamy, Morshedi Shahrebabaki, and Parvin - "Comparison of Calibrated Highway Safety Manual Model and Jurisdiction-Specific Safety Performance Functions for Rural Two-Lane Highways"
- Goswamy and Morshedi Shahrebabaki - "Identification of Risk Factors Affecting Crash Frequency and Severity on Horizontal Curves Along High-Speed Divided Highways"
- Hu - "An Investigation of Taxi Travel Patterns and Implications on the Feasibility of Electric Taxis"
- Huang - "Leading Pedestrian Interval Implementation as a Marginal Costs and Benefits Problem"
- Huang and Lu - "Assessing Urban Freeway Work Zone Capacity Based on Logistic Modeling of Speed-Density Relationship"
- Kirsch - "Factors Affecting Driver Yielding Compliance at Uncontrolled Midblock Crosswalks on Low-Speed Roadways"
- Liu - "Macroscopic Evaluation of Advance Video Detectors for Adaptive Control Input"
- Liu - "Effect of Narrower Lane Width on Traffic Operations for Urban Midblock Segments"
- Nightingale and Parvin - "Skew Angle Influencing Crash Frequency at High-Speed Rural Intersections"
- Wang - "Analyzing and Improving the Performance of Dynamic Message Sign Reporting Work Zone Related Congestion"
- Wang - "Big-Data-Driven Traffic Surveillance System for Work Zone Monitoring and Decision Supporting"
- Alaa Elsis - "Evaluation of Finger Plate and Flat Plate Connection Design"

Student Poster Presentations

Mid-Continent Transportation Research Symposium, Madison, Wisconsin, October 24–25, 2016

- Barrette - "Safety Impacts of Access Point Proximity to Freeway Ramps"
- Goswamy - "Identification of Risk Factors for Horizontal Curves in Iowa"
- Hamzeie - "Assessing the Effect of State-Specific Laws on Impaired Driving and Crash Severities"
- Kirsch - "Development of a Highway Safety Improvement Program Framework"
- Nightingale - "An Investigation on the Relationship between Intersection Skewness and Crash"
- Thapu - "Spatial Distribution of Distracted Driving Crashes in Des Moines MPO"
- Thompson - "Safety Effects of Access Point Density on Developing Corridors"
- Thompson - "Safety Performance of High-Speed Highways with Differential Speed Limits for SPFs for Urban and Suburban Arterials in Michigan"
- Vafaei - "Safety and Operations Impacts of Rumble Strips Installation in Narrow Pavements"

Transportation Research Board Annual Meeting, Washington, DC, January 8–12, 2017

- Abatan - "U.S. County-Level Cross-Sectional Study of Pedestrian and Bicyclist Crashes, Population Characteristics, and Mode of Commuting"
- Bou Saab - "Systemic Safety Risk Factor Evaluation Summary and Risk Factor Focus Group Results"
- Chakraborty - "Outlier Mining-Based Traffic Incident Detection Using Big Data Analytics"
- Hamzeie and Vafaei - "A Short-Term Evaluation of the Transition from a Differential to Uniform Speed Limit"

Articles and Papers

- AASHTO Brochures - The American Association of State Highway Transportation Officials included the MTC project "Evaluation of Finger Plate and Flat Plate Connection Design" in the 2016 High Value Research Project section of their supplemental brochures.
- Edara - "System-wide Safety Treatments and Design Guidance for J-Turns," report featured in *TRB E-News*.
- Hu, Hong, Li, Jeong, and Tenold - "On-Board Analysis of Degradation Mechanisms of Lithium-Ion Battery using Differential Voltage Analysis," submitted to *Applied Energy* (2017).
- Hubbard, Bavlik, Hegde, and Hu - "Online Prognostics of Lithium-Ion Battery using Sparse Kernel Regression," preparing for submittal to *Applied Energy* (2017).
- Boeckmann - "Design of Maintainable Drains for Earth Retaining Structures," Deep Foundations Institute (2016).
- Shafei and Smadi - "Management of Bridges under Aging Mechanisms and Extreme Events: A Risk-Based Approach," *Transportation Research Record: Journal of the Transportation Research Board* (2016).
- Dissanayake - "Crash Modification Factors for Lane Departure Countermeasures in Kansas," Proceedings of the Transportation Research Board Annual Meeting (2017).
- Ashlock - "Cost-Effective Field Test Methods for LRFD"

Resistance Factors of Drilled Shafts,” Proceedings of the Transportation Research Board Annual Meeting (2017).

