U.S. Department of Transportation
Research and Innovative Technology Administration
University Transportation Center Grant Agreement

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Mod 1, 2, & 3
Mountain-Plains Consortium, North Dakota State University
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North Dakota State University
Upper Great Plains Transportation Institute
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Reporting Period End Date: September 30, 2019
Semi-Annual PPPR#12
Final

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1. Accomplishments: What was done? What was learned?

a. What are the major goals of the program?

The overall objectives are to: (1) conduct basic and applied research, the products of which are judged by peers or other experts in the field of transportation to advance the body of knowledge in transportation; (2) offer an education program in transportation that includes multidisciplinary course work and participation in research; (3) conduct workforce development activities and programs to expand the workforce of transportation professionals; and (4) provide an ongoing program of technology transfer to make transportation research results available to potential users in a form that can be readily used. Other program goals are to select projects and activities using peer review principles and procedures and client input that: (1) address the Secretary's five strategic goals, and (2) leverage UTC funds with matching funds from state and local governments and private industry. The chief operational goals are to make important contributions to research and technology transfer in key areas related to the Secretary's goals of State of Good Repair, Safety, and Economic Competiveness, Environmental Sustainability, and Livable Communities while addressing critical issues of the region and stakeholder groups.

b. What was accomplished under these goals?

i. Project Selection

Ninety research projects were selected from 2013 to present under this grant. Projects have been selected for the original grant, Modification 1, 2, and 3. The projects reflect substantial input and matching resources from state departments of transportation and MPOs in the region. Collectively, this set of projects addresses all five of the Secretary's strategic goals and several of USDOT's requested emphasis areas under State of Good Repair—e.g., (1) bridge condition monitoring, (2) locating critical infrastructure defects, (3) identifying tools to prevent and detect corrosion in transportation infrastructure, (4) analytical tools for infrastructure performance management, and (5) methods and criteria to measure performance of new materials and methods. MPC projects selected under this grant include; MPC-371,409, MPC-446 to MPC-532. A complete list of selected projects can be found in Appendix A.

ii. Educational Accomplishments

The transportation and transportation-related courses offered during this reporting period are listed in Appendix C. which is organized by major subject area. In some cases, courses with the same titles were offered at more than one MPC university.

Altogether, 147 transportation and transportation-related courses were offered this reporting period, for a total of 1033 transportation courses offered since the beginning of this grant. In addition to the courses listed in Appendix C, foundational courses in engineering materials, mechanics, structural analysis, and geotechnical engineering were offered at most MPC universities.

iii. Workforce Development Accomplishments: The following ninety-seven training events were provided for transportation professionals during this reporting period:

ADA Ramp Design	Load Securement (with CDL Briefing)
Aggregate materials certification	Maintenance Welding Basics, Safety, & Repair Techniques
Asphalt Recycling: A National Perspective with MnROAD Findings	Motor Grader
Asphalt Density	Motor Grader Operator
Asphalt materials certification	OSHA 10 - Workplace, Equipment and Jobsite Safety

ATSSA Flagger Certification	Paperwork & Reporting, SWPPP Info/updates
ATSSA Flagger Instructor Training	Pavement Preservation: Crack Sealing, Spray Patching and Roadway Condition Review
ATSSA Traffic Control Supervisor	PE Exam Preparation for Civil Engineers
ATSSA Traffic Control Technician	Perpetual Pavement Concepts
Basic Surveying Methods for Local Highway Agencies	Registered Storm Water Inspector Registered SWPPP Writer
Bikes and Pedestrians	Retention & Detention Ponds
Concrete materials certification	Roundabout Design Basics
Culvert Hydraulics	Safety - The Route to Get Home Safety OSHA 10-Hour
Design & Construction of Full-Depth Portland Cement Reclaimed Bases	Soil Nailing for Slope Stability
Fall Protection - Trenching and excavating	Technical & Business Writing in a DOT: Documents & Style (Part 5 of 5)
Flagger Certification	Technical & Business Writing in a DOT: Documents & Style (Part 4 of 5)
Glue for Gravel Roads	Technical & Business Writing in a DOT: Problem Words & Phrases (Part 2 of 5)
Handling of Hazardous Materials	Technical & Business Writing in a DOT: Sentences, Paragraphs & Punctuation (Part 3 of 5)
Heavy Equipment Operation (Hands On)	Technical & Business Writing in a DOT: Word Types & Basic Grammar Rules (Part 1 of 5)
Heavy Truck Preventative Maintenance	Tractor Mower Safety Training
Inspection & Maintenance of Ancillary Highway Structures	Welding Basics, Safety and Repair Techniques
Leadership and Effective Communication	Work Zone
Leadership and Team Work	Work Zone Safety for Local Agencies
Leadership and Team Work in Transportation	Working with the Media & How to Develop Good Public Relation Practices
Leadership and Vision in Transportation	

Our online modules are also included in our workforce development. efforts This period we offered 56 online modules, listed below, which offered individualized training to 215 transportation professionals.

ATSSA: Safe Installation and Removal of Temporary Traffic Control Devices
ATSSA: Work Zone Safety Performance Measures
Bridge Construction Inspection: Heavy Equipment
Bridge Site Safety Worker Orientation
Introduction to NDDOT Construction Automated Records System (CARS)

Materials Testing: Introduction to the Soil-Moisture Density Relationship
Road Safety 365: A Safety Course for Local Governments – Module 1: The Need for Road Safety
Seal Coat Module 1: Pavement Preservation, Handbook, Design, & Pay Items
TC3 3D Engineered Models for Construction Series: 3D Engineered Models in Highway Design
TC3 AASHTO Designation: T209
TC3 AASHTO T 308: Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
TC3 Advanced Self-Consolidating Concrete
TC3 Aggregate Sampling Basics
TC3 Basic Construction Surveying
TC3 Basic Materials for Highway Structure Construction
TC3 Best Practices for High Friction Surfaces
TC3 Bloodborne Pathogens
TC3 Bolted Connections
TC3 Bridge Cleaning
TC3 Bridge Construction Inspection Safety
TC3 CDL Series
TC3 Change Orders, Claims, and Dispute Resolutions
TC3 Chip Seal Best Practices
TC3 Clean Water Act Compliance During Construction
TC3 Compaction Technician Basics
TC3 Concrete Series
TC3 Construction Inspection of Structures Series
TC3 Construction Inspector Orientation
TC3 Construction of Mechanically Stabilized Earth (MSE) Walls
TC3 Construction of PCC Pavement Series
TC3 Corrosion of Structures
TC3 Drilled Shaft Inspector Tutorial
TC3 Earthwork Series
TC3 Environmental Predecessor Series: Air Quality
TC3 Erosion & Sediment Control
TC3 Flexible Pavement Preservation Treatment Series
TC3 GPS Technology
TC3 Guardrail Series
TC3 High Visibility Garments
TC3 HMA Paving Field Inspection
TC3 Improving the Daily Diary
TC3 Job Hazard Analysis
TC3 Maintenance Training Series

