**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**
**Denver.tolliver@ndsu.edu**
**(701)231-7190**

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**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**

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**Semi-Annual PPPR#5**

**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 Competiveness, while addressing critical issues of the region and stakeholder groups.

### b. What was accomplished under these goals?

#### i. Project Selection

Seventy-twoy research projects were selected from 2013 to present under this grant. Projects have been selected for the original grant, Modification 1 and 2 while projects are still being submitted for the Modification 3 to the original grant. Thus the peer review process is ongoing for possible selection. 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 Competiveness, Livable Communities, and Environmental Sustainability. MPC Projects selected under this grant include; MPC-371, 409, 447, 451, 472 (Year 2), MPC-446 through MPC-511.

**Table 1: MPC Research Projects Most Directly Correlated with Safety**

1. MPC-453: Speed Selection Behavior during Winter Road Conditions
2. MPC-454: Regional Implementation of Tribal Transportation Safety Program
3. MPC-455: Why Are Bike-Friendly Cities Safer for All Road Users?
4. MPC-458: Application of a Multi-Agent System with the Large-Scale Agent-Based Model for Freight Demand Modeling
5. MPC-460: Technology and Workforce Development for Remote Sensing of the Transportation Infrastructure
6. MPC-461: Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards
7. MPC-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory
8. MPC-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges
9. MPC-467: Self-Regulation and Distraction
10. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
11. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation

12. MPC-472: Developing an Optimization Model for Managing County Paved Roads
13. MPC-473: Bicycle and Pedestrian Design for Rural Communities
14. MPC-474: Highway Safety Manual Part D: Validation and Application in Wyoming
15. MPC-475: Analysis of the Relationship of Roadside Inspections on Large Truck Crashes
16. MPC-476: Highway-Rail Grade Crossing Traffic Hazard Forecasting Model
17. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
18. MPC-480: A Comprehensive Safety Assessment Methodology for Innovative Geometric Designs
19. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
20. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
21. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges
22. MPC-491: Self-Centering Buckling Restrained Braces for Curved Bridges
23. MPC-495: Safety Effects of Protected and Protected/Permitted Left-Turn Phases
24. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
25. MPC-503: Characterization of Crushed Bases in Wyoming
26. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
27. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation

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

1. MPC-446: A Modified Approach for Predicting Fracture of Steel Components under Combined Large Inelastic Axial and Shear Strain Cycles
2. MPC-447: Post-Fire Ground Treatments for Protection of Critical Transportation Structures
3. MPC-448: Reducing Flood Vulnerability of Communities with Limited Road Access by Optimizing Bridge Elevation
4. MPC-449: Determining the Uncertainty in the Current Condition of Bridges for Use in Risk Based Inspection and Management
5. MPC-450: Using Building Information Modeling to Track and Assess Structural Condition
6. MPC-451: Assessing the Cost-Effectiveness of Wyoming's CMAQ Unpaved Road Dust Suppression Program
7. MPC-452: Updating the Highway Safety Manual 2010 - Part C: Regional Consideration of the Rocky Mountains and Plain Regions
8. MPC-456: Performance of Steel Girders Repaired with Advanced Composite Sheets in a Corrosive Environment: A Multi-Physics Approach Leading to Practical Design Recommendations
9. MPC-458: Application of a Multi-Agent System with the Large-Scale Agent-Based Model for Freight Demand Modeling
10. MPC-460: Technology and Workforce Development for Remote Sensing of the Transportation Infrastructure
11. MPC-461: Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards
12. MPC-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory
13. MPC-463: Rehabilitation Project Selection and Scheduling in Transportation Networks

