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

Grant No. DTRT13-G-UTC38
DTRT13-G-UTC38, Mod 1, 2, & 3
Mountain-Plains Consortium, North Dakota State University
Denver Tolliver, Director
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(701)231-7190

March 30, 2017

DUNS: 803882299 and EIN: 45-6002439

North Dakota State University
Upper Great Plains Transportation Institute
NDSU Dept. 2880, P.O. Box 6050, Fargo, ND 58108-6050

Grant period: October 1, 2013 – September 30, 2018

Reporting Period End Date: March 30, 2017
Semi-Annual PPPR#7

Denver D. Tolliver

Director, Mountain-Plains Consortium
North Dakota State University
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 Competitiveness, while addressing critical issues of the region and stakeholder groups.

b. What was accomplished under these goals?

i. Project Selection
Eighty-seven 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. Other research projects are related to the Secretary’s strategic goals of Safety, Economic Competitiveness, Livable Communities, and Environmental Sustainability. MPC projects selected under this grant include; MPC-371, 409, 447, 451, 472 (Year 2), MPC-446 through MPC-531.

<table>
<thead>
<tr>
<th>Table 1: MPC Research Projects Most Directly Correlated with Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. MPC-453: Speed Selection Behavior during Winter Road Conditions</td>
</tr>
<tr>
<td>2. MPC-454: Regional Implementation of Tribal Transportation Safety Program</td>
</tr>
<tr>
<td>3. MPC-455: Why Are Bike-Friendly Cities Safer for All Road Users?</td>
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<td>4. MPC-458: Application of a Multi-Agent System with the Large-Scale Agent-Based Model for Freight Demand Modeling</td>
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<td>5. MPC-460: Technology and Workforce Development for Remote Sensing of the Transportation Infrastructure</td>
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<tr>
<td>6. MPC-461: Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards</td>
</tr>
<tr>
<td>7. MPC-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory</td>
</tr>
<tr>
<td>9. MPC-472: Developing an Optimization Model for Managing County Paved Roads</td>
</tr>
<tr>
<td>10. MPC-473: Bicycle and Pedestrian Design for Rural Communities</td>
</tr>
<tr>
<td>12. MPC-475: Analysis of the Relationship of Roadside Inspections on Large Truck Crashes</td>
</tr>
<tr>
<td>13. MPC-476: Highway-Rail Grade Crossing Traffic Hazard Forecasting Model</td>
</tr>
</tbody>
</table>
15. MPC-480: A Comprehensive Safety Assessment Methodology for Innovative Geometric Designs
16. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
17. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
18. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges
19. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
20. MPC-503: Characterization of Crushed Bases in Wyoming
21. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
22. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation
23. MPC-507: Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging
24. MPC-515: Redefining the Child Pedestrian Safety Paradigm
27. MPC-519: Operational and Safety Analysis with Mitigation Strategies for Freeway Truck Traffic in WY
30. MPC-531: Flood Hydrograph Generation for Predicting Bridge Scour in Cohesive Soils

Table 2: MPC Research Projects Most Directly Correlated with State of Good Repair

1. MPC-447: Post-Fire Ground Treatments for Protection of Critical Transportation Structures
2. MPC-448: Reducing Flood Vulnerability of Communities with Limited Road Access by Optimizing Bridge Elevation
3. MPC-449: Determining the Uncertainty in the Current Condition of Bridges for Use in Risk Based Inspection and Management
4. MPC-451: Assessing the Cost-Effectiveness of Wyoming's CMAQ Unpaved Road Dust Suppression Program
5. MPC-452: Updating the Highway Safety Manual 2010 - Part C: Regional Consideration of the Rocky Mountains and Plain Regions
7. MPC-458: Application of a Multi-Agent System with the Large-Scale Agent-Based Model for Freight Demand Modeling
8. MPC-460: Technology and Workforce Development for Remote Sensing of the Transportation Infrastructure
9. MPC-461: Analytical Modeling for Progressive Failure Assessment of Curved and Skewed...
Highway Bridges Subjected to Seismic Hazards

10. MPC-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory

11. MPC-463: Rehabilitation Project Selection and Scheduling in Transportation Networks

12. MPC-464: Development of Network-Based Measures and Computational Methods for Evaluating the Redundancy of Transportation Networks