TC3 PCC Pavement Preservation Series
TC3 Personal Protective Equipment (PPE)

TC3 Pipe Installation, Inspection, and Quality
TC3 Plan Reading
TC3 Portland Cement Concrete Paving Inspection
TC3 Recognizing Roadside Weeds
TC3 Revegetation During Construction
TC3 Safe Use of Basic Carpentry Tools
TC3 Safe Use of Hand and Power Operated Tools
TC3 Superpave for Construction
TC3 Superpave Mix Design Process and Analysis
TC3 Understanding Materials Testing for Inspectors
TC3 Warm Mix Asphalt

iv. Research Accomplishments

The following twenty-one peer reviewed final research reports were published during the reporting period from grant DTRT13-G-UTC38 and previous grants.

Project #	Title	Date	Report No.
MPC-515	Redefining the Child Pedestrian Safety Paradigm	Jul-19	MPC 19-374
MPC-489	The Unresolved Relationship between Street Trees and Road Safety	Jul-19	MPC 19-376
MPC-471	Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, and Construction in the State of Wyoming	Mar-19	MPC 19-380
MPC-475	Analysis of the Relationship of Roadside Inspections on Large Truck Crashes	Apr-19	MPC 19-381
MPC-383	Seismic Performance of Highway Embankments	Apr-19	MPC 19-382
MPC-404	Seismic Performance of Circular Concrete Filled Steel Tube Columns for Accelerated Bridge Construction	Jul-19	MPC 19-383
MPC-505	Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation: Track Surface Abnormality Identification with Smartphone-Based App	Jul-19	MPC 19-384
MPC-474	Highway Safety Manual Part D: Validation and Application in Wyoming	May-19	MPC 19-385
MPC-451	Assessing the Cost-Effectiveness of Wyoming's CMAQ Unpaved Road Dust Suppression Program, Year 1	Sep-19	MPC 19-386A
MPC-451	Assessing the Cost-Effectiveness of Wyoming's CMAQ Unpaved Road Dust Suppression Program, Year 2	Sep-19	MPC 19-386B
MPC-512	Prestress Losses and Development of Short-term Data Acquisition System for Bridge Monitoring	Jun-19	MPC 19-387
MPC-467	Cognitive Underpinnings of Beliefs and Confidence in Beliefs about Fully Automated Vehicles	Jun-19	MPC 19-388
MPC-523	Methodology for Load Rating Double-Tee Bridges	Jul-19	MPC 19-389
MPC-483	Interaction Analysis of Long-span Bridges and Traffic System Subjected to Earthquakes	Jul-19	MPC 19-390

Project #	Title	Date	Report No.
MPC-465	Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges	Jun-19	MPC 19-391
MPC-528	Hotspot and Sampling Analysis for Effective Maintenance Management and Performance Monitoring	Jul-19	MPC 19-392
MPC-453	Speed Selection During Winter Road Conditions	Aug-19	MPC 19-394
MPC-461	Analytical Modeling of Seismic Performance of Curved and Skewed Bridges	Aug-19	MPC 19-395
MPC-519	Operational and Safety Analysis with Mitigation Strategies for Freeway Truck Traffic in Wyoming	Aug-19	MPC 19-396
MPC-500	Rehabilitation of Longitudinal Joints in Double-Tee Girder Bridges	Aug-19	MPC 19-398
MPC-525	Bad Driving is Associated with Lower Awareness of Driving	Sep-19	MPC 19-400

c. How have the results been disseminated?
The research results are being disseminated in a variety of ways, including: (1) workshops and conferences, (2) videoconferences, (3) online modules, (4) presentations at conferences, (5) publications, (6) Internet-based dissemination including broadcast emails, website postings, and webinars, and (8) a variety of social media means to include Facebook, and Twitter posts.

d. What do you plan to do during the next reporting period to accomplish the goals/objectives?
This is the last reporting period for grant DTRT13-G-UTC38 which ended on September 30, 2019.

2. Products: What has the program produced?
Due to the length constraints of this document, a listing of publications, conference papers and presentations from MPC primary investigators have been consolidated into Appendix B. Other products are listed below.

- Publications, conference papers, and presentations, Appendix B.
- Website(s) or other Internet site(s);
  - The MPC website
  - The MPC Key Center Directory
- North Dakota State University
  - Thapa, K.B., Received an Award, Runner up at the ASCE Geo-Institute (G-I) Student Poster Competition, Engineering Mechanics Institute Conference, California Institute of Technology, Pasadena, CA, June 20, 2019.
- South Dakota State University
  - Acharya, R. "Evaluation of the Moisture-Induced Damage Potential of Asphalt Mixes and Asphalt Binder-Aggregate Systems." Masters Thesis, South Dakota State University, Summer 2018. Acknowledgement of federal support: Yes.
  - The numerical models for scour prediction produced by this project have been archived and will be make available through the SDSU's institutional data repository Open Prairie (http://openprairie.sdstate.edu) upon submission of the project final report.
- Technologies or techniques;
  - Nothing to report at this time.
- Inventions, patent applications, and/or licenses; and
  - Nothing to report at this time.
- Other products, such as data or databases, physical collections, audio or video products,
  - Nothing to report at this time.

3. Participants and Other Collaborating Organizations: Who has been involved?

a. What other organizations have been involved as partners?

As projects were selected and work plans completed the timing of match funding and the commitments of collaborators vary widely throughout the life of the grant. During this period, we had fifty-three committed collaborators, who provided different support such as financial, in-kind, equipment, supplies, software, or data support. In addition, many provide a direct link for collaboration of research, survey mechanisms, and project activities.