14. MPC-464: Development of Network-Based Measures and Computational Methods for Evaluating the Redundancy of Transportation Networks
15. MPC-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges
16. MPC-468: Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance)
17. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
18. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
19. MPC-472: Developing an Optimization Model for Managing County Paved Roads
20. MPC-477: Characterizing the ductility of Portland cement stabilized soil
21. MPC-478: Long-Term Behavior of Precast Concrete Bridges
22. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
23. MPC-481: Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure
24. MPC-482: Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems
25. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
26. MPC-484: Effect of Service Temperature on Joint Removal in Steel Bridges
27. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
28. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges
29. MPC-492: Early-Age Fiber-Reinforced Concrete Properties for Overlays
30. MPC-493: Incorporating Maintenance Costs and Considerations into Highway Design Decisions
31. MPC-494: Statistical Analysis and Sampling Standards for Maintenance Management Quality Assurance (MMQA)
32. MPC-496: Prevention of Low Temperature Cracking of Pavements
33. MPC-497: Compaction Testing of Granular Materials
34. MPC-500: Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
35. MPC-501: Development of an Alternative to the Double Tee Bridge System
36. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
37. MPC-503: Characterization of Crushed Bases in Wyoming
38. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
39. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation

**Table 3: MPC Research Projects Most Directly Correlated with Economic Competitiveness**

1. MPC-451: Assessing the Cost-Effectiveness of Wyoming's CMAQ Unpaved Road Dust Suppression Program
2. MPC-456: Performance of Steel Girders Repaired with Advanced Composite Sheets in a Corrosive Environment: A Multi-Physics Approach Leading to Practical Design Recommendations
3. MPC-460: Technology and Workforce Development for Remote Sensing of the Transportation Infrastructure
4. MPC-463: Rehabilitation Project Selection and Scheduling in Transportation Networks

5. MPC-464: Development of Network-Based Measures and Computational Methods for Evaluating the Redundancy of Transportation Networks
6. MPC-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges
7. MPC-466: First and Last Mile Strategies for Transit Systems
8. MPC-468: Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance)
9. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
10. MPC-470: Evaluating Transportation Professional Development and Continuing Education Courses
11. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
12. MPC-472: Developing an Optimization Model for Managing County Paved Roads
13. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
14. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
15. MPC-488: Effects of Infill Development and Regional Growth on At-Risk Populations' Exposure to Traffic Density
16. MPC-494: Statistical Analysis and Sampling Standards for Maintenance Management Quality Assurance (MMQA)
17. MPC-497: Compaction Testing of Granular Materials
18. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
19. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
20. MPC-500: Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
21. MPC-501: Development of an Alternative to the Double Tee Bridge System
22. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
23. MPC-503: Characterization of Crushed Bases in Wyoming
24. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
25. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation

**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-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges
4. MPC-466: First and Last Mile Strategies for Transit Systems
5. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
6. MPC-473: Bicycle and Pedestrian Design for Rural Communities
7. MPC-485: Development of a Model to Assess the Feasibility of Transit-Oriented Development (TOD) Projects
8. MPC-489: The Unresolved Relationship between Street Trees and Road Safety

9. MPC-490: Longevity of Air Pollution Mitigating Photo-Catalytic Coatings on Transportation Infrastructure
10. MPC-491: Self-Centering Buckling Restrained Braces for Curved Bridges
11. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
12. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications

**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
4. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
5. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
6. MPC-472: Developing an Optimization Model for Managing County Paved Roads
7. MPC-473: Bicycle and Pedestrian Design for Rural Communities
8. MPC-477: Characterizing the ductility of Portland cement stabilized soil
9. MPC-485: Development of a Model to Assess the Feasibility of Transit-Oriented Development (TOD) Projects
10. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
11. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges
12. MPC-488: Effects of Infill Development and Regional Growth on At-Risk Populations' Exposure to Traffic Density
13. MPC-489: The Unresolved Relationship between Street Trees and Road Safety
14. MPC-490: Longevity of Air Pollution Mitigating Photo-Catalytic Coatings on Transportation Infrastructure
15. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
16. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
17. MPC-503: Characterization of Crushed Bases in Wyoming

