

# **iMPact**

2016 Mountain-Plains Consortium  
Annual  
Highlights

# INTRODUCTION

The Mountain-Plains Consortium (MPC) is a competitively selected University Transportation Center, funded by the U.S. Department of Transportation to serve Region 8 – the Upper Great Plains and the Intermountain West. MPC, through the efforts of its faculty and staff, strives to be a leader in transportation by promoting its critical importance to the nation's infrastructure, energy development, and safety through research, interdisciplinary education, workforce development, and technology transfer while serving the unique and critical needs of the Mountain-Plains Region.

Participating Universities include:

- [Colorado State University](#)
- [North Dakota State University](#)
- [South Dakota State University](#)
- [University of Colorado Denver](#)
- [University of Denver](#)
- [University of Utah](#)
- [University of Wyoming](#)
- [Utah State University](#)

## Preserving the Transportation System

Until 2021, the MPC will receive about \$2.5 million per year under the U.S. Department of Transportation's [University Transportation Centers](#) (UTC) Program. MPC's work focuses on preserving the existing transportation system. The MPC, led by the Upper Great Plains Transportation Institute at North Dakota State University, has won each funding in each UTC competition since the program was established in 1988. MPC was one of 35 grants awarded in the competition.

"This funding is critical to continuing our work on infrastructure preservation," noted MPC director Denver Tolliver. "Finding innovative ways to monitor, maintain, repair and enhance our existing infrastructure is essential to making the most of investments in transportation infrastructure and assuring the mobility of people and goods in the mountain-plains region and beyond."

In addition to research, the collaborating universities of the MPC will continue to educate the transportation professionals of tomorrow and to assist in workforce development to meet the needs of today's transportation industry.

# **iMPaCt** *by the Numbers*

<b>30</b>	Undergraduate courses
<b>83</b>	Graduate courses
<b>17</b>	Master's level programs
<b>16</b>	Doctoral level programs
<b>16</b>	Undergraduate students participating in transportation research
<b>167</b>	Graduate students participating in transportation research
<b>18</b>	Master's students earned degrees
<b>7</b>	Doctoral students earned degrees
<b>65</b>	Research Projects
<b>162</b>	Peer-reviewed journal articles and conference papers presented by faculty or students
<b>35</b>	MPC-supported conferences and workshops
<b>1,097</b>	Number of transportation professionals participating in those events
<b>\$7,717,600</b>	Dollar value of applied research projects

# iMPaCt *on Students*



## Holly Lloyd | 2016 Student of the Year

Holly Lloyd, a December 2016 graduate of Utah State University's master's program in civil engineering, was named the 2017 Student of the Year for USDOT's Region 8. Lloyd's master's project involved the analysis of the safety effectiveness of the diverging diamond interchanges in Utah. Her advisor was MPC researcher Ziqi Song and her work is part of MPC Project 480.

Lloyd grew up in Roy, Utah, and attended Weber State University where she earned her bachelor's degree in business administration with an emphasis in supply chain management. After working in the private sector, she decided to continue her education and pursue a master's degree in civil engineering with an emphasis on transportation.

The diverging diamond interchange is a possible solution to problematic interchange locations because it can accommodate higher and unbalanced traffic flows. The analysis results demonstrated statistically significant decreases in crashes at most of the locations studied. This analysis can be used by government agencies and other transportation engineering professionals considering the implementation of diverging diamond interchanges.

Lloyd also won the ITE Intermountain Section Student Paper competition and presented her research at the ITE Intermountain Section annual conference.



# MPC student selected for health research program



Bakare

Bukola Bakare, an MPC doctoral student at North Dakota State University, is among 40 graduate students from across the country selected to participate in the Robert Wood Johnson Foundation's new Health Policy Research Scholars program. Bakare, a doctoral student in the interdisciplinary Transportation and Logistics Program at NDSU, will conduct research at the Upper Great Plains Transportation Institute into the intersection of population health and transportation and logistics issues. Her goal is to explore ways to make health care better and more equitable.