- AAA Foundation for Traffic Safety, Washington, DC, financial support
- Ajou University, Suwon, South Korea, in-kind support
- American Wood Council, Washington, DC, in-kind support
- Campbell County Road and Bridge Department, Gillette, WY, collaborative research
- Campbell Scientific, Bridge Diagnostic Inc., Logan, UT, in-kind support
- City of Brookings, SD, collaborative research
- Colorado Associate of Geotechnical Engineers, Denver, CO, personnel exchanges (technical support)
- Colorado Department of Transportation, Denver, CO, collaborative research
- Colorado Department of Transportation, Denver, CO, financial support
- Colorado Department of Transportation, Denver, CO, subject matter experts and financial support
- Converse County Road and Bridge Department, Douglas, WY, collaborative research
- Crook County Road and Bridge Department, Sundance, WY, collaborative research
- East Dakota Water Development District, Brookings, SD, financial support
- FHWA, Wyoming Division, Cheyenne, WY, subject matter experts
- Forest Products Lab, Madison, WI, in-kind support
- Gage Brothers Concrete Products, Sioux Falls, SD, in-kind support
- Geneva Rock, Salt Lake City, UT, in-kind support
- Gruenwald Engineered Laminates, Tea, SD, in-kind support
- Headed Reinforcement Corporation, Fountain Valley, CA, in-kind support
- Indian Highway Safety Program, BIA, Albuquerque, NM, subject matter experts
- James River Water Development District, Huron, SD, financial support
- Lincoln County Road and Bridge Department, Kemmerer, WY, collaborative research
- Mandan Hidatsa Arikara Nation, Fort Berthold Reservation, ND, subject matter experts
- Missouri Department of Transportation, Columbia, MO, collaborative research
- NDDOT Safety Division, Bismarck, ND, in-kind support
- Nibley City, Nibley, UT, facilities
- North Dakota State University
- Northern Plains Railroad, Fordville, ND, data collection support
- Northern Plains TTAP (No longer active), Bismarck, ND, subject matter experts
- Pacific Earthquake Engineering Research Center, University of California at Berkeley, Berkeley, CA, collaborative research
- Penn State University, University Park, PA, collaborative research
- Sisseton Wahpeton Oyate Reservation, Agency Village, SD, collaborative research
- South Dakota Department of Transportation, Pierre, SD, financial support
- South Dakota State University, Brookings, SD, facilities and in-kind support
- Spirit Lake Nation, Fort Totten, ND, subject matter experts
- Standing Rock Sioux Tribe Indian Reservation, Fort Yates, ND, collaborative research
- Standing Rock Sioux Tribe, Standing Rock Reservation, ND & SD, subject matter experts

- Structural Technologies Inc., Columbia, MD, financial and in-kind support
- Teton County Road and Bridge Department, Jackson, WY, collaborative research
- United State Bureau of Reclamation, Denver, CO, subject matter experts
- University of California at Los Angeles, Los Angeles, CA, collaborative research and in-kind support
- University of Colorado Denver
- University of Colorado Denver, Denver, CO, facilities and in-kind support
- University of Utah
- University of Utah, Salt Lake City, UT, financial support
- University of Wyoming
- USDA Forest Service, Fort Collins, CO, land access for sampling
- Utah Department of Transportation, Salt Lake City, UT, financial support
- Utah Department of Transportation, Taylorsville, UT, financial support
- Wisconsin Department of Transportation, Madison, WI, financial support
- Wyoming Department of Transportation, Cheyenne, WY, financial support, subject matter experts, and facilities
- Wyoming Technology Transfer Center, Laramie, WY, collaborative research
- Yankton Sioux Tribe, Wagner, SD, collaborative research

Due to the life of this grant ending this reporting period, the list of collaborators provided match, in-kind, financial, equipment, or collaboration of research shows the strong federal, state, local, and private industry of MPC research.

b. What individuals have worked on the program?
The following are the principal investigators, faculty, administrators, and students participating in MPC research projects this period:

Fourteen principal investigators, faculty, and administrators are participating in MPC projects at **Colorado State University**: Rebecca Atadero, Suren Chen, Yanlin Guo, John W. van de Lindt, Gaofeng Jia, Jeffrey Niemann, Douglas Woolridge, Joseph Scalia, Chris Bareither, Aditi Bhaskar, Thomas Bradley, Paul Heyliger, Peter A. Nelson and Mehmet E. Ozbek. In addition, fourteen students are working on MPC research projects: Abdelrahman Abdallah, Yangyang Wu, Guangyang Hou, Kaisen Yao, Brandon Perry, Min Li, Douglas Woolridge, Zana Taher, Katie Knight, Constance Dayan, Qiling Zou, David Trinko, Aaron Rabinowitz, and Chao Jiang.

Eleven principal investigators, faculty, and administrators are participating in MPC projects at **North Dakota State University** are: Ying Huang, Pan Lu, Raj Bridgelall, Dinesh Katti, Kalpana Katti, Denver Tolliver, Kimberly Vachal, NeTia Bauman, Sharma Kshitij, Kenneth Davis and Laurel Benson. In addition, thirteen students are working on MPC project: Mu'ath Al-Tarawneh, Mohanad Alshandah, Xinyuan Yang, Xinyi Yang, Hafiz Usman Ahmed, Keshab Thapa, H M Nasrullah Faisal, Neeraj Dhingra, Amin Keramati, Xiaoyi Zhou, Leonard Chia, Bhavana Bhardwaj, and Bukola Bakare.

Four principal investigators, faculty, and administrators are participating in MPC projects at **South Dakota State University** are: Junwon Seo, Ahmad Ghadban, Nadim Wehbe, and Rouzbeh Ghabchi. In addition, seven students are working in MPC research projects: Euiseok Jeong, Ibin Amatya, Marco Paulo Pereira Castro, Maria Laura, Velazco Fasce, Prateek Rai, and Brian Kidd.

Eight principal investigators, faculty, and administrators are participating in MPC projects at the **University of Colorado Denver** are: Wesley Marshall, Bruce Janson, Moatassem Abdallah, Caroline Clevenger, Yail Jimmy Kim, Meng Li, Carolyn McAndrews, and Farnoush Banaei-Kashani. In addition, fourteen students are working on

MPC research projects: Shahryar Monghasemi, Ahmed Ibrahim, Mallory Redmon, Shalini Mahanthege, Alayna Truong, Ricardo Gonzalez, Brady Heath, Molly North, Ghazal Batouli, Nick Ferenchak, Nick Coppola, Yaneev Golomber, Shahryar Monghasemi, and Robert Fitzgerald.

One principal investigator, faculty, and administrator is participating in MPC projects at the **University of Denver**: Patrick Sherry. In addition, three students are working on MPC research projects: Sree Sinha, Emma Porter, and Jessica Mantia.