### iii. Educational Accomplishments

The transportation and transportation-related courses offered during Fall 2015 and Spring 2016 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 6: Transportation and Transportation-Related Courses Offered This Period**

| Major Subject Area | Course Title |
|---|---|
| **Engineering & Design** | CIVE 303 Infrastructure and Transportation Systems |
| | CIVE 355 Geotechnical Engineering |
| | CIVE 467 Design of Reinforced Concrete Structures |
| | CIVE 566 Advanced Steel Behavior and Design |
| | CIVE 567 Advanced Concrete Design |
| | CIVE 577 GIS in Civil and Environmental Engineering |
| | CIVE 581 Bridge Engineering and Hazards |

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|---|---|
| | CEE 452/552 Prestressed Concrete |
| | CEE 732 Advanced Foundation Engineering |
| | CEE 754 Advanced Steel Structures |
| | CEE 106/106L Elementary Surveying and Lab |
| | CEE 792 Topics-Advanced Topics in Reinforced Concrete |
| | CEE 759 Structural Dynamics |
| | CEE 458/558 Timber Design |
| | CEE 456 Theory and Design of Reinforced Concrete |
| | CEE 447/547 Foundation Engineering |
| | CVEN 3602 Transportation Engineering |
| | CVEN 4602 Highway Engineering |
| | CVEN 5602 Advanced Street & Highway Design |
| | CVEN 5682 Pavement Design |
| | CvEEN 2130 Statistics and Economics |
| | CvEEN 5420 Open Channel Flow |
| | CvEEN 5570 Pavement Design |
| | CvEEN 5510 Highway Design |
| | CvEEN 5500 Sustainable Materials |
| | CvEEN 5220 Concrete Design II |
| | CvEEN 6225 Concrete Science |
| | CvEEN 7920 Advanced Material Testing |
| | CvEEN 7250 Structural Earthquake Engineering |
| | CE 4510/5510 Pavement Design |
| | CE 3500 Highway Engineering |
| | CEE 3210 Introduction to Transportation Engineering |
| | CEE 3080 Reinforced Concrete Design |
| | CEE 6930 Prestressed Concrete Design |
| | CEE 6140 Bridge Design |
| | CEE 6130 Structural Dynamics and Seismic Design |
| **Freight & Logistics** | TL 711 Logistics Systems |
| | TL 811 Modeling for Logistics Research |
| | TL 782 Highway Planning and Logistics |
| **Planning & Environment** | CVEN 5612 Traffic Impact Assessment |
| | CVEN 5460 Introduction to Sustainable Urban Infrastructure |
| | URPL 5040 Urban Sustainability |
| | URPL 5050 Urban Development |
| | URPL 6300 Planning Healthy Communities |
| | URPL 6350 Form and Formation of Cities |
| | URPL 6399 Introduction to Sustainable Urban Infrastructure |
| | URPL 6400 Community Development |
| | URPL 6550 Transportation Planning/Policy |
| | URPL 6645 Disaster/Climate Change Planning |
| | URPL 6370 Sprawl and Growth Management |
| | URPL 5000 Planning History and Theory |