# NDSU students present to Midwest Academy of Management



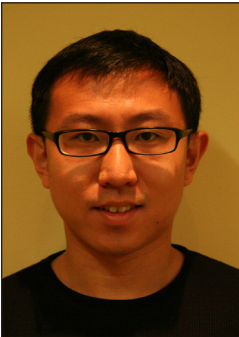
Xu

NDSU transportation and logistics doctoral students Yuan Xu and Mingwei Guo presented papers at the 2016 Midwest Academy of Management annual meeting, Oct. 6-8 in Fargo. The professional organization is a forum for the latest management theory and research by members.

The NDSU College of Business was a leading sponsor of this year's conference. The conference features a wide range of work in research, teaching and practice that explores the issues of engaging business with academia, using connections as a means to create value and managing talent and transitions.

Xu presented "A system dynamics model for energy saving in US food industry." The study evaluated policy alternatives for reducing food-related energy consumption. In the research, a system dynamics model was built to dynamically model the problem for the U.S. food system. Policy options of

reducing waste percentage and improving energy productivity in industrial processing are incorporated for building the energy use mitigation scenarios. By implementing the integrated mitigation scenarios, the model predicts that a 9.43 percent reduction in total food system energy consumption can be attained by 2030.



Guo

Guo presented "Brief research on global third party logistics and consolidation for e-commerce retailers using simulation." Based on recent developments and the practices of global retailers and manufacturers, the paper provides a brief analysis of global third-party logistics and formulates a consolidation model for third party logistics service providers.

## University of Utah ITE Student Chapter earns award

The University of Utah Institute of Transportation Engineers (ITE) Student Chapter received the [Student Chapter Award Honorable Mention](#) at the [Western ITE Region meeting](#) July 12 in Albuquerque, NM. A total of 29 student chapters competed for the award and for the second year in a row, University of Utah's chapter earned the runner-up title. The award encourages student chapters to promote the advancement of transportation and traffic engineering profession by fostering the close association of students with the transportation and traffic engineering profession and to acquaint chapter members with topics of interest in the field.



## Utah State University Student Wins ITE Paper Contest

Utah State University student Holly Lloyd recently won first place in the Institute of Transportation Engineers Intermountain Section Student Paper Competition. The competition was part of the annual section conference in Jackson Hole, WY, in May.

The paper featured her master's project focusing on the safety effectiveness of diverging diamond interchanges in Utah. Her advisor is MPC researcher Dr. Ziqi Song and the work was part of MPC project 480. The diverging diamond interchange is a possible solution to problematic interchange locations because it can accommodate higher and unbalanced traffic flows. The analysis results demonstrated statistically significant decreases in crashes at most of the locations studied. This analysis can be used by government agencies and other transportation engineering professionals considering the implementation of diverging diamond interchanges.

Lloyd is a native of Roy, UT, and earned a bachelor's in business administration at Weber State University. After working in the private sector, she decided to pursue an M.S. in civil engineering emphasizing in transportation at Utah State University.

## University of Utah Students Picked for Exclusive Leadership Development Program



Tasic

MPC students, both from the [University of Utah](#), were chosen to be part of the [Eno Future Leaders Development Conference](#) in Washington, D.C., in June.

Ivana Tasic, a Ph.D. student in civil and environmental engineering at the University of Utah, is the winner of the Charles William Koch Award which recognizes exceptional academic achievement and leadership qualities in a student specializing in transportation operations. Tasic's academic program and research focus is on urban multimodal transportation. She is a member of the American Society of Civil Engineers, Institute of Transportation Engineer Transportation Research Board and the Women's Transportation Seminar's "Transportation YOU" program, which supports young women in transportation. Tasic also served as a Transportation Research Board (TRB) ambassador for the 2014 TRB Annual meeting and is involved with four TRB standing committees as a paper reviewer. Her research includes quantifying the traffic impacts of Traffic Oriented development, Crash Modification Factors for Intersections and a Light Rail Transit Analysis in Salt Lake City. Tasic holds a diploma in traffic and transport engineering from the University of Belgrade, Serbia, and a master's degree from the University of Utah.