Nine principal investigators, faculty, and administrators are participating in MPC projects at the **University of Utah** are: Xiaoyue Cathy Liu, Chris P. Pantelides, Steven Bartlett, Evert Lawton, Pedro Romero, Chris Pantelides, Tiffany Hortin, Mark Bryant, and Xianfeng Terry Yang. In addition, twenty students are working on MPC research projects: Zhuo Chen, Nima Haghighi, Zhiyan Yi, Roghayeh Zoleikani, Dipendra Thapa, Ijan Dangol, Faramarz Safazadeh, Abu Sufian Mohammad Asib, Shuanli Bao, Swastik Pohkrel, Emad Ghodrati, Henrik Burns, Nadereh Adham, Kaden Harris, Ijan Dangol, Dipendra Thapa, Faramarz Safazadeh, Abi Sufian Mohammed Asib, Bahar Azin, and Qinzheng Wang.

Five principal investigators, faculty, and administrators are participating in MPC projects at the **University of Wyoming** are: Jennifer Tanner, Khaled Ksaibati, Promothes Saha, Er Yue, and Amirarsalan Mehrara Molan.. In addition, eleven students are working on MPC research projects: Md. Tarik Hossain, Fayez AlMutawa, Milhan Moomen, Mustaffa Raja, Mohammed Mahdi Rezapour Mashhadi, Waleed Aleadelat, Omar M. Albatayneh, Mutasem Alzoubaidi, Milhan Moomen, Sahima Nazneen, and Anas Alrejjal.

Nine principal investigators, faculty, and administrators are participating in MPC projects at **Utah State University** are: Ziqi Song, Patrick Singleton, Andrew Sorensen, Robert J. Thomas, John Rice, James Bay, Michelle Mekker, Marvin Halling, and Marc Maguire. In addition, fifteen students are working on MPC research projects: Zhaocai Liu, Prasanna Humagain, Ferdousy Runa, Kevin Brown, Michael Ruiz-Leon, Seth Thompson, Joshua Ward, Nicholas Markosian, Brad Davis, Pilaiwan Vaikasi, Ashikur Rahman, Zhcaocai Liu, Yi He, Pilaiwan Vikasi, and Jared McRory.

USDOT support through this grant, has allowed us to encourage and support 6sixty-one primary investigators and faculty, at eight Universities throughout Region 8. In addition, we have been able to support, mentor, and develop research skills and knowledge in transportation for ninety-seven students from the US and countries all around the world.

c. Have other collaborators or contacts been involved?

Nothing to report at this time.

4. Impact/ Expected Impacts: What is the impact of the program? How has it contributed to transportation education, research, and technology transfer?

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

MPC's research is having meaningful impacts on the body of knowledge and state of practice of: (1) bridge design and rehabilitation, (2) bridge planning and design in seismic- and flood-prone regions, (3) the longevity and cost-effectiveness of paved roads, (4) asset management and road maintenance, (5) highway and truck safety, (6) automated inspection/assessment of transportation infrastructure, (7) sustainability of transportation systems, and (8) traffic modeling.

Colorado State University

These projects have developed many outcomes, including new analytical methodology, numerical model and laboratory tests related to transportation systems. The detailed outcomes are summarized as below:

MPC-447 — Post-Fire Ground Treatments for Protection of Critical Transportation Structures, Year 1

a) Developed relationships that document the effectiveness of straw mulch as a post-fire ground treatment to limit erosion to pre-burn levels.

b) Documented the validity of small-scale laboratory tests to assess post-fire erosion and runoff from slopes, which can help evaluate other potential post-fire ground treatments.

c) Developed a numerical model that documents the effectiveness of ground cover to mitigate erosion.

MPC-448 — Reducing Flood Vulnerability of Communities with Limited Road Access by Optimizing Bridge Elevation, one MS student was trained as part of this project resulting in an increase in the number of well qualified engineers able to do both hydraulic analysis and structural engineering design.

MPC-461 — Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards, a new methodology to analyze the bridge under traffic and seismic impacts was proposed. A comprehensive case study has been conducted to disclose some interesting findings about curved and skewed bridge performance under seismic loads.

MPC-481 — Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure. No outcomes occurred during the reporting period. However, when published, the journal article is expected to provide an increased understanding of the role of river network structure on hydrologic response of basins. In addition, the developed modeling methodologies are expected to result in improved techniques for evaluating transportation infrastructure from a hydrologic perspective.

MPC-482 — Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems.A finite element model (FEM) of a flexible steel, ring-net barrier was developed to simulate the coupled interactions of a debris-flow impacting the barrier and deformation of the barrier. Barrier deformation and stresses induced in the cables predicted with the FEM were comparable to the institute field test performed by Ferrero et al. (2015). The FEM yielded a closer prediction of final barrier deformation to actual barrier deformation as compared to an analytical model used in Ferrero et al. (2015). Induced cable tensions predicted by the FEM were comparable to measured tensions and tensions predicted via the analytical model. The FEM developed coupled a debris flow and structural barrier to create a model that captured interaction between a flow and the barrier. Complexity in the numerical simulation of the ring-net structure limited the extent of modeling completed for the debris flow. The debris flow was modeled with individual blocks representing a part of a debris flow instead of simulating the overall flowing mass. The segmented block flow was representative of an actual debris flow in regards to comparisons of the structural response of the field-scale experiment. Thus, the segmented debris flow used in the FEM can provide insight on behavior of the barrier during loading; however, additional research is needed to evaluate how different simulations of the debris flow influence response of the flexible ring-net barrier system.

MPC-483 — Interaction Analysis of Girder Bridges and Traffic System Subjected to Earthquakes, Year 1. This study increases understanding of bridge seismic performance by developing an advanced analytical tool of bridge, traffic and earthquake interaction analysis

MPC-486 — Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness. This work will help expand the range of application of heated surfaces to extend beyond residential and airport use to more widely used (but greatly dispersed) transportation surfaces. The knowledge gained by the completed analyses give better estimates of the range of temperatures required for maintaining snow-free surfaces than those that existed in the past.

MPC-487 — Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges, Year 1. This project resulted in an improved understanding of the need for detailed design of bridge decks from cross laminated timber.

MPC-507 — Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging. We have obtained structural response estimates of vibrational frequencies and stresses for passive structures based only on image data. To our knowledge, this methodology is unique and will provide a valuable tool for broader analysis applications including but not limited to transportation structures.

MPC-508 — Experimental Evaluation of a New Double Composite System for Steel Bridges

a) developing new analytical tool for analysis of double composite bridges

b) devising new design approach for double composite bridges

MPC-509 — Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment.
Expected outcomes from this project include increased understanding and awareness of expansive soil treatment methods in the mountain plains region, as well as increased understanding and awareness of polymer treatment technologies for the mitigation of expansive soils in transportation applications. The project will increase the body of knowledge on expansive soil treatment technologies, and potentially improve how transportation earthworks address expansive soil treatment in an economical and sustainable manner. This project may also lead to the adoption of new polymer treatment technologies for the prevention of expansive soil damage to transportation earthworks.