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|---|---|
| | URPL 5010 Planning Methods |
| | URPL 6650 Planning in the Developing World |
| | CvEEN 5560 Transportation Planning |
| | CEE 5240 Urban and Regional Transportation Planning |
| | TL 752 Transportation Planning and Environmental Compliance |
| | TL 723 Advanced Supply-Chain Across the Enterprise |
| | TL 823 Contemporary Supply Chain Research |
| | TL 785 Spatial Analysis in Transportation |
| **Public Transportation** | CVEN 5800 Transit Construction |
| | TL 786 Public Transportation |
| | TL 787 Public Transportation II |
| **Traffic & Operations** | CEE 363 Highway and Traffic Engineering |
| | CVEN 5621 Highway Capacity Analysis |
| | CVEN 5622 Traffic Operations and Control |
| | CvEEN 3520 Transportation Engineering |
| | CvEEN 6525 Highway and Traffic Engineering |
| | CEE 5220 Traffic Engineering |
| **Transportation Safety** | CVEN 5611 Traffic and Safety Data Analysis |
| | CVEN 5662 Transportation System Safety |
| | CvEEN 7520 Transportation Safety |
| | CE 5560 Traffic Safety |
| | CEE 6250 Transportation Data/Safety Analysis |
| | TL 719 Crisis Analysis and Homeland Security |
| **Transportation Systems** | URPL 6555 Transportation and Land Use |
| | CVEN 5633 Case Studies in Sustainable Transportation |
| | CvEEN 7540 Intelligent Transportation Systems |
| | CEE 6290 Transportation Network Analysis |
| | CEE 6210 Transportation Systems Analysis |
| | TL 751 Transportation Systems Security |
| | TL 754 Urban Transportation Systems Analysis |
| | TL 756 Transportation Systems Laboratory |
| | TL 783 Transportation Systems II |

Altogether, 83 transportation and transportation-related courses have been offered this reporting period, for a total of 362 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.

1. 2015 Highway Capacity Manual Overview & Related Software Changes

2. AGC Private Course
3. Asphalt Maintenance: Crack Sealing to Surface Repair
4. Asphalt Paving Maintenance 1
5. Asphalt Paving Maintenance 2
6. ATSSA Application & Operation of Truck-Mounted Attenuators
7. ATSSA Flagger Certification
8. ATSSA Flagger Instructor Training
9. ATSSA Traffic Control Supervisor
10. ATSSA Traffic Control Technician
11. Basic Construction Survey
12. Basics of a Good Road
13. Communication Skills for Supervisors
14. Confided Space Training
15. Construction Project Management
16. Designing for Pedestrian and Bicycle Safety
17. Erosion & Sediment Control: Construction Certificate Training
18. Erosion and Sediment Control
19. Erosion Control Options
20. Evaluation of Grouted Spliced Sleeve Connections for Reinforced Concrete Bridge Piers
21. Excavating and Trench Awareness
22. Fork Lift Certification
23. Fundamentals of PROW ADA Ramp Design, Layout, Inspection and Construction
24. Future of Transportation in Denver Summit
25. Guardrail Installation and Inspection
26. Guardrail Maintenance
27. Heavy Equipment Operation (Hands On)
28. Heavy Equipment Safety Operations
29. Highway Pipe Installation - Construction Installation & Inspection
30. Implementation of Low Temperature Tests For Asphalt Mixtures
31. John Maxwell:  Sometime You Win, Sometimes You Learn
32. John Maxwell's Becoming a Person of Influence: How to Positively Impact the Lives of Others
33. Joint Detailing for Improved Performance of Double Tee Bridge System
34. Keyhole Technology for Urban Utility Excavations to Reduce the Impact of Pavement Cuts
35. Local Roadway - Signing 101
36. Math for Survey and Construction
37. MUTCD Training
38. NDACE Conference
39. NDLTAP Advisory Board Meeting
40. Negotiation Strategies and Techniques to Improve Construction Project Management
41. New Supervisor Training "You Earned the Position, Now Let's Make the Most of it!"
42. OSHA 10-Hr Training Specifically of Roadway Construction
43. Pedestrian and Bicycle Safety
44. Pipe Jacking for Culverts and Storm Sewers
45. Practical Bridge Scour Analysis, Methods & Countermeasures
46. Preventing Runovers & Backovers / Road Safety
47. Reducing Roadway Departure Crashes
48. Registered Stormwater Inspector

49. Research Presentation - Implementation of Low Temperature Tests for Asphalt Mixtures
50. Roadway Drainage
51. Roadway Foundation Demonstration Workshop
52. Roadway Materials
53. Roundtable: Traffic Data Collection
54. Seal Coat Workshop
55. Sign Truck Show N Tell
56. Stormwater Detention and Design
57. The Balancing Act: Stress and Productivity
58. UGPTI Annual Banquet
59. Unpaved Road, Maintenance and Design
60. 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.