14. MPC-472: Developing an Optimization Model for Managing County Paved Roads

15. MPC-477: Characterizing the ductility of Portland cement stabilized soil

16. MPC-478: Long-Term Behavior of Precast Concrete Bridges

17. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints

18. MPC-481: Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure

19. MPC-482: Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems

20. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes

21. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness

22. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges

23. MPC-497: Compaction Testing of Granular Materials

24. MPC-500: Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders

25. MPC-501: Development of an Alternative to the Double Tee Bridge System

26. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders

27. MPC-503: Characterization of Crushed Bases in Wyoming

28. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation

29. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation

30. MPC-506: Reliable Prediction of Shear Strength of Swelling Clays

31. MPC-507: Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging

32. MPC-511: Mechanical Bar Splices for Accelerated Bridge Construction of Columns

33. MPC-512: Pre-stress Losses and Development of Short-Term Data Acquisition System for Bridge Monitoring

34. MPC-516: Innovative Strengthening for Deteriorated Concrete Bridges Using Embedded Composite Sheets Bonded with Polyester-silica

35. MPC-519: Operational and Safety Analysis with Mitigation Strategies for Freeway Truck Traffic in WY

36. MPC-522: Development of a Guideline for Selection of Tack Coats in South Dakota

37. MPC-523: Methodology for Load Rating Double-Tee Bridges

38. MPC-530: Screening of South Dakota Asphalt Mixes for Moisture Damage using Conventional and Innovative Approaches

39. MPC-531: Flood Hydrograph Generation for Predicting Bridge Scour in Cohesive Soils
<table>
<thead>
<tr>
<th>No.</th>
<th>Project Code</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>MPC-451</td>
<td>Assessing the Cost-Effectiveness of Wyoming's CMAQ Unpaved Road Dust Suppression Program</td>
</tr>
<tr>
<td>2.</td>
<td>MPC-456</td>
<td>Performance of Steel Girders Repaired with Advanced Composite Sheets in a Corrosive Environment: A Multi-Physics Approach Leading to Practical Design Recommendations</td>
</tr>
<tr>
<td>3.</td>
<td>MPC-460</td>
<td>Technology and Workforce Development for Remote Sensing of the Transportation Infrastructure</td>
</tr>
<tr>
<td>4.</td>
<td>MPC-463</td>
<td>Rehabilitation Project Selection and Scheduling in Transportation Networks</td>
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<td>5.</td>
<td>MPC-464</td>
<td>Development of Network-Based Measures and Computational Methods for Evaluating the Redundancy of Transportation Networks</td>
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<td>Developing an Optimization Model for Managing County Paved Roads</td>
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<td>8.</td>
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<td>Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints</td>
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<tr>
<td>11.</td>
<td>MPC-488</td>
<td>Effects of Infill Development and Regional Growth on At-Risk Populations' Exposure to Traffic Density</td>
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<tr>
<td>12.</td>
<td>MPC-497</td>
<td>Compaction Testing of Granular Materials</td>
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<td>13.</td>
<td>MPC-498</td>
<td>Development of Mixed Media Filtration for Stormwater Runoff Treatment</td>
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<tr>
<td>14.</td>
<td>MPC-499</td>
<td>Reuse of Aqueous Waste Streams in Transportation-Related Applications</td>
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<td>MPC-500</td>
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<td>MPC-501</td>
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<td>MPC-505</td>
<td>An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation</td>
</tr>
<tr>
<td>21.</td>
<td>MPC-509</td>
<td>Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment</td>
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<tr>
<td>22.</td>
<td>MPC-511</td>
<td>Mechanical Bar Splices for Accelerated Bridge Construction of Columns</td>
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<tr>
<td>23.</td>
<td>MPC-513</td>
<td>Optimal Deployment of Wireless Charging Facilities for an Electric Bus System</td>
</tr>
<tr>
<td>24.</td>
<td>MPC-514</td>
<td>Impacts of Ridesourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior</td>
</tr>
<tr>
<td>25.</td>
<td>MPC-516</td>
<td>Innovative Strengthening for Deteriorated Concrete Bridges Using Embedded Composite Sheets Bonded with Polyester-silica</td>
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<td>Screening of South Dakota Asphalt Mixes for Moisture Damage using Conventional and Innovative Approaches</td>
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</table>
Table 4: MPC Research Projects Most Directly Correlated with Livable Communities

1. MPC-454: Regional Implementation of Tribal Transportation Safety Program
2. MPC-455: Why Are Bike-Friendly Cities Safer for All Road Users?
3. MPC-473: Bicycle and Pedestrian Design for Rural Communities
4. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
5. MPC-485: Development of a Model to Assess the Feasibility of Transit-Oriented Development (TOD) Projects
6. MPC-489: The Unresolved Relationship between Street Trees and Road Safety
7. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
8. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
9. MPC-510: Business and Commute Optimization System: Development and Denver-Based Case Study
11. MPC-514: Impacts of Ridesourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior
12. MPC-515: Redefining the Child Pedestrian Safety Paradigm
15. MPC-520: Financial Benefits of Proposed Access Management Treatments

Table 5: MPC Research Projects Most Directly Correlated with Environmental Sustainability