North Dakota State University

Technology-based enhancements were generated in state of good repair for structural performance of bridges and railroad infrastructure in continuous and smart monitoring practices. Smarter safety decisions are supported by the improved data-mining algorithm with gradient boosting for the commercial truck safety and improved understanding of crash data collection practices among Tribal Nations.

South Dakota State University

The research work at SDSU resulted in the development of field compaction test methods to improve construction quality control, increased understanding of using low-cost filtration materials for stormwater treatment that could be used by transportation agencies to reduce environmental impacts of stormwater runoff, development of a new rehabilitation method for increasing the service life of double-tee bridges, increased awareness of access management for South Dakota Highways, better understanding of tack coats and their effect on the pavement performance, development of visual load rating method for double-tee bridges that can be used by bridge inspectors, enhanced body of knowledge on the effects of moisture damage on pavements, and development of a new method for generating future hydrographs for predicting the time history of pier and contraction scour in cohesive soils and assessing the scour risk.

University of Colorado Denver

Our MPC projects under the MAP 21 grant were innovative and impactful. For instance, we developed a proactive (instead of reactive) approach for assessing pedestrian/bicyclist safety, estimated the transportation impacts of ride-hailing services such as Uber and Lyft, and changed the narrative surrounding clear zones and safety in urban areas.

University of Denver

The main outcome has been the application the results of the instrument assessments which has contributed to increases in managers understanding of how to improve safety culture at the MBTA in Boston Results of the assessment were used to make changes in the various activities and practices at MBTA operated by the Keolis Company.

University of Utah

The research carried out increased our understanding of innovative intersection and interchange designs potentially improving their safety. Research resulted in an improved clustering-based sampling method for roadway asset condition inspection, and in improved support tools to make decisions on selection of new and upgraded barrier and drainage systems. Our research improved insight into consumer attitudes and beliefs about automated vehicles and how to change these beliefs. Research increased our understanding of cell phone use affecting driving and driving safety. We improved our understanding regarding durability of pavement surface materials, and improvement of technologies for longer lasting pavements, transportation material testing and selection. Research showed that titanium dioxide cements applied to fresh concrete are not a longevity solution due to carbonation of the cement. A new device for predicting the water to cement ratio in concrete, was found not to be precise. Improved methods were developed to connect to liquefaction data in a supported database to visualize, analyze, and manage existing liquefaction data. Improved technologies were developed for seismic retrofit and seismic repair of existing bridge wall piers with conventional and fiber reinforced polymer materials.

University of Wyoming

Again, as mentioned above all projects under this contract have been completed successfully. The findings of the studies will definitely increase the body of knowledge. In addition, they will provide cost effective solutions for on-going transportation issues.

Utah State University

I think we have certainly contributed to the awareness of transportation issues. The prestress loss project was important to us because it involved industry (Campbell's Scientific) and well as government (Nibley City and UDOT). It is also right next to a high school which has been nice when the students ask. We are hopeful that the results from the soil stabilization project will be able to improve processes and/or techniques.

b. What is the impact on other disciplines?

Colorado State University

All the projects have made significant impact on improving the understanding, mitigation of negative impacts and durability of transportation systems. Specific impacts are listed as below.

MPC-447 — Post-Fire Ground Treatments for Protection of Critical Transportation Structures, Year 1. Enhance preparedness in responding to post-fire burned soils that need ground cover to mitigate erosion and runoff. The findings will help decisions makers determine quantities of straw mulch to apply to burned slopes.

MPC-448 — Reducing Flood Vulnerability of Communities with Limited Road Access by Optimizing Bridge Elevation. The project resulted in an increased understanding of bridge heights required to reduce risk in mountain roads.

MPC-461 — Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards. The study will help design and build more earthquake-resistant bridges, which can improve the performance of transportation system as a whole.

MPC-481 — Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure. The STT method produced in this project overcomes key limitations of existing methods that estimate stream flow in response to specified rainfall (e.g., a design storm). In particular, it accounts for the nonlinearity in the relationship between basin runoff and stormflow at the basin outlet. In addition, it considers the channel network type that occurs in the basin (e.g., dendritic or parallel). The STT method is simple enough to be implemented in a spreadsheet by practicing engineers and could be implemented in modeling software such as HEC-HMS because it does not require hydrologic computations on a grid. Ultimately, the use of this method would allow design flows to be estimated with greater accuracy, which would improve the reliability of the transportation infrastructure.

MPC-482 — Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems .Enhance the ability to design flexible ring-net barriers along transportation corridors.

MPC-483 — Interaction Analysis of Girder Bridges and Traffic System Subjected to Earthquakes, Year 1. This study may contribute to possible revision of AASHTO LRFD bridge design code.

MPC-486 — Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness. This work furthers applications of keeping transportation surfaces free of snow during inclement weather.

MPC-487 — Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges, Year 1. This project will enable the possible use of CLT for repair of existing wood bridges. CLT is a sustainable product that sequesters carbon for a positive environmental imprint, unlike steel and concrete.

MPC-507 — Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging. This methodology can be applied to determine the residual strength and stiffness of damaged or degraded structures in a systematic and quantifiable way by measuring the changes in mechanics quantities (displacement and stress) between the original and damaged structure.

MPC-508 — Experimental Evaluation of a New Double Composite System for Steel Bridges. We expect many DOTs to start considering double composite bridges for the design and construction of new bridges

MPC-509 — Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment. Results will be transferred to DOTs to help in the assessment of commercial polymer-based expansive soil mitigation technologies.

North Dakota State University

ITS applications in rail track monitoring establishes a foundation for a tool that could enhance knowledge of factors that contribute to track surface abnormality identification and increase the efficiency of track condition monitoring and maintenance operations. Hence, less rail track down time and higher rail revenue via increased in-service time. Also contributing to state of good repair, understanding key mechanisms that influence the shear strength of expansive (swelling) clays, has the potential to significantly reduce clay swelling damage to transportation infrastructure. The bridge inspection information fusion and data mining research provide engineers at large with effective solution on how to extract accurate and reliable data and on how to extract critical information from data, potentially reducing risk to public safety.

South Dakota State University

The research at SDSU is expected to develop: compaction testing methods to decrease the time required to obtain target density of granular materials, inexpensive filter materials to remove contaminants in stormwater runoff, cost-effective rehabilitation methods for longitudinal joints of double-tee bridges, methods to fully assess financial impacts of access management treatments in South Dakota, guideline for selection of tack coats in South Dakota, load rating method for double tee bridges based on visual assessment of damaged girders, accurate screening of asphalt mixes for stripping susceptibility, and site-specific method for predicting pier and contraction scour in cohesive soils.