Wood

Jonathan Wood, an M.S. and B.S. graduate in civil and environmental engineering at the University of Utah and MPC Student of the Year in 2013, is the winner of the Dr. Thomas D. Larson Fellowship, which recognizes an individual who is enrolled in a Ph.D. program in transportation and reflects Dr. Larson's commitment to improving the transportation field. He is currently a graduate student instructor in civil engineering at Penn State University. This year he was named Student of the Year from the Mid-Atlantic Universities Transportation Center. He received the Dwight D. Eisenhower Fellowship from the Federal Highway Administration and a Distinguished Teaching Fellowship from the Penn State College of Engineering. He is a member of the Institute of Transportation Engineers, the American Society of Civil

Engineers and the Associated General Contractors. His research interests include transportation safety, highway and street design, roadside design, econometric modeling, reliability theory and optimization applications.

Tasic and Wood were among 20 of the nation's top graduate students in transportation who received a first-hand look at how national transportation policies are developed. Students selected as "Eno Fellows" come to Washington, DC, for a week in the spring of meetings with federal officials and leaders of business and non-profit organizations. Nominees demonstrate leadership ability and the potential to assume a senior role in a transportation-related organization in the future.

# iMPaCt *through Education*

MPC faculty members taught 30 undergraduate courses and 83 graduate courses last year at participating universities. Students (16 undergraduate and 167 graduate) were also involved in MPC research projects. MPC funds also support 17 master's level degree programs and 16 doctoral programs. MPC's educational plan is consistent with national goals to:

- Introduce transportation concepts in elementary and secondary education
- Provide vocational and technical training
- Build transportation degree programs that are international and multidisciplinary
- Provide mid-career transportation training

To accomplish these goals, MPC universities incorporate new technology and transportation concepts into programs and coursework to provide tomorrow's transportation professionals key conceptual and practical knowledge. Programs and courses are increasingly offered online to make them more accessible to those already employed or are looking for mid-career training. Students involved in MPC research provide valuable insight and expertise while gaining experience and exposure to real-world transportation issues.

For more information on educational programs offered by MPC cooperators, visit <http://www.mountain-plains.org/education/>

## MPC supports transportation scholarships at NDSU

Four North Dakota State University undergraduate students were recently awarded \$1,500 scholarships funded by the MPC. Agribusiness students Brooks Larson and Jordan Alvin Rolstad received the [Paul E.R. Abrahamson Transportation Scholarship](#). Larson is from Cando, ND. Rolstad is from Sisseton, SD. The Scholarship recognizes outstanding students with an interest in the transportation and logistics of agricultural products.



Larson



Rolstad



Renner



Vanderheiden

Nathan Renner and Jennifer Vanderheiden are seniors in civil engineering and received the [Transportation Engineering Scholarship](#). Renner is from Audubon, MN. Vanderheiden is from St. Michael, MN. Both students are student design assistants with the Upper Great Plains Transportation Institute's Department of Transportation Support Center.



## Happy campers in 2016 as MPC reaches secondary school students



### Students enter bridge design/build competition at SDSU

In June, 36 local middle and high school students participated in the week-long Youth Engineering Adventure (YEA) Camp at South Dakota State University. Bridge engineering was the focus of one of the camp's activities. In a hands-on exercise, participants learned about different bridge systems and how they function by following instructions to construct different types of bridges using index cards and common craft/office supplies. Bridges were tested with weights to compare how the bridges performed.

In a design/build competition, student teams were given a site layout that required a bridge with two unequal spans to cover a gap with elevation and plan changes. The loading represented a pair of live loads that move across the bridge at the same time. The building materials could be purchased from the "store" for varying prices, and each team had to complete their bridge on a \$10 budget. The team that spent the least, yet still safely transported the moving loads, was named the winner. The winning bridge cost was about \$6.50.