1. MPC-447: Post-Fire Ground Treatments for Protection of Critical Transportation Structures
2. MPC-458: Application of a Multi-Agent System with the Large-Scale Agent-Based Model for Freight Demand Modeling
3. MPC-460: Technology and Workforce Development for Remote Sensing of the Transportation Infrastructure
5. MPC-472: Developing an Optimization Model for Managing County Paved Roads
6. MPC-473: Bicycle and Pedestrian Design for Rural Communities
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14. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
15. MPC-503: Characterization of Crushed Bases in Wyoming
16. MPC-509: Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment
17. MPC-510: Business and Commute Optimization System: Development and Denver-Based Case Study
18. MPC-513: Optimal Deployment of Wireless Charging Facilities for an Electric Bus System
19. MPC-514: Impacts of Ride sourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior

iii. Educational Accomplishments

The transportation and transportation-related courses offered during fall 2016 and spring 2017 are listed in Table 6, organized by major subject area. In some cases, courses with the same titles were offered at more than one MPC university. In these cases, the number of courses offered is shown in parenthesis.

<table>
<thead>
<tr>
<th>Major Subject Area</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>Engineering &amp; Design</td>
<td>CIVE 303 Infrastructure and Transportation Systems</td>
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<tr>
<td></td>
<td>CIVE 355 Introduction to Geotechnical Engineering</td>
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<tr>
<td></td>
<td>CIVE 455 Applications in Geotechnical Engineering</td>
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<td></td>
<td>CIVE 467 Design of Reinforced Concrete Structures</td>
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<td></td>
<td>CIVE 508 Bridge Engineering</td>
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<td></td>
<td>CIVE 561 Advanced Steel Behavior and Design</td>
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<td></td>
<td>CIVE 565 Finite Element Method</td>
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<td>CIVE 580B1 Structural Inspection, Management, and Repair</td>
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<td></td>
<td>CEE 106 Elementary Surveying and Lab</td>
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<td></td>
<td>CEE 443 Matrix Analysis of Structures</td>
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<td>CEE 792 Topics-Advanced Topics in Reinforced Concrete</td>
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<td></td>
<td>CEE 769 Bridge Design</td>
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<td></td>
<td>CEE 456 Theory and Design of Reinforced Concrete</td>
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<tr>
<td></td>
<td>CEE 446 Theory and Design of Reinforced Concrete</td>
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<td></td>
<td>CEE 546 Advanced Geotechnical Engineering</td>
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<td></td>
<td>CEE 765 Pavement Design</td>
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<tr>
<td></td>
<td>CEE 363 Highway and Traffic Engineering</td>
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<td></td>
<td>CEE 492 Introduction to Traffic Safety</td>
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<td></td>
<td>CEE 755 Advanced Reinforced Concrete</td>
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<td></td>
<td>CEE 455 Steel Design</td>
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<td></td>
<td>CEE 749 Advanced Geotechnical Testing</td>
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<td></td>
<td>CEE 458 Design of Timber Structures</td>
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<td></td>
<td>CVEN 3602 Transportation Engineering</td>
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<td></td>
<td>CVEN 4602 Highway Engineering</td>
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<tr>
<td></td>
<td>CVEN 5602 Advanced Street &amp; Highway Design</td>
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<tr>
<td></td>
<td>CVEN 5682 Pavement Design</td>
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<tr>
<td></td>
<td>CE 3500 Transportation Engineering</td>
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<tr>
<td></td>
<td>CE 5585 Pavement Management System</td>
</tr>
<tr>
<td></td>
<td>CE 5550 Pavement Materials</td>
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<tr>
<td></td>
<td>CE 4550 Pavement Materials</td>
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</tbody>
</table>
Altogether, 64 transportation and transportation-related courses have been offered this reporting period, for a total of 501 total transportation courses offered this grant period. In addition to the courses listed in Table 6, foundational courses in engineering materials, mechanics, structural analysis, and geotechnical engineering were offered at most MPC universities.