University of Colorado Denver

The results of our MPC projects are helping improve the built environment and extend the longevity of the existing infrastructure. These projects are also helping make our roads safer and more efficient. In terms of improvements in practice, MPC-510 applied their commute optimization research to an existing business and that business has found more sustainable commuter outcomes.

University of Denver

The impact of our research on the effectiveness of the transportation system can and will be seen in the form of improved safety culture and fewer accidents and injuries among transportation organization employees. Successful adoption of our instrument as a standard operating tool for planning, prevention and training means that it has had an impact and has led to improvements in the organizational culture and specific practices and techniques employed by transportation safety professionals.

University of Utah

Results regarding innovative intersections and interchanges have been shared with the Utah and Virginia DOT. Many consumers with the most negative views of automated vehicles were highly uninformed. Other research developed better understanding of materials so that specific materials for specific conditions can be selected to optimize pavement performance. Titanium dioxide used for "smog-reducing concrete" is not effective for new concrete since increased carbonation increases steel corrosion potential. An analysis of barrier and drainage system costs with a detailed life cycle cost analysis are expected to guide decisions on their design and installation. Research on low temperature cracking will improve understanding of pavement materials and allow development of a better product that can satisfy the demands of the public. A vetted and community database of case histories of liquefaction-induced lateral spread is being assembled for further research. The study on cell phone use while driving, contributes to transportation safety by furthering our understanding of determinants for driving safety and performance. Seismic repair of wall piers using fiber reinforced polymer composites increases the seismic safety of existing bridges. An asset sampling method was developed by selecting sample roadway segments that contain multiple types of assets for accurate estimation of their respective levels of maintenance.

University of Wyoming

All UW projects concentrate on applied research with specific outcomes which can be implemented. As an example, MPC 451 can be implemented to better allocate limited resources to chemically treat gravel roads. MPC 471 has already been implemented by WYDOT as part of the state implementation of the MEPDG. The findings of all the studies have expanded the body of knowledge in several areas such as transportation safety as well as pavement design.

Utah State University

Accurate estimation of prestress losses is a nationwide issue. Prestressed concrete girder bridges are a bread-and-butter bridge type that is built all across the United States. Information that can reduce the up front cost as well as long-term durability can have immediate and lasting impacts. There are regional variabilities and the more that we understand this behavior the better we can become with the design. Truck traffic has become a major issue in the United States. The need to transport goods is increasing and the impact it has on the users of the infrastructure in terms of delays, repairs and congestion are likely to become even worse. This project focuses on the potential improvements to address these problems.

c. What is the impact on the development of transportation workforce development*?*

Colorado State University

All these projects have contributed to the workforce development in the field of transportation. Specific details are listed as follows.

MPC-447 — Post-Fire Ground Treatments for Protection of Critical Transportation Structures, Year 1
The project has produced an MS student, who is now an engineering consultant with a geotechnical engineering firm, and a PhD student, who is now an Assistant Professor at Montana State University.

MPC-448 — Reducing Flood Vulnerability of Communities with Limited Road Access by Optimizing Bridge Elevation An MS student graduated and is now working in industry as a structural design engineer as a result of training from this project.

MPC-461 — Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards This study provided research opportunity for graduate students. The findings in this study will also be included in bridge design courses offered to new generation of engineers.

MPC-481 — Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure Funding from MPC was used to support graduate students during their MS degree studies in the field of hydrology, who are expected to become members of the transportation workforce.

MPC-482 — Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems The project produced one MS student who is currently an engineering consultant.

MPC-483 — Interaction Analysis of Girder Bridges and Traffic System Subjected to Earthquakes, Year 1
The study helped training graduate students.

MPC-486 — Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness This work could reduce needed mundane snow removal and be able to redirect workforce impacts to more urgent needs.

MPC-487 — Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges, Year 1 Student involved in the project completed his masters and is now working on his Ph.D. here at CSU.

MPC-507 — Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging Being able to triage the repair of damaged transportation systems would greatly improve the efficiency of DOT crews responsible for fixing or replacing damaged components. By rapidly determining if a structure is still sound, these crews could potentially leave a damaged structure in place if it can still do the job.

MPC-508 — Experimental Evaluation of a New Double Composite System for Steel Bridges
a) Provide new skilled students that are able to analyze and design composite bridges
b) Develop open-access analysis modules that can be used by existing engineers and train new engineers

MPC-509 — Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment
Project has supported an M.S. (now PhD) student in the Department of Civil and Environmental Engineering at Colorado State University. Through the research, this project provides valuable training in geotechnical engineering of expansive soils. This student is expected to become part of the transportation workforce as a geotechnical engineer.

North Dakota State University

The MPC research has extensive student involvement in field experiments, data collection and ITS applications. Students will take this working knowledge into classroom application and eventually into the workforce. In

addition, these students gain valuable experience in disseminating their research to peers and professionals through paper and presentations. The research presents rail industry practitioners and researchers with a working knowledge of advance signaling data processing and new modeling options. In addition, the MPC projects have extended research and outreach opportunities with Native Nations in attracting new students and developing local capacity of transportation practitioners.

South Dakota State University

The research at SDSU will allow for an increased level of construction quality control for the transportation workforce, increase the environmental awareness of the general transportation workforce, and provide research training for graduate student with extensive experimental work in transportation-related fields, .

University of Colorado Denver

During the current reporting period, our MPC projects provided opportunities to three graduate students. Over the course of the grant, this extends to dozens. All of our MPC students gained valuable experience in research methods, paper writing, and presenting as well as developing new skills. These projects also provided them with the opportunity to attend conferences and interact with and share our work with other researchers and the broader transportation community.

University of Denver

The results of the project will have a positive impact on understanding how the introduction of autonomous vehicle technology will affect workforce behavior regarding safety culture which can influence the number of accidents and injuries. The results of the research will lead to the development of education materials and course content that can be used by educators throughout the US.

University of Utah

The applications developed for innovative intersections and interchanges were used in transportation-related courses and students were exposed to material that did not exist in their textbooks. Research of highway surface treatments has produced new educational materials that could be incorporated in manuals to improve exposure to issues facing the transportation infrastructure. A final presentation on selection of barrier and drainage systems will be delivered to engineers as part of an organized event at the Utah Department of Transportation, which will provide PDH to participants. The project on low temperature cracking of pavements will improve the performance and skills of professionals in the field. The project on seismic repair of bridge wall piers provided opportunities to two undergraduate students to be exposed to research, and two graduate students to develop skills that would be useful in seeking employment in the transportation industry. Computer science domain methods such as high-dimensional clustering techniques and asset condition prediction will be transferred to class-teaching modules for use in data-related transportation courses.