| **Project #** | **Title** | **Date** | **Report No.** |
|---|---|---|---|
| 423 | Impact of Energy Sector Growth on Perceived Transportation Safety in the 17-County Oil Region of Western North Dakota: A Three-Year Case Study | Oct 2015 | MPC 15-289 |
| 367 | Indian Reservation Safety Improvement Program: A Methodology and Case Study | Nov 2015 | MPC 15-291 |
| 386 | Use of Travel Time, Travel Time Reliability, and Winter Condition Index Information for Improved Operation of Rural Interstates | Dec 2015 | MPC 15-295 |
| 384 | Understanding Public Perceptions of Different Options to Fund the Highway System | Dec 2015 | MPC 15-300 |
| 327 | Seismic Risk Assessment for the I-25/I-70 Corridor in the Mountain Plains Region of the U.S. | Dec 2015 | MPC 15-296 |
| 428 | Risk of Alkali-Silica Reaction when Using Recycled Concrete Aggregate in New Concrete | Dec 2015 | MPC 15-302 |
| 410 | Predicting Fatigue Service Life Extension of RC Bridges with Externally Bonded CFRP Repairs | Dec 2015 | MPC 15-292 |
| 343 | Innovative and Economical Steel Bridge Design Alternatives for Colorado | Dec 2015 | MPC 15-298 |
| 442 | Improving Rural Emergency Medical Services (EMS) through Transportation System Enhancements Phase II | Dec 2015 | MPC 15-301 |
| 427 | Fire Performance of Bridge Members Retrofitted with Near-surface-mounted Carbon Fiber Reinforced Polymer Composites | Dec 2015 | MPC 15-303 |
| 417 | Developing a Livability Program for Indian Reservations: A Methodology and Case Study | Dec 2015 | MPC 15-293 |

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|---|---|---|---|
| 429 | Developing A Methodology to Inspect and Assess Conditions of Short Span Structures on County Roads in Wyoming | Dec 2015 | MPC 15-290 |
| 432 | Could Cattle Guards Augmented with Electrified Pavement Prevent Mule Deer and Elk Access to Highways? | Dec 2015 | MPC 15-297 |
| 431 | Connected Vehicle Weather Data for Operation of Rural Variable Speed Limit Corridors | Dec 2015 | MPC 15-299 |
| 365 | Calibration of the Mechanistic-Empirical Pavement Design Guide for Local Paved Roads in Wyoming | Dec 2015 | MPC 15-294 |
| 470 | Guidelines for Effective LTAP Course Evaluation | Jan 2016 | MPC 16-305 |
| 408 | Evaluation of New Reactive FRP Reinforcement Assemblies for Reinforced Concrete Transportation Structures | Jan 2016 | MPC 16-304 |
| 445 | A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness | Feb 2016 | MPC 16-306 |
| 366 | Structural Health Monitoring of Highway Bridges Subjected to Overweight Trucks, Phase I - Instrumentation Development and Validation | Mar 2016 | MPC 16-307 |

### 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

- 2016 ASCE Geotechnical and Structural Engineering Congress, Phoenix, Arizona, February 14-17, 2016
- 95th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan 10-14, 2016
- ACI Fall 2015 Convention, Denver, CO
- Active Living Research Conference, Clearwater, FL
- American Concrete Institute Convention, Denver, CO
- Association of Collegiate Schools of Planning Conference, Houston, TX
- Convergence: the Intersection of Technology and Transportation, Eno Center for Transportation, Washington, D.C.
- Disrupting Mobility Summit, Boston, MA