### iv. Workforce Development Accomplishments

**Training:** A list of training events provided for transportation professionals during this reporting period is presented below.
- 10 Ways to Handle Your Overburdened Inbox
- Asphalt Maintenance: Crack Sealing/Pouring & Spot Surface Repairs
- Asphalt Paving Maintenance 1
• ATSSA Flagger Certification
• ATSSA Flagger Instructor Training
• ATSSA Traffic Control Supervisor
• ATSSA Traffic Control Technician
• Basics of a Good Road
• Communication Skills for Supervisors
• Concrete Pavement
• Confided Space Training
• Confined Space Awareness
• Confrontation Management & Conflict Resolution
• Construction Project Management/Contract Administration
• Creative Problem Solving
• Designing for Pedestrian and Bicycle Safety
• Designing, Constructing & Maintaining Facilities for All Users (inc ADA)
• Developing "Bench Strength" in Your Public Sector Organization
• Fork Lift Certification
• Fundamentals of PROW ADA Ramp Design, Layout, Inspection and Construction
• Heavy Equipment Operation (Hands On)
• Heavy Equipment Safety Operations
• High Strength Bolt Installation & Inspection
• How Great Organizations Create a Culture of Engagement
• Lead Effective Meetings
• Local Roadway Signing 101 On-site - Adams County
• Local Roadway Signing 101 On-site - Ramsey County
• Low Cost Safety Improvements
• LPA
• MUTCD Training
• Pavement Management: Full-Depth Reclaim & Stabilized Full-Depth Webinar
• Pavement Management: Hot-In-Place Recycling (HIP) Webinar
• Pavement Management: Micro-Surfacing & Slurry Seals Webinar
• PCCP Urban Joint Layout & Design
• Piling Basics - Design to Construction
• Preventing Runners and Backovers
• Preventing Runovers and Backovers
• Registered Stormwater Inspector
• Roadway Drainage
• Roadway Materials
• Seal Coat Workshop
• Selecting and Applying Asphalt Projects.
• Sign Truck Show N Tell Workshop On-site - Ramsey County
• Successful Public Speaking
• The Public Land Survey System - 1785 to Present - Part II
• Traffic Calming - Considerations, Applications & Impact

Workplace, Equipment and Jobsite Training v. Research Accomplishments
The following peer reviewed research reports were published during the rating period from grant DTRT13-G-UTC38.

<table>
<thead>
<tr>
<th>Project #</th>
<th>Title</th>
<th>Date</th>
<th>Report No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>425</td>
<td>Building a Sustainable GIS Framework for Supporting a Tribal Transportation Problem</td>
<td>Mar 2017</td>
<td>MPC 15-287</td>
</tr>
<tr>
<td>441</td>
<td>Pavement Management System for City of Madison</td>
<td>Nov 2016</td>
<td>MPC 16-314</td>
</tr>
<tr>
<td>421</td>
<td>Seismic Rehabilitation of Skewed and Curved Bridges Using A New Generation of Buckling Restrained Braces</td>
<td>Dec 2016</td>
<td>MPC 16-315</td>
</tr>
<tr>
<td>444</td>
<td>Data-Driven Freeway Performance Evaluation Framework for Project Prioritization and Decision Making</td>
<td>Jan 2017</td>
<td>MPC 16-316</td>
</tr>
<tr>
<td>403</td>
<td>Simplified Web-Based Decision Support Method for Traffic Management and Work Zone Analysis</td>
<td>Jan 2017</td>
<td>MPC 16-317</td>
</tr>
<tr>
<td>418</td>
<td>400 South Corridor Assessment</td>
<td>Mar 2017</td>
<td>MPC 16-318</td>
</tr>
<tr>
<td>419</td>
<td>Cracking and Debonding of Thin Fiber Reinforced Concrete Overlay</td>
<td>Apr 2017</td>
<td>MPC 16-319</td>
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<tr>
<td>392</td>
<td>Evaluation of Grouted Splice Sleeve Connections for Precast Reinforced Concrete Bridge Piers</td>
<td>Apr 2017</td>
<td>MPC 16-320</td>
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<tr>
<td>405</td>
<td>Seismic Retrofit of Spliced Sleeve Connections for Precast Bridge Piers</td>
<td>Mar 2017</td>
<td>MPC 16-321</td>
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<tr>
<td>407</td>
<td>Cell Phone Use Diminishes Self-Awareness of the Adverse Effects of Cell Phone Use on Driving</td>
<td>Mar 2017</td>
<td>MPC 16-322</td>
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<tr>
<td>407</td>
<td>Why Drivers Use Cell Phones and Support Legislation to Restrict This Practice</td>
<td>Apr 2017</td>
<td>MPC 16-323</td>
</tr>
<tr>
<td>379</td>
<td>Plastic-Aluminum Composites in Transportation Infrastructure</td>
<td>Mar 2017</td>
<td>MPC 16-324</td>
</tr>
</tbody>
</table>

c. How have the results been disseminated?
The 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) webpage postings and displays, and (7) Internet-based dissemination media, including broadcast emails and webinars.

d. What do you plan to do during the next reporting period to accomplish the goals/objectives?

No changes are foreseen to the accepted plan and implementation schedule.