University of Wyoming

Several workshops were presented by the University of Wyoming and the Wyoming LTAP to transportation professionals across the state. Some of these workshops are required for transportation professionals to do their daily jobs. This would include certifications in aggregate, asphalt, and concrete.

Utah State University

Each of the projects employs graduate students in order to perform the research. Each of these students will then in turn enter the workforce with this experience. It is a wise investment into the industry and the infrastructure.

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

Colorado State University

Some of the studies show promising potentials to be adopted in new practices. Following is the detailed information for each project.

MPC-447 — Post-Fire Ground Treatments for Protection of Critical Transportation Structures, Year 1

The findings have the potential to change the applications rates of straw mulch to limit erosion of new soil slopes and post-burned soil slopes along transportation corridors.

MPC-448 — Reducing Flood Vulnerability of Communities with Limited Road Access by Optimizing Bridge Elevation NA
MPC-461 — Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards The study can help improving existing design guidelines and analytical methods in design codes like AASHTO bridge design manuals.
MPC-481 — Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure We expect these methods to be adopted by hydrologists who work in transportation and other related fields. The new method is expected to produce more accurate estimates of streamflow, which should improve the safety bridges and culverts.
MPC-482 — Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems New finite element model to assess flexible ring-net barriers.
MPC-483 — Interaction Analysis of Girder Bridges and Traffic System Subjected to Earthquakes, Year 1
It is hoped that the study may help USDOT and AASHTO to develop improved bridge seismic analysis methodology. MPC-487 — Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges, Year 1 NA
MPC-507 — Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging It is possible that the technology could be commercialized and develop a product that would run a complete analysis from images to final results.
MPC-508 — Experimental Evaluation of a New Double Composite System for Steel Bridges
a) the results will be shared with DOTs
b) Colorado DOT is likely to adopt this approach for design of some of their new bridges
MPC-509 — Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment
Mechanisms learned from research should assist in refinement of commercial polymer-based expansive soil treatments.

North Dakota State University

The state of good repair gain is evident in research to develop a state-of-the-art design procedures to correctly analyze and accurately predict the engineering response of swelling clays. In addition, improvements to rail and highway asset monitoring could be realized. Technology transfer of results can encourage institution of more effective and efficient bridge monitoring and an easy-to-use tool for railroad track condition monitoring.

South Dakota State University

The expected impacts are: reduce current construction monitoring inefficiencies, reduce the contamination caused by stormwater water runoff, allow for rehabilitation of double-tee girder longitudinal joints, ensure consistency in evaluating the benefits of access management treatments, lower repair and maintenance costs of asphalt pavements, reduce moisture-induced damage in asphalt pavements, assess double tee bridge load rating based on visual inspection, and modify codes for scour calculations. MPC-486 — Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness The main impact has been to numerically validate what are now quite soft design guidelines for heated concrete.

University of Colorado Denver

With MPC-455, for instance, the results suggest that greater investment in protected and separated bike facilities is significantly associated with reduced fatalities for all road users. These results and the most recent published paper received a lot of attention from the popular press and by the planning/engineering staff of many cities. Cities will hopefully put these results to good use and help save lives. MPC-515 is another example that will hopefully lead to safer streets and better road safety outcomes. The project focused on a proactive approach to child pedestrian safety, and the results got the attention of Nancy Pullen-Seufert, the director of the National Center for Safe Routes for Schools. We recently had a meeting to discuss how our tool could be put into practice by their school partners. No start-up companies have been initiated.

University of Denver

The expected impact on new practices would be that the knowledge gained in this project will lead to the adoption of state of the art approaches that will aide transportation agencies and private non-governmental companies in the improvement of their safety program.

University of Utah

Results and applications of the project regarding innovative intersections and interchanges have been shared with the transportation community through publications and presentations and operational safety modules have been used in follow-up projects. Our research indicates that the combination of titanium dioxide and new concrete is not a smog-reducing solution. Results of research on barrier and drainage system selection
provide valuable recommendations and life cycle cost estimates for transportation agencies, which will lead to changes in guidelines for barrier and drainage system selection. The project on low temperature cracking of pavements has the potential to lead to new commercial developments in
the area of transportation material testing. New methods for assessing liquefaction hazards will likely be implemented by State DOTs to perform liquefaction evaluations. Results of the study on cell phone use will help in training new drivers and improving driving safety. The expected impact of the research on seismic repair of bridge wall piers is the adoption of new materials such as fiber reinforced polymer composites.

University of Wyoming

WYDOT has already implemented the findings of MPC 471. The Wyoming LTAP is discussing with the Wyoming County Commissioners Association doing additional work on MPC 472 to implement a state wide PMS for county paved roads.

Utah State University

The exciting thing about these three projects are the range in scope of their impact. MPC 477 and 512 will likely have impact in the design where government and industry are the most involved. MPC 479 can have a little broader impact depending on the results. The economic competitiveness of the project can reach almost all sectors of the transportation industry. It is difficult to envision all the possibilities but this couldn't include commercialization and practices.

e. What is the impact on technology transfer?

Researchers at South Dakota State University are making significant advances to improve the performance, reduce construction costs, and enhance safety of the transportation infrastructure in South Dakota and Transportation Region 8. They have evaluated and developed innovative testing methods, bridge systems, rehabilitation techniques, paving materials, and analytical models in the fields of bridge engineering, pavement, highway water runoff quality, and highway safety.

The University of Utah, research enhances traffic control and traffic safety. In addition, the research will impact psychological science by increasing our knowledge of the dynamics of human performance. The research enhances knowledge in asphalt pavement design, and concrete. The research will impact positively soil liquefaction principles and the seismic retrofit of bridge piers.

f. What is the impact on society beyond science and technology?

Colorado State University

These projects have made considerable impact on the body of scientific knowledge. The details of each project are listed below.
MPC-447 — Post-Fire Ground Treatments for Protection of Critical Transportation Structures, Year 1
Experimental procedure: Documented the validity of small-scale laboratory tests to assess post-fire erosion and runoff from slopes, which can help evaluate other potential post-fire ground treatments. Numerical model: Developed a numerical model that documents the effectiveness of ground cover to mitigate erosion.
Fire science: Developed relationships that document the effectiveness of straw mulch as a post-fire ground treatment to limit erosion to pre-burn levels.
MPC-448 — Reducing Flood Vulnerability of Communities with Limited Road Access by Optimizing Bridge Elevation NA
MPC-461 — Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards This study can help improve the bridge seismic analysis theory and methodology by incorporating the contribution of passing traffic, which reflects more realistic scenarios on bridges. In all existing works, the traffic impacts were not considered at all or not to this level of details.