### Ninth graders study transportation up close at University of Utah

The Civil and Environmental Engineering Department at the University of Utah hosted 23 ninth grade students interested in exploring transportation engineering for the annual National Transportation Summer Institute Camp July 11-15. Four groups of students created digital presentations covering various transportation topics. They defined transportation engineering, explained how infrastructure is built and paid for, outlined the cost of transportation infrastructure, and described new innovations and designs of traffic systems. Campers also interacted with guest speakers from Union Pacific, UTA, UDOT, and the Federal Highway Administration (FHWA). A favorite activity was visiting the UDOT Airport Hangar and driving the simulator in the Civil Engineering Traffic Lab. Students also tested the speed of cars driving around campus with radar guns and visited the UDOT Traffic Operations Center, several construction sites, and local transit facilities.



## UGPTI Activities Boost Transportation Awareness



NDSU's Upper Great Plains Transportation Institute (UGPTI) celebrated transportation in May with activities on campus and outreach to more than 250 elementary schools across North Dakota.

NDSU students Jessica Murray and Ali Rahim Taleqani were selected to win gift cards to the NDSU bookstore for displaying "Moving Forward with Transportation" bumper stickers as part of a social media contest sponsored by UGPTI.

On May 4, transportation and logistics students and student workers in the UGPTI's Department of Transportation Support Center on campus greeted visitors to the NDSU Memorial Union, handing out treats and information during dead week. The

information they provided increased awareness of the importance of transportation and prompted discussion about careers and academic opportunities in transportation.

NDSU students, faculty and staff who visited the Memorial Union during that time received the bumper stickers. Those who applied the sticker to their cars and posted a photo on Facebook or Twitter were entered into the contest.

UGPTI also mailed activity packets to 730 classrooms in more than 250 elementary schools across the state. Amanda Hlibichuck's 4th grade classroom at Lincoln Elementary School in Dickinson, ND, won a pizza party for its creativity in using the materials. "Our class celebrated transportation week by drawing transportation pictures. We also built bridges and tested how much weight they would be able to hold, Hlibichuck said.

The packet included a proclamation recognizing the importance of transportation from N.D. Governor Jack Dalrymple as well as activity sheets to help students recognize



Winning 4th grade classroom: Lincoln Elementary, Dickinson, ND  
Teacher: Amanda Hlibichuk

how important transportation is to their lives, their families and their communities. To be eligible for the pizza party contest, teachers submitted photos of their classrooms and students to UGPTI.

At NDSU, the Transportation and Logistics Program has been one of the fastest-growing graduate degree programs on campus and currently has 46 master students (all online) and 40 Ph.D. students. The Transportation Institute's Department of Transportation Support Center (DOTSC) design center puts undergraduate and graduate engineering students to work on real-world transportation designs and engineering issues. Teams of students work under the direction of NDDOT engineers to prepare plans, estimates, and studies for real-world transportation projects in North Dakota. Design Center graduates are in demand by the NDDOT, other departments of transportation, engineering consultants, and other employers.

Since 1962, Congress has designated the third week of May as National Transportation Week to increase the awareness and appreciation of the transportation industry and to celebrate the transportation professionals who keep our country on the move. NDSU celebrates transportation earlier in the month in order to do so before students leave for semester break.

## Tolliver receives Lifetime Achievement Award

MPC Director Dr. Denver Tolliver recently received the [Lifetime Achievement Award](#) from the Upper Great Plains Transportation Institute Advisory Council for his long-term achievements as an educator and researcher. He has been director of the UGPTI since 2012. Under Tolliver's leadership, the MPC has won competitive grant funding from the USDOT's University Transportation Centers Program since 1988.

Other transportation leaders honored with awards at the Oct. 5 banquet included Paul Diederich, president of Industrial Builders and past president of the Associated General

Contractors of America, and Dan Zink, vice-president for the Red River Valley & Western Railroad Company, a shortline railroad headquartered in Wahpeton, ND.