2. Products: What has the program produced?

a. Publications, conference papers, presentations

   i. Key Conferences and Workshops

   - 2nd Serbian Road Congress
   - ASCE GeoChicago 2016: Sustainability, Energy, and the Geoenvironment
   - Asphalt Maintenance - Crack Sealing to Surface Repairs
   - ATSSA Traffic Control Technican
   - ATSSA Truck Mounted Attenuators
   - Basic Construction Survey
   - Basic Sign Installation
   - Changing Perspectives
   - Construction Project Management: Contract Administration
   - Construction Research Congress
   - Development of a Model to Assess the Feasibility of Transit-Oriented Development
   - Electrical Plan Reading - Inspection & Installation
   - Erosion Control Options
   - Ethics Awareness for the Transportation Industry
   - Evaluation of Grouted Spliced Sleeve Connections Reinforced Precast Concrete Bridge Piers -MPC Research Project
   - Fundamentals of Geometric Design: Exploring the Green Book
   - Gravel Roads Maintenance - New Manual Review
   - Guardrail Installation & Inspection
   - Guardrail Maintenance
   - Highway Pipe Installation
   - Hosted by Mineta Transportation Institute/San Jose State University
   - Implementation of Low Temperature Tests for Asphalt Mixtures
   - International Conference on Transport & Health
   - ITE Colorado-Wyoming Section Transportation Symposium
   - ITE Western District Annual Meeting
   - John Maxwell: 15 Invaluable Laws of Growth
   - John Maxwell: Sometimes You Win, Sometimes you Learn
   - John Maxwell: Today Matters
   - John Maxwell's Becoming A Person of Influence: How to Positively Impact the Lives of Others
• Joint Detailing for Improved Performance of Double Tee Bridge Systems - MPC Research Project
• Keyhole Technology for Urban Utility Excavations to Reduce the Impact of Pavement Cuts
• Leadership - Developing a Presence
• Leading a Successful Change Initiative
• Live Ride Share
• Technical Communication as a Writer & Presenter - 6 Sessions Webinar
• The Public Land Survey System - 1785 to Present - Part I
• Math for Survey and Construction
• Midyear Meeting of the TRB Geometric Design Committee (AFB10), Operational Effects of Geometrics Committee, and AASHTO Technical Committee on Geometric Design
• Midyear Meeting of the TRB Highway Safety Performance Committee (ANB25)
• Negotiation Strategies & Techniques to Improve Construction Project Mgmt
• Organized by the Transportation Public Health Link in Partnership with the
• PE Exam for Civil Engineers
• Pedestrian and Bicycle Safety
• Pipe Jacking for Culverts and Storm Sewers
• Practical Bridge Scour Analysis, Methods & Countermeasures
• Presenting the Story of Your Data
• Pro Walk/Pro Bike/Pro Place
• Reducing Roadway Departure Crashes
• Results Based Performance Mgmt
• Route & Preliminary Survey and LiDAR 3-D Modeling
• Seal Coat Workshop
• SHRP2 Implementation Assistance Program Issues Resolution Workshop
• Stormwater Detention & Design
• The Balancing Act: Stress and Productivity
• The Transportation Research Board Innovations in Travel Modeling Conference
• Tier IV Regeneration & Digital Multi-Meter Principles
• Tractor Mower Safety Training
• Traffic Data Collection
• Trenching Safety Practices
• Understanding Linear Scheduling for Roadway Construction Projects
• United States Centers for Disease Control & Prevention
• Utah Society of Professional Engineers Continuing Education Conference

ii. Key Publications


• Guoqing Gui, Hong Pan, Zhibin Lin, Yonghua Li and Zhijun Yuan, Data-Driven Support Vector Machine with Optimization Techniques for Structural Health Monitoring and Damage Detection, KSCE Journal of Civil Engineering, Volume 21, Issue 2, pp 523–534, 2017


• Kim, Y.J., Bumadian, I., and Park, J.-S. 2016. Galvanic current influencing interface deterioration of CFRP bonded to a steel substrate, Journal of Materials in Civil Engineering, American Society of Civil Engineers (ASCE), 28(2), 04015129

• Kim, Y.J. and Bumadian, I. 2016. Electrochemical reaction for steel beams strengthened with CFRP sheets, Engineering Structures, Elsevier, 125, 471-480


• Piatkowski, D., Marshall, W., and Johnson, A. Bicycle backlash: A qualitative examination of aggressive driver-bicyclist interactions. Transportation Research Record (doi: 10.3141/2662-03).


• Y. He, Z. Song, Z. Liu, Updating Highway Asset Inventory Using Airborne LiDAR, Measurement (2017), doi: http://dx.doi.org/10.1016/j.measurement.2017.03.026

iii. Key Conference Papers


iv. Key Presentations

- Bond behavior of GFRP bar-concrete interface: from prediction, damage evolution assessment to durability, American Concrete Institute (ACI) Convention, Philadelphia, PA, Oct. 24, 2016.
• Integrated Wireless Sensor Networks with UAS for Damage Detection and Monitoring of Bridges and Other Large-Scale Critical Civil Infrastructures, NDE/NDT for Highways & Bridges: Structural Materials Technology 2016, Portland, OR, Aug. 29-31, 201
• Piatkowski, D., Marshall, W., and Johnson, A. Bicycle backlash: A mixed-methods examination of aggression toward bicyclists. Association of Collegiate Schools of Planning Annual Conference; Portland, OR; November 2016.
- Terrill, T. and Ksaibati, K.;” Technology Challenges within Transportation Safety Among Several Indian Reservations”; Annual National Tribal Transportation Conference, Anaheim, CA, 2016.
- Terrill, T. and Ksaibati, K.;” Technology Transfer to Improve the Safety of the State Highway System on the Wind River Indian Reservation”; Annual National Tribal Transportation Conference, Anaheim, CA, 2016.