- ISU News Service - Article about ISU researchers entitled “Iowa State engineers dive into big data to develop better system to manage traffic incidents” was published on ISU News Service website (2017).

Other

- Rasheed - Development and distribution of two software packages for bridges.
- Safety Workshops - Workshops were held at six locations in Iowa enabling law enforcement and engineering professionals to learn about ways to improve safety on local roads and about safety project funding programs and research, ISU researchers helped conduct these workshops.
- Dong - A database of individual vehicles’ fuel consumption, GPS location and speeds.
- Nemmers- Featured guest on the Kansas City Public radio station KCUR, discussing impacts of I-70 on Kansas and Missouri (2017).
- Keren - Application for visualization of road infrastructure in full-scale 3D mode
- October MTC Quarterly Newsletter - The October 2016 edition of the newsletter featured all MTC programs.
- InTrans En Route – The newsletter, distributed March 2017, highlighted MTC research.

3. Participants and Collaborating Organizations

The MTC utilizes many colleges, departments, and centers at ISU as internal partners: Civil, Construction, and Environmental Engineering; National Concrete Pavement Technology Center; Center for Transportation Research and Education; Bridge Engineering Center; National Center for Wood Transportation Structures; Center for Earthworks Engineering Research; Engineering Research Institute; Aerospace Engineering; Center for Weather Impacts on Mobility and Safety; Electrical and Computer Engineering; Business and Finance; Statistics; Industrial and Manufacturing Systems Engineering; Chemical and Biological Engineering; Center for Biorenewable Chemicals; Food Science and Human Nutrition; Supply Chain and Information Systems; Landscape Design; Agricultural and Biosystems Engineering; Transportation Services; and the Virtual Reality Application Center.

Other collaborative efforts with external entities (other than collaborations among MTC partner universities) are summarized in the following table:

Summary of Collaborative Activities

External Partners/ Collaborators	Partner Type	State/Country	Financial Support	In-Kind Contributor	Research Collabo- rator	Facilities	Personnel Exchange	Materials	Data
Ann L. Schneider & Associates, LLC	Industry	Missouri			X				
Argo Genesis,	Industry	USA	X						
Arizona State University	University	Arizona			X				
Asphalt Paving Association of Iowa	Industry	Iowa			X				
BASF	Industry	Iowa						X	
Caterpillar	Industry	USA	X						
City of Belton	Government	Missouri			X				
City of Chesterfield	Government	Missouri			X				
City of Columbia	Government	Missouri	X		X				
City of Grandview	Government	Missouri			X				
City of Jefferson City	Government	Missouri			X				
Collins Engineering	Industry	Missouri			X				
Consulting Engineers Association	Industry	Missouri			X			X	
Costello & Associates, Inc.	Industry	Missouri			X				
Creative Visions Human Development Institute	University	Iowa			X				
Embry-Riddle Aeronautical University	University	Florida			X				
HDR Consultants	Industry	Missouri			X				
HR Green	Industry	Iowa			X				
Illinois Department of Transportation	Government	Illinois			X				
Illinois State Highway Patrol	Government	Illinois			X				X
International Association of Transportation Regulators	Non Profit	Canada			X				
Iowa Department of Transportation	Government	Iowa	X					X	X
Iowa Counties (Various)	Government	Iowa			X				
Iowa Highway Research Board	Government	Iowa	X		X				
Jiangsu Research Institute of Building Science Company	Industry	China			X				
Kansas Department of Transportation	Government	Kansas			X				X
Kansas State Highway Patrol	Government	Kansas							X
Lambert Airport	Industry	Missouri		X			X		X
Liberal High School	School	Missouri					X		

External Partners/ Collaborators	Partner Type	State/Country	Financial Support	In-Kind Contributor	Research Collabo- rator	Facilities	Personnel Exchange	Materials	Data
Metropolitan Taxi Commission	Industry	Missouri	X	X					
Mid-American Air Museum Foundation	Non Profit	Kansas				X			
Midwest Transportation Workforce Center (UTC)	University	Wisconsin			X				
Missouri Counties (Various)	Government	Missouri			X				
Missouri Department of Transportation	Government	Missouri	X						X
Missouri State Highway Patrol	Government	Missouri			X				X
NASA Ames Research Center	Government	California			X				
National Advanced Driving Simulator	University	Iowa			X				
National Ilan University	University	Taiwan			X				
Nebraska Department of Roads	Government	Nebraska							X
Nebraska State Patrol	Government	Nebraska							X
Norwich University	University	Vermont			X				
Road Industry Safety Consensus	Committee	Iowa			X				
Science Center of Iowa	Non Profit	Iowa			X				
Shrive Hattery	Industry	Iowa			X				
Skyline Steel	Industry	Missouri			X			X	
St. Louis Board of Aldermen	Government	Missouri					X		
St. Louis Street Department	Government	Missouri			X				
Syracuse University	University	New York			X				
Terminal Railway Association of St. Louis	Industry	Missouri	X	X					
The Airport Ground Transportation Association	Industry	Missouri			X				
The Taxi, Limousine, and Paratransit Association	Industry	Missouri			X				
Transdev On Demand, Inc	Industry	Missouri			X				
Trinity Products	Industry	Missouri						X	
U.S. Army Corps of Engineers	Government	USA			X				
Union Pacific Railroad	Industry	Missouri			X				
University of Missouri Extension	University	Missouri			X				
University of Iowa	University	Iowa			X				