Tolliver

## Jia Joins MPC faculty at Colorado State University

Dr. [Gaofeng Jia](#) has joined the MPC faculty as an assistant professor of civil and environmental engineering at Colorado State University. He has expertise in natural hazard risk assessment and mitigation, robust analysis and design of complex engineering systems and high performance structures, risk-informed decision making, aging and deterioration of civil infrastructure, and automated condition assessment of infrastructure. Jia earned his bachelor's degree in civil engineering and master's degree in disaster prevention and mitigation from Beijing Jiaotong University in China. He earned his PhD degree in civil engineering from the University of Notre Dame. Before joining CSU, he was a postdoctoral research associate at the University of Notre Dame and at the University of Illinois at Urbana-Champaign. He received the Young Researcher Best Paper Award at the 2013 International Conference on Soft Computing Technology in Civil, Structural and Environmental Engineering and the Best Student Paper Award at the 2012 American Society of Civil Engineers Engineering Mechanics Institute/Probabilistic Mechanics Conference.



Jia



## Wood and Ghabchi join MPC faculty at SDSU

Wood



The newest MPC faculty member at South Dakota State University, is a familiar name. Dr. Jonathan Wood, an assistant professor in the Department of Civil and Environmental Engineering, was MPC's 2013 Outstanding Student of the Year. He received his B.S. and M.S. degrees in civil engineering from the University of Utah and his PhD in civil engineering from the Pennsylvania State University (2016). His research interests include methods for improving the accuracy of statistical estimates and reducing biases inherent to observational studies with an emphasis on applications in transportation safety, public transportation, and human factors (e.g., driver, cyclist, and pedestrian behavior); and improving decision-making by engineers, including developing improved guidance and tools that assist engineers in making well-informed decisions that consider the effects and trade-offs to efficiency, safety, reliability, and quality of service of the transportation system.

Ghabchi



Dr. Rouzbeh Ghabchi is also an assistant professor in the Department of Civil and Environmental Engineering. He received his PhD from the University of Oklahoma and was also a post-doctoral research fellow there. His research interests include pavement engineering, innovative transportation infrastructures' materials, environmentally-friendly pavement technologies, pavement performance and asphalt materials. More specifically, his research areas include characterization and performance enhancement of asphalt mixes containing reclaimed asphalt pavement and recycled asphalt shingles, ground tire rubber, warm mix asphalt, tack coat, modified asphalt binder and asphalt binder-aggregate bonding and stripping mechanisms.

## Porter Addresses 2nd Serbian Road Congress

Porter



Dr. Richard Porter, associate professor of civil engineering at the University of Utah, was a keynote speaker in the open plenary session of the [2nd Serbian Road Congress](#) in Belgrade Serbia, June 9-10. Porter's presentation was, "Substantive Safety Analysis: Tools for Practitioners." The event is intended to encourage the exchange of experience and knowledge among regional and European road professionals. More than 300 professionals attended.

## Pantelides studies fix for earthquake-damaged bridge columns

Pantelides



Repair of damaged bridge columns following an earthquake is a good alternative to replacement. Benefits include cost savings, reduction in construction time, and decreased interruption of emergency services. Dr. Chris Pantelides, professor of civil and environmental engineering at the University of Utah has developed a [repair technique](#) that uses materials that are easy to install, including epoxy anchored headed steel bars, CFRP sheets and either nonshrink or expansive concrete. In tests, the strength and displacement capacity of damaged bridge columns was restored. The result is a cost

effective repair which could be installed within a few days. The research was supported by the MPC and the Utah, New York State and Texas Departments of Transportation. A paper on the research, "Seismic Repair of Severely Damaged Precast Reinforced Concrete Bridge Columns Connected with Grouted Splice Sleeves," was recently published by the [ACI Structural Journal](#).

## Marshall earns CU honor for teaching and creative activities

Marshall



MPC faculty member [Wesley Marshall](#), associate professor of civil engineering at University of Colorado Denver, will receive the campus-level 2016 Excellence in [Research and Creative Activities Award](#). The award recognizes University of Colorado Denver tenured and tenure-track faculty who have demonstrated exemplary research activity with significant evidence of impact in their field of work. Awards are made in each of CU Denver's schools and colleges, but one winner is selected to receive the campus-level award. Marshall will receive a recognition plaque and a \$1,000 stipend at the university's awards luncheon in September.