v. Other Items Produced During this Period


b. Books or other non-periodical, one-time publications

Nothing to report at this time.

c. Website(s) or other internet site(s)

The MPC website is fully operational at: http://www.mountain-plains.org/

The MPC Center Director can be found at: http://www.mountain-plains.org/personnel/

d. Technologies or Techniques

Nothing to report at this time.

e. Inventions, patent applications, and/or licenses?

Nothing to report at this time.

f. Other

Nothing to report at this time.

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

a. What individuals have worked on the program?

The principal investigators, faculty, and administrators participating in MPC projects:
Twelve principal investigators, faculty, and administrators participating in MPC projects at Colorado State University are: Christopher Bareither, Paul Heyliger, John W. van de Lindt, Bolivar Senior, Rebecca Atadero, Mehmet Ozbek, Suren Chen, Jeffrey D. Niemann, Hussam Mahmoud, Kelly Strong, Joseph Scalia and Scott Glick. In addition, fifteen students are working on MPC research projects at Colorado State University: Doctorate Students – Guanyang Hou, Luke Chen, Yufen Zhou, Chao Jiang; Masters Students – Kristen Peterson, Kayla Moden Taylor Ray, David Turner, Almotasem Maamon, Kelsey Czyzyk, Aliena Debelak, Avi Sharma, Xin Huang, Zana Taher and Trai Nguyen.


Eleven principal investigators, faculty, and administrators participating in MPC projects at South Dakota State University are: Allen L. Jones, Guanghui Hua, Christopher Schmit, Kyungnan Min, Nadim Wehbe, Mostafa Tazarv, Junwon Seo, Mostafa Tazarv, Jonathan Wood, Rouzbeh Ghabchi, and Aaron Breyfogle. In addition, fifteen students are working on MPC research projects at South Dakota State University: Masters Students - Ghaem Hooshyari, Peng Dai, Gregory Hansen, Lucas Bohn, Michael Mingo, Zachary Carnahan, Eduardo Torres, William Augustus Schaffer, Abdullah Al Hashib, Puskar Kumar Duhal, Shaohu Zhang Buddhika Prasad, and Mohammad Khazaeei; Undergraduate Students - Jason Weber and Sara Schoening.

Nine principal investigators, faculty, and administrators participating in MPC projects at the University of Colorado Denver are: Wesley Marshall, Carolyn McAndrews, Bruce Janson, Jimmy Kim, Austin Troy, Matthew Cross, Carolyn McAndrews, Yaill Jimmy Kim, and Farnoush Banaei-Kashani. In addition, ten students are working on MPC research projects at the University of Colorado Denver: Doctorate Students - Nick Ferenchak, Ibrahim Bumadian, Yaneev Golombek, Alejandro Henao, Abdullah Alajmi, Rob Fitzgerald; Masters Students – Ahmed Ibrahim, Nick Coppola, Rosenlieb E, and Yifeo Chai.

One principal investigator, faculty, and administrators participating in MPC projects at the University of Denver is: Patrick Sherry. In addition, 2 students are working on MPC research projects at the University of Denver: Masters Students - Jessica Mantia and Clare Jinzhao Zhao.

Fourteen principal investigators, faculty, and administrators participating in MPC projects at the University of Utah are: Richard J. Porter, Milan Zlatkovic, Tiffany Hortin, Cathy Liu, David Sanbonmatsu, David Strayer, Joel Cooper, Pedro Romero, Amanda Bordelon, Chris P. Pantelides, Juan Medina, and Brendan Duffy. In addition, twenty-four students are working on MPC research projects at the University of Utah: Doctorate Students - Ivana Tasic, Jeff Taylor, Kiavash Fayyaz, Arwen Behrends, Yu Song, Catalina Arboleda, Joel Parks, MJ Ameli, Anurag Upadhyay, Ruoyang Wu, Min Ok Kim, Anusha Musunuru, Zhuo Chen, and M. Scott Shea; Masters Students - Jem Locquiao, Daniel Sudbury, Yang Li, Lingkun Li, James Holt, Martin Dinsmore, Siddartha Rayaprolu, , Ryan Betz, Ariel Froerer, Daniel Sudbury, Joseph Herkimer, Kyle Strayer, Sean Strayer, and Donald Godfrey.
Ng, Promotes Saha, and Milan Zlatkovic. In addition, thirteen students are working on MPC research projects at the University of Wyoming: Masters Students - Chris Chamberlin, Mohammed Okok, Rameshwor Chalise, Sandeep Thapa, Trenna Terrell, Melake Brhanemeskel, Waleed Mohammed Abd Allah Al Eadelat, Sadia Sharmin, Muhammad Tahmidul Haq, Sherif Gaweesh, Thomas Peel and Dawit Mebrahtom; Undergraduate Student - Nicole Peterson.