- Institute of Transportation Engineers (ITE) Utah Chapter Annual Conference, Salt Lake City, UT
- International Forum on Traffic Records and Highway Information Systems, Costa Mesa, CA
- Rocky Mountain Asphalt User Producer Group (RMAUPG) Semi-Annual Meeting. Salt Lake City, UT
- SPIE Smart Structures/NDE 2016, Las Vegas, NV, March 24, 2016
- The 8th International Engineering and Construction Conference (ISEC-8), Sydney, Australia
- Transportation 101, Wyoming Engineering Society Annual Meeting, Sheridan, WY Feb. 2016
- University of Utah: Transportation Research Board 95th Annual Meeting, Washington, D.C.
- Utah Department of Transportation (UDOT) Annual Conference, Sandy, UT
- Western Association of State Highway Officials (WASHO) Materials Meeting. Salt Lake City, UT
- Western Regional Science Association Annual Meeting, Big Island of Hawaii

### ii. Key Publications

- Accident Prediction for Highway-Rail Grade Crossings using Decision Tree Approach: An Empirical Analysis
- Bridgelall, R., Rafert, J. B., Tolliver, D., Lee, E., "Resolution Agile Remote Sensing for Hazardous Material Spill Detection," Transportation Research Record: Journal of the Transportation Research Board, (in press).
- Eadelat, W.A., Saha, P., and Ksaibati, K. "Development of Serviceability Prediction Model for Local County Paved Roads." International Journal of Pavement Engineering. DOI: 10.1080/10298436.2016.1176167
- Eadelat, W.A., Saha, P., and Ksaibati, K. "Relationship between the International Roughness Indices determined by Android-based Smartphone Application and Inertial Profiler for Local Roads".
- Fayyaz S., S.K., Liu, X.C., and Porter, R.J. "A Genetic-Algorithm and Regression-Based Model for Analyzing Fare Payment Structure and Transit Dwell Time," accepted for publication in Transportation Research Record: Journal of the Transportation Research Board, 2016. (yes)
- Fei Yan and Zhibin Lin, New strategy for anchorage reliability assessment of GFRP bars to concrete using hybrid artificial neural network with genetic algorithm, Composites Part B: Engineering, Vol.92, 2016, p. 420–433.
- Kim, Min Ook, and Amanda Bordelon. Fiber effect on interfacial bond between concrete and fiber-reinforced mortar, Journal of the Transportation Research Board: Transportation Research Record, No. 2591, 2016, pp. 11-18. (yes)
- Kim, Y.J. 2015. Modeling of NSM CFRP for strengthening RC beams in sustained load, ACI Structural Journal, American Concrete Institute (ACI) , 112(6), 805-813
- Kim, Y.J. and Namrou, A. 2016. Interface between near-surface-mounted CFRP-concrete interface in thermal distress ACI Structural Journal, American Concrete Institute (ACI), 113(1), 29-38
- 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
- Marshall, W., and Ferenchak, N. Assessing Equity and Urban/Rural Road Safety Disparities in the U.S. Journal of Urbanism (revise and resubmit).