Marshall has expertise in transportation demand, safety, and sustainability as well as in urban design, congestion pricing, street networks, and parking. He was a 2006 recipient of the Dwight D. Eisenhower Transportation Fellowship and received the 2008 Charley V. Wootan Award for Outstanding paper in Policy and Organization from the Transportation Research Board.

## MPC researcher is CUTC president

[Jill Hough](#), associate professor of transportation, at North Dakota State University's Upper Great Plains Transportation Institute was named president of the [Council of University of Transportation Centers \(CUTC\)](#) at the group's annual meeting in June in Los Angeles. CUTC provides a forum for transportation research centers and institutes in the United States to interact collectively with government and industry. Hough is active in three university transportation centers. She is a principal investigator in the MPC and she is director of UGPTI's Small Urban and Rural Transit Center (SURTC) which is a partner with the University of South Florida's Center for Urban Transportation Research. SURTC is also a part of the Small Urban and Rural Livability Center, a collaboration with Western Transportation Institute at Montana State University. Hough servers as deputy director in that effort.



Hough

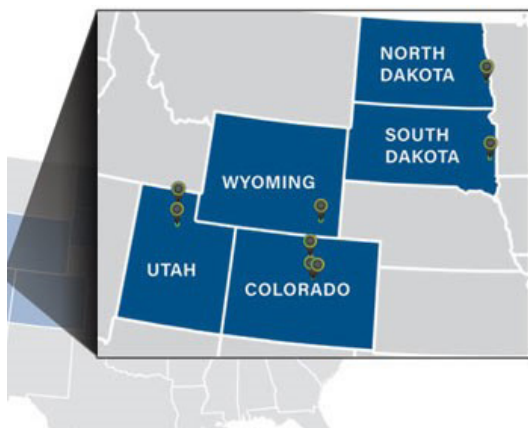
# Outreach/Workforce Development

## Technical training

MPC's technical training program is having a major impact in the region. Online modules, short courses, webinars, and on-site/videoconferencing events are reaching state and local transportation department employees and tribal transportation planners. By harnessing the capabilities of the four LTAP centers located at MPC universities and the multimedia capabilities of the Transportation Learning Network (which was founded and is partly funded by MPC) about 141 technical training events were offered in 2016 with more than 6,045 transportation professionals attending. These training modules and short courses are critical to transportation agencies that need to improve or renew the skills of engineering technicians and other frontline workers. Many MPC courses or training events result in the certification of workers. Even when certification is not required, TLN's online learning management system allows employees and employers to set learning goals and monitor progress toward these goals.

## Graduate students

Altogether, 183 undergraduate and graduate students are working on MPC research projects under the tutelage of faculty researchers. These graduate students represent the researchers and technical analysts of tomorrow. Without the MPC program and the stipend funds that it provides, these students may not be specializing in transportation; but instead would be seeking career opportunities in other fields. The MPC research program allows faculty to mentor graduate students while allowing the students to work on projects for federal and state transportation agencies, thereby gaining valuable practical experience.



## MPC website integrates more info from consortium members

The [Mountain-Plains Consortium](#) has updated the "About Us" section of its website. The clickable map is your link to key information, projects, faculty, research, publications, and resources at each of the MPC member universities. The website also integrates transportation facts about the region and about each of the states in the region.



# RESEARCH

## Weaving New Alternatives: Testing FRP Composite Waves and Helices for Reinforcing Concrete

Corrosion of steel rebar is the leading source of deterioration of concrete transportation structures. Fiber reinforced polymer composites (FRP) are potentially more durable, but their unique properties mean that simply replacing steel bar with FRP bar may not realize the full benefits of FRP.

In this study at Colorado State University, two reinforcement geometries were designed, fabricated and tested in small concrete beams. The reinforcements made use of helical and wave geometries intended to induce compression in the neighboring concrete when the FRP reinforcement experienced tension due to flexural loading. The testing compared the performance of the beams with the alternative FRP reinforcement geometries to beams with straight FRP bars of approximately equal cross-sectional area.

This project contributes research seeking the best ways to take advantage of FRP to enhance the longevity of transportation infrastructure. By exploring alternatives that are distinct from the classic straight bar used for steel reinforcement, we may find ways that take better advantage of the unique properties of FRP and reduce or eliminate the drawbacks of FRP reinforcement such as its lower bond strength and brittle nature.