MPC-481 — Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure The STT method has been used to better understand the dependence of basin response (i.e. flood discharges) on the structure of the river network. In particular, it has shown that dendritic, parallel, pinnate, rectangular, and trellis networks have different hydrologic behaviors.
MPC-482 — Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems Document that a coupled numerical model can link impact forces from a debris flow on a flexible ring-net barrier. This was possible via a simplified block-load mechanism for the debris flow and a sophisticated ring-net.
MPC-483 — Interaction Analysis of Girder Bridges and Traffic System Subjected to Earthquakes, Year 1
This study will increase the knowledge of bridge seismic engineering
MPC-486 — Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competitiveness Transient heat transfers through concrete subjected to accumulating snow has seen little study, and this work has added to a very limited body of knowledge.
MPC-487 — Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges, Year 1. The testing within this project resulted in a better understanding of chord forces within flat/horizontal CLT (cross laminated timber) wood. No knowledge of these chord forces was available other than through basic design calculation, but verification by experiment enables confidence in such computations.
MPC-507 — Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging This method combines existing techniques into a single method that can lead to a change in viewpoint about damaged structures. For example, some structures that have been damaged may not need any adjustment or remediation, saving significant time and effort.
MPC-508 — Experimental Evaluation of a New Double Composite System for Steel Bridges
It is expected that the outcome of this work will provide new theoretical knowledge for the design and analysis of double composite bridges. Such knowledge does not exist.
MPC-509 — Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment
The results and findings from this study will increase the base of knowledge on the functionality of commercially available polymer treatment technologies for mitigation of expansive soils in Civil Engineering.

North Dakota State University

Bridge inspection advances in data mining and information fusion impacted the base of knowledge in data collection with a high accuracy and timely method. Contribution was made in ITS knowledge for the state of good repair with the review of inertial signaling data processing methods including the pros and cons for methods and potential for fusion. Transportation safety professionals would benefit from the research to improve their base knowledge on what and how contributors impact on commercial truck crash severity.

South Dakota State University

The impacts or expected impacts are: addition of a new tool to the stormwater best management practices, shared experimental data on large-scale testing of bridges with the bridge engineering community, development of a software tool which implements the proposed feasibility assessment method for access management, in-depth understanding of the role that tack coats play in pavement performance, and better understanding of the effect of flow history on the time development of scour in cohesive soils.

University of Colorado Denver

In terms of our contribution to the body of scientific knowledge, these MPC projects filled literature gaps on the topics of road safety, travel behavior, emerging mobility modes, road design, and advanced infrastructure composites.

University of Denver

This research will demonstrate a conceptual link between new technology and safety culture and other aspects of workforce attitudes towards technology. A significant impact in the literature will be in connecting the concept of safety culture to the behavioral realm of fatigue risk management.

University of Utah

Research on innovative intersections and interchanges has extended the methodologies for operational and safety analysis and has developed crash modification factors for diverging diamond interchanges and continuous flow

intersections. Research on automated vehicles showed that judgmental confidence is grounded in general self-confidence, and perceived rather than real knowledge; thus, confidence is often based on factors that are superfluous to the soundness of judgment. A study on cell phone use contributes to psychological science by increasing our knowledge of the dynamics of task performance. Research on highway surface treatments will result in longer lasting pavement surfaces, and adoption of performance-based material specifications will allow for road surfaces that better serve the traveling public. Data collected for the liquefaction database will include measurements of post-liquefaction ground deformations for historical earthquakes. The methods developed for seismic retrofit and repair of existing bridges are extending the life of existing bridges that would otherwise have to be demolished.

University of Wyoming

The significant number of refereed publications which resulted from this contract clearly indicate the impact on the body of knowledge.

Utah State University

From a structural engineering prospective the results of MPC 512 can aid in the design of the structural by providing actual behavior that can improve design methodologies. From a geotechnical engineering prospective the MPC 477 will provide basic data and testing to improve the foundational systems of the infrastructure. From a transportation engineering prospective, MPC 479 can improve the over ridership of the system. Any improvement in these areas needs the basic research and data from these projects.

5. Changes/Problems

Colorado State University

Most projects have no change except for one project:
MPC-509 — Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment
Project delayed to allow for development and validation of representative testing equipment (MPC-538), and procurement of significantly larger masses of materials (expansive soil) that were originally anticipated. The need for larger-scale representative testing equipment was identified through this project to provide an accurate answer to project questions (i.e., are commercially available polymers effective for the treatment expansive soils).

South Dakota State University

MPC-520 was initially delayed due to data lack of availability and gathering. Data gathering has progressed and is near completion. Analysis and development have been delayed due to these prior delays; however, progress has been made recently.

Utah State University

I don't see any big problems. I would like to have seen MPC 477 a little further along. The PI was on sabbatical last year and while the student was here working, the absence of the advisor always seems to delay a little of the work. MPC 512 was completed and Ziqi is always good with his projects.

5a. Additional Information Regarding Products and Impacts: UTC's are encouraged to consider identifying program results by outputs, outcomes, or impacts and they should be linked to National goals expressed in the Secretary's Strategic Goals.

Based on the above responses, please address any significant impacts?

North Dakota State University

The MPC research has extensive student involvement in field experiments, data collection and ITS applications.

University of Denver

Development of a new measure of Safety Culture for transportation agencies normed on transportation professionals for use by transportation professionals.

University of Utah

The results of the project regarding innovative intersections and interchanges have been shared with the Utah Department of Transportation and Virginia Department of Transportation. For the project on selection of barrier and drainage systems, the results and findings will be incorporated into guidelines of transportation agencies. For

the project on the liquefaction database, dissemination tools will be developed for future assessment and model development by interested researchers. Driving education programs will teach drivers that monitoring their driving performance and state is central to safely operating a motor vehicle. The methods for seismic retrofit and repair of existing bridges will be used to extend the life of existing bridges in seismic regions. The ability to select sample segments with multiple types of representative assets of the full inventory directly translates to efficient maintenance activity management.

Utah State University

I think we have received some good press from the prestress loss project and vehicle characterization on that project. I think we need to see how the remaining two projects play out in terms of findings in order to determine news releases or what we want to focus on.

6. SPECIAL REPORTING REQUIREMENTS: None