Twelve principal investigators, faculty, and administrators participating in MPC projects at Utah State University are: Anthony Chen, Xiangdong Xu, Sarawut Jansuwan, Jim Bay, John Rice, Paul Barr, Marv Halling, Ziqi Song, and Paul J. Barr. In addition, ten students are working on MPC research projects at Utah State University: Doctorate Students – Yi He, Zhaocai Liu, Yi He, Seungkyu Ryu, and Sohrab Mamdoohi; Masters Students - Nirdosh Gaire, Jen Ostrowski, Phillip Powelson, Ethan Pickett, and Holly Llyod.

b. What other organizations have been involved as partners?
The timing of match funding and the commitments of collaborators vary widely throughout the life of the grant. During this period, we have the following committed collaborators.

1. Ajou University, Korea
2. Campbell County Road and Bridge Department
3. Campbell's Scientific
4. Colorado Department of Transportation
5. Consideration of the Rocky Mountains and Plain Regions
6. Converse County Road and Bridge Department
7. Crook County Road and Bridge Department
8. Denver Regional Transportation District
9. Digital Glove Foundation
10. East Dakota Water Development District
11. FHWA, Wyoming Division.
12. Inberg Miller Engineers, Casper WY
13. James River Water Development District
14. Key Laboratory of Road and Traffic Engineering, Tongji University, Shanghai, China.
15. Lincoln County Road and Bridge Department
16. Michigan Technological Research Institute
17. National Institute of Development Administration (NIDA), Bangkok, Thailand.
18. New Jersey City University
19. Nibble City (Utah), Campbell Scientific, Bridge Diagnostic Inc. (BDI)
20. North Carolina Pedestrian and Bicycle Information Center
21. North Dakota Department of Transportation
22. Penn State University
23. Roaring Fork Transportation Authority
24. Sisseton Wahpeton Oyate Reservation
25. South Dakota Department of Environment and Natural Resources
26. South Dakota Department of Transportation
27. Standing Rock Sioux Tribe Indian Reservation
28. Teton County Road and Bridge Department
29. University of Colorado Boulder
30. University of Nebraska-Lincoln
31. Utah Department of Transportation
32. Virginia Tech  
33. Wisconsin Department of Transportation  
34. Wyoming Technology Transfer Center  
35. Yankton Sioux Tribe  

c. Have other collaborators or contacts been involved?  

The list of collaborating organizations in 3(b) is complete, as of this grant period.  

4. Impact/ Expected Impacts  

a. Impacts  

North Dakota State University: Students supported by UTC funds here at North Dakota State University have gone onto very successful positions with fortune 500 companies, academia, federal, state, and local transportation agencies. Students continue to excel while building transportation skills that will enhance the transportation workforce now into the future. With the support of UTC funds, NDSU researchers have been able to focus on tribal needs throughout the state, infrastructure assessment, asset management, bridge strength analysis, and technology transfer. These efforts will continue to develop the skills and knowledge of the transportation workforce to face the challenges of the 21st century. NDSU researchers continue to move into sensor networks, smart city applications, and addressing the needs and challenges of public transportation in rural and metropolitan areas. Research findings are being disseminated through webinars, transportation learning network, newsletters, social media, and email blasts.  

Wyoming: The MPC projects provided excellent learning opportunities to students at the graduate level as well as the undergraduate levels. Several students graduated from the program. The UW research projects helped in implementing PMS on county paved roads. In addition, the tribal safety studies helped several tribes in the region implement a safety improvement program.  

Colorado State University: Several graduate students working on MPC projects at CSU have earned their degrees and are now part of the civil engineering and transportation workforce. The journal paper on using BIM for tracking bridge structural condition has been a frequently downloaded paper for the Journal of Bridge Engineering, which suggests that it is having an impact on the research community.  

South Dakota State University: The projects provided research and learning experience for 15 graduate students. Thirty-one engineers learned about a new detailing for longitudinal joints in double tee girders which will lead to the design of better and long lasting bridges on county roads in transportation Region 8. SDDOT will achieve efficiency with construction quality control of compaction activities. Potential reuse of MIEX brine for ice control at SDDOT which could lead to the implementation of beneficial reuse of this waste stream at SDDOT. Development of standard SCC mix design and new recommendations for prestressed SCC mix design.  

University of Colorado Denver: For the Civil Engineering discipline, the MPC associated research and education efforts have been instrumental in helping grow our transportation program and establish a solid reputation. We have once again broadened our reach and brought in researchers from not only Urban Planning but also Geography, GIS, Computer Science, and Construction Engineering. Our efforts are helping build a transportation workforce with both technical skill and expertise as well as the ability to understand the larger context of their work. Our affiliation with the MPC and the UTC program is the improving national reputation of CU Denver's research and education work within the field of
transportation. This program period continues our successes with regard to publications, presentations, and popular press articles related to these efforts. The research activities address three important national issues - infrastructure deterioration, safety, and sustainability. Our educational program is also helping building better students in areas of national need.

**University of Utah:** The program already shows substantial support in the area of workforce development, with 24 undergraduate and graduate students heavily involved in the research projects.

**Utah State University:** We have a multi-disciplinary approach with transportation, structures and geotechnical engineering on these projects so the research impact is broad in terms of scope within civil engineering. Each project has at least one graduate student (at the MS or PhD level) and many also involve undergraduate students. We also hope and anticipate that the technology or research findings will be distributed through reports, conferences and journal publications.

**b. Expected Impacts**

**North Dakota State University:** NDSU transportation and logistics students will continue to infiltrate the transportation workforce bringing excellent data analysis and assessment skills to the organizations. Students continue to present and participate in industry workshops and conferences, and seek top level transportation positions around the world. NDSU researchers continue to disseminate the results of ongoing projects and research to transportation professionals around the state. Expected outcomes will continue to be shared through technology transfer opportunities, webinars, and social media.

**Wyoming:** The MPC funding will continue supporting graduate students who will join the transportation workforce after graduation. The research studies conducted will facilitate selecting maintenance and rehabilitation strategies on local paved roads, reduce crashes on tribal roads, enhance the effectiveness of air quality programs such as the CMAQ program, and reduce truck related crashes in rural areas.

**Colorado State University:** In addition to the educational impacts that are currently being realized, projects in the CSU program are expected to help engineering designers and decision makers make more effective choices in a variety of transportation related fields including design for resilience, planning, and asset maintenance and management.

**South Dakota State University:** Development of a low-maintenance, low-cost mixed-media filtration system for storm water treatment. This filtration system can be used to reduce the impact of highway runoff on surface waters and improve the environmental sustainability of transportation. Transform waste streams that are now environmentally and financially expensive to discard into valuable materials for transportation-related applications and improve the performance of ice and dust control on roadways. Reuse of waste streams for transportation applications in South Dakota. Development of new rehabilitation techniques for bridge girder joints. Extending the useful life and eliminating the need for replacement of many existing bridges on local roads. Final reports and digital brochures will be prepared to disseminate the findings to DOTs, bridge engineers, local governments, and bridge owners.

**University of Colorado Denver:** Expanding our portfolio of work has continued to help grow the UTC program at CU Denver. More importantly, the work we are doing is helping develop the next generation of transportation professionals and doing so in a way that will benefit society in many different fashions. These projects will be of particular benefit to those looking to provide and promote a safer and more resilient transportation system.

**University of Utah:** Results of the ongoing projects are expected to be implemented in state
transportation and transit agency policies, procedures, and practices related to road and transit infrastructure planning, design, construction, and operations. Example expected broader project outcomes include: the ability to more thoroughly assess innovative intersection/interchange designs; increase transit ridership through more accessible stations, improve infrastructure resiliency to earthquakes, gain greater insights to distracted driving behavior, extend pavement life, quantify benefits of transit signal priority implementations, and improve air quality. Expected outcomes will also include training of the next generation of the transportation workforce in these areas, by working with undergraduate and graduate students in the research and by incorporating results into existing and future transportation courses at the University of Utah. Chances of implementation and technology transfer have been maximized by including transportation agency practitioners in the formulation and review of research problem statements. Practitioners are also providing feedback to the research teams on a regular basis through technical advisory committees formed for each project.

**Utah State University:** The individual projects have addressed the specific impacts for their projects. From an overall prospective, the UTC funding is creating opportunities. These opportunities are within the university as well as with agencies outside the university. They are providing students with unique transportation related research that they would not have otherwise and giving them connections for potential jobs and mentoring after school. There is long term impacts of a growth in the transportation workforce through projects that are exciting for these students.

5. **Changes/Problems**

No changes are foreseen at this time.

5a. **Additional Information Regarding Products and Impacts**

Nothing to report at this time.

**PROGRAM OUTPUTS:** Nothing to report at this time.

**PROGRAM OUTCOMES:** Nothing to report at this time.

**PROGRAM IMPACTS:** Nothing to report at this time.

6. **SPECIAL REPORTING REQUIREMENTS:** None