Principal investigator for this project was Rebecca Atadero at Colorado State University. For more information, see report [MPC 16-304](#).

## Building Better LTAP Courses: Guidelines for Effective Evaluation

If a goal of continuing education is to help employees keep up to date with technologies and regulations, it is necessary to provide training opportunities that facilitate this. Strong course evaluation instruments ensure that training courses are meeting stated objectives and participants feel that it will help them better complete their job functions. Throughout the United States, departments of transportation spend millions of dollars each year on continuing education and professional development. Current evaluations fail to tie responses to course objectives and often do not evaluate how participants use their knowledge in the field.

This research at Utah State University outlined the scope of the current Utah LTAP evaluation process and provides recommendations for strengthening course evaluation tools and processes to better facilitate instruction to meet course objectives for participants. Principal investigator for this project was Jim Dorward at Utah State University. For more information, see report [MPC 16-305](#).



## Talk to Me: Smart Pavements and Connected Vehicles Communicate Road Condition and Maintenance Effectiveness

Raj Bridgelall, North Dakota State University researcher at the Upper Great

Plains Transportation Institute, developed an approach to enable smart pavements. Embedded sensors report parameters to determine traffic-loading characteristics, structural health, and ride quality. The technology will enable agencies to remotely monitor pavement assets comprehensively, without regularly deploying expensive field equipment and personnel.

In addition to making the sensors more rugged so that they would last throughout the asset lifecycle, this research developed a new method that extended the capability of the sensors beyond an ability to measure just pavement loading and condition parameters. Specifically, the research linked the sensor output to common roughness indices. To maintain a high accuracy of measuring numerous pavement loading and condition parameters throughout the life cycle of the pavement asset, data from connected vehicles was used to constantly calibrate the pavement sensors.

When smart cities design and construct new pavements with the sensors already embedded in the materials, those pavements will save agencies tens of billions of dollars by eliminating the need to regularly deploy expensive probing equipment and personnel.

Principal investigator for the project was Raj Bridgelall at North Dakota State University. For more information, see report [MPC 16-306](#).



## Bridge Doctors Monitor Effects of Overweight Trucks

Researchers at the University of Wyoming developed a structural health monitoring system for bridges using fiber optic gratings (fiber Bragg gratings) as strain sensors. The objectives are to provide long-term sensing of bridges that are subjected to overweight and oversize vehicles so that the accuracy of bridge rating software can be evaluated.

Instrumentation, packaging, installation techniques and data collection and storage for a structural health monitoring system were developed in the laboratory. The essential elements of the system include (a) sensor installation and protection techniques, (b) instrumentation for interrogating network, and (c) a triggering system based on RFID technology.

The sensors are shown to be effective, economical, and long-lasting components of an monitoring system for bridges. The system developed in this research includes a radio-frequency identification (RFID) triggering system that activates the monitoring system when a vehicle that has been issued a permit to be oversize or overweight approaches a bridge. Bridge response data is then automatically recorded and transmitted to a server so that post processing can be performed for comparison to bridge rating analysis software.

Principal investigator for this project was Richard J. Schmidt at the University of Wyoming. For more information, see report [MPC 16-307](#).

## Analysis of Risk Factors in Severity of Rural Truck Crashes

Trucks are a vital part of the logistics system in North Dakota. Recent energy developments have generated exponential growth in the demand for truck services. With increased density of trucks in the traffic mix, it is reasonable to expect some increase in the number of crashes.

However, analysis at the Upper Great Plains Transportation Institute at North Dakota State University shows that the crash-injury risk associated with trucks cannot be explained solely with the traffic growth. Recent crash data was analyzed to better understand characteristics and contributing factors in truck-involved crash events. Results reveal predictors associated with an increased likelihood for severe driver injury. Seat belt use was a significant predictor for severe injury likelihood in all models. Failure to stop or yield, rollover event, multiple truck involvement, curves and intersections were associated with increased likelihood for severe injury to truck drivers. Severe injury to other drivers

in truck-involved crashes was associated with alcohol or drug involvement, head-on and sideswipe collisions, rollover event, weather and distracted driving.