External Partners/ Collaborators	Partner Type	State/Country	Financial Support	In-Kind Contributor	Research Collabo- rator	Facilities	Personnel Exchange	Materials	Data
University of Maryland	University	Maryland			X				
University of Wisconsin	University	Wisconsin			X				

4. Impacts

What is the impact on the development of the principal discipline(s) of the program?

The results of MTC-sponsored research conducted by faculty in transportation-related disciplines at all partner institutions fundamentally affect the understanding, teaching, and ultimately the state of the practice related to enhancing infrastructure condition, safety, and project delivery. As a consequence, the state of transportation infrastructure and operations is enhanced.

What is the impact on other disciplines?

As stated in Section 3, Collaborating Organizations, the MTC regularly partners with faculty in other disciplines and related organizations, such as Electrical and Computer Engineering; Business and Finance; Statistics; Industrial and Manufacturing Systems Engineering; Chemical and Biological Engineering; Center for Biorenewable Chemicals; Food Science and Human Nutrition; Supply Chain and Information Systems; Landscape Design; Agricultural and Biosystems Engineering; and the Virtual Reality Application Center.

These partnering activities in research and beyond serve to broaden the understanding of these disciplines to include transportation-related issues, enhancing a multidisciplinary approach to transportation-related problem solving.

What is the impact on transportation workforce development?

Although long-term impacts of the MTC's workforce development activities are difficult to quantify, a direct result of these activities is that hundreds of public school students are now being exposed to information about transportation-related careers and encouraged to pursue studies in disciplines that will help them succeed in such careers. In addition, university students pursuing transportation-related programs of study are being reinforced and challenged to higher achievements in such pursuits. For example, students who will be participating in the Study Abroad in Great Britain in summer 2017 will broaden their understanding of the complexities of transportation infrastructure construction and operations outside the US to an extent that wouldn't have been possible without the MTC sponsorship.

Some of the specific numbers include the following:

- Over 1,000 K–12 teachers were passively reached through Go!
- 461 K–12 students actively participated in targeted activities
- The MTC is working with the regional transportation workforce center to coordinate workforce development activities
- 48 students are participating in the MTC Transportation Scholars Program

- About 57 students participated in 10 spring semester seminar activities/presentations
- 25 students are planning to attend the Study Abroad in Great Britain
- MTC supports various activities for transportation student organizations

What is the impact on physical, institutional, and information resources at the partner institutions?

See the lists in Section 2, Products.

What is the impact on technology transfer?

Through direct MTC sponsorship and management of workshops and other events, approximately 600 people received face-to-face training during the reporting period. See the complete discussion of Outreach/Technology Transfer (page 7) in Section 1, Accomplishments, and the lists in Section 2, Products (page 14). The MTC is helping support the 2017 Mid-Continent Research Symposium, to be held August 16–17 in Ames, Iowa, and sponsored by ISU's Institute for Transportation and the Iowa Department of Transportation.

A research brief on a new bridge structural health monitoring system has been posted on the MTC website and a webinar on the topic is scheduled at noon CDT on July 19, 2017. The brief, titled "Bridge Structural Health Monitoring System Can Provide Immediate and Accessible Data," is the third in a series of MTC one-page documents that highlight research results. The previous two briefs are "Safety Benefits of Safety Edge" and "Evaluation of Low-Cost Traffic Calming."

What is the impact on society beyond science and technology?

MTC research has led to information that agencies utilize to improve traffic safety, reduce impact of construction, and reduce costs for agencies. Currently we are working on developing information that will allow us to quantify these impacts.

5. Changes/Problems

Nothing to report.

6. Special Reporting Requirements

Nothing to report.