- Marshall, W., Piatkowski, D., and Johnson, A. Scofflaw Bicyclists – Illegal but Rational. Journal of Transport and Land Use (revise and resubmit).
- MPC-476: Highway-Rail Grade Crossing Traffic Hazard Forecasting Model
  In press: journal of transportation research records 2016
- Namrou, A. and Kim, Y.J. 2016. Residual performance of concrete-adhesive interface at elevated temperatures, Construction and Building Materials, Elsevier, 105, 113-12
- Rafert, James Bruce, Jaime Zabalza, Stephen Marshall, Jinchang Ren, "Singular spectrum analysis: A note on data processing for Fourier transform hyperspectral imagers", Applied Spectroscopy (in press)
- Sanbonmatsu, D. M., Strayer, D. L., Behrends, A. A., Medeiros-Ward, N., and Watson, J. M. (2016). Why drivers use cell phones and why they support legislation to restrict this practice. Accident Analysis and Prevention. 92, 22-33. (yes)
  http://dx.doi.org/10.1016/j.aap.2016.03.010
- Sanders, P.B., Atadero, R.A., Ozbek, M.E. Methodology For Uncertainy-Based Inspection Planning of Concrete Bridge Decks for Delamination, Journal of Bridge Engineering, under revision.
- Song, Y., Zlatkovic, M., and Porter, R.J. "GPS-Based Transit Signal Priority for Mixed-Traffic Bus Rapid Transit," accepted for publication in Transportation Research Record: Journal of the Transportation Research Board, 2016. (yes)
- Tasic, I. and Porter, R.J. "Modeling Spatial Relationships between Multimodal Transportation Infrastructure and Traffic Safety Outcomes in Urban Environments," In Safety Science 82, 2016, pp. 325-337. (no)
- Tasic, I., Porter, R.J., and Brewer, S.C. "Applications of Generalized Additive Models and Bayesian Hierarchical Models for Areal Safety Analysis of Urban Multimodal Transportation Systems," accepted for publication in Transportation Research Record: Journal of the Transportation Research Board, 2016. (no)
- Wehbe, Nadim, Michael Konrad, Aaron Breyfogle. Joint Detailing between Double Tee Bridge Girders for Improved Serviceability and Strength. Transportation Research Record, Washington, D.C., 2016 (in print). MPC support is acknowledged.
- Wen, H. and Mahmoud, H. (2016) "Block Shear. I: Numerical Simulation and Fracture Characterization", ASCE Journal of Structural Engineering, Submitted for Review.
- Wen, H. and Mahmoud, H. (2016) "Block Shear. II: Failure Classification and Strength Evaluation", ASCE Journal of Structural Engineering, Submitted for Review.
- Xiao, Qin, Zhao Shen, and Nadim Wehbe. Predicting Collision Risk between Trucks and Interstate Overpasses. Journal of Transportation Engineering (in print). MPC support is acknowledged.
- Xu, X., A. Chen, and C. Yang. A review of sustainable network design for road networks. KSCE Journal of Civil Engineering 20(3), 1084-1098, 2016.
- Zhuo Chen and Xiaoyue Liu. Spatial sampling with Fisher information for optimal maintenance management and quality assurance (MMQA). ASCE Journal of Transportation Engineering, under review. (yes)

### iii. Key Conference Papers

- Bridgelall, R., Rafert, J. B., Atwood, D., Tolliver, D., "Hyperspectral Range Imaging for Transportation Systems Evaluation," in Proc. SPIE Smart Structures/NDE 2016, Las Vegas, NV, March 24, 2016.
- Bridgelall, R., Rafert, J. B., Tolliver, D., Lee, E., "Resolution Agile Remote Sensing for Transportation Safety," in Proc. Transportation Research Board, Washington, D.C., Jan 10-14, 2016.

- Bumadian, I. Kim, Y.J., and Ji. Y 2015. Electrode potentials deteriorating behavior of CFRP-strengthened steel beams, 12th International Symposium on Fiber Reinforced Polymers for Reinforced Concrete Structures, Nanjing, China
- Fayyaz S., S.K., Liu, X.C., and Porter, R.J. "A Genetic-Algorithm and Regression-Based Model for Analyzing Fare Payment Structure and Transit Dwell Time," Compendium of Papers from the 95th Annual Meeting of the Transportation Research Board, Washington, D.C., January 10-14, 2016.
- Ferenchak, N. and Wesley E. Marshall. Relative (In)Effectiveness of Bicycle Sharrows on Ridership and Safety Outcomes. Transportation Research Board, Washington, D.C., January, 2016.
- Jansuwan, S., A. Chen, K. Subprasom, K. Pinthong, N. Indra-Payoong. "Development of a Decision Support System for Assessing Vulnerability of National Highway Networks: Case Study of 2011 Mega Flood in Thailand." 20th Hong Kong Society of Transportation Studies Conference: Urban Transport Analytics, Hong Kong, P.R. China, 2015.
- Song, Y., Zlatkovic, M., and Porter, R.J. "GPS-Based Transit Signal Priority for Mixed-Traffic Bus Rapid Transit," Compendium