Understanding factors associated with increased likelihood for severe injury by driver group can encourage targeted interventions and countermeasures, which will improve safety by reducing incidence of severe injury crashes involving trucks. Insight into truck crashes may allow drivers and businesses to identify areas for safety performance improvement.

Principal investigator for this project was Kimberly Vachal at North Dakota State University. For more information, see report [MPC 16-308](#).



## Livability and Neighboring Street Networks

University of Colorado Denver researchers found that the character of nearby arterial roads influence residential livability across a number of livability measures. The work suggests that planners and engineers looking to promote residential livability need to begin taking a broader, network perspective to understanding livability.

Livable residential streets can be only part of the solution. More livable arterial roads are also required. Land-use policies, enforcement of social norms and the design of pedestrian and transit environments can be used as measures to maximize the contributions of commercial arterials to neighborhood livability.

Principal investigator for this project was Wes Marshall at the University of Colorado Denver. For more information, see report [MPC 16-309](#).

## Potential New Tools for Tracking Bridge Condition

Bridge information modeling (BIM) is software that has the potential to significantly improve the documentation of bridge inspection findings. Colorado State University researchers investigated the capabilities of several existing BIM packages to determine their applicability to the challenge of documenting bridge condition data. They found that although no package was fully ready to accept the desired damage information, Revit had the best flexibility to accommodate this alternative use. The report also suggests that enhancements to BIM software would further facilitate its use for bridge inspection documentation. This project demonstrates to agencies conducting bridge inspections the potential of BIM to allow them to take fuller advantage of visual bridge inspections.



BIM gives agencies the opportunity to document what they observe as opposed to somewhat subjective bridge inspector ratings.

Principal Investigator for this project was Rebecca Atadero at Colorado State University. For more information, see report [MPC 16-310](#).



## Researchers Find New Ways to Assess Crash Risks

This research at Colorado State University investigated interactions between traffic accidents, various driving environments and mitigation efforts such as law enforcement. A comprehensive historical data analysis of traffic accidents in Colorado was conducted. As a result, researchers developed a series of

advanced traffic accident frequency and injury severity prediction models. They also gained insights about the safety performance of highways in the state and made observations that were helpful to improving the safety prediction, management, and law enforcement of highways across the country.

Principal investigator for this project was Suren Chen at Colorado State University. For more information, see report [MPC 16-311](#).



## Can Complex Bridges Survive the Shaking

Reinforced concrete bridges with both skew and curvature are common in areas with complex terrains. These bridges are irregular and have complex geometric designs and comprehensive seismic risk studies are not always required. Researchers at Colorado State University conducted analytical fragility studies on four typical bridge designs with different geometric configurations in the mountain

West. Results show the curved and skewed geometries can considerably affect the bridge seismic fragility in a complex manner. Further seismic risk assessments of these bridges are needed in regions with low-to-moderate seismic activity. The findings will lead to improved seismic designs for curved and skewed bridges.

Principal investigator for this project was Suren Chen at Colorado State University. For more information, see report [MPC 16-312](#).



## Technology offers New Transportation Monitoring Options

This research developed an affordable framework to capture and classify hyperspectral images for transportation systems planning, analysis and performance assessments. The rapid reduction in size and cost of both unmanned aircraft systems and hyperspectral image sensors provide

new approaches to remote sensing for roadway congestion forecasting, railway condition monitoring, pipeline risk management and other applications. Researchers at the Upper Great Plains Transportation Institute at North Dakota State University prepared a detailed scenario for using the technology for rapid detection of hazardous spills, illustrating the potential for significant improvements in cost and effectiveness over existing approaches.

Principal investigator for this project was Raj Bridgelall at North Dakota State University. For more information, see report [MPC 16-313](#).

For more information on any of the accomplishments, projects or research presented in this report, please visit [www.mountain-plains.org](http://www.mountain-plains.org) or contact us at the address or phone number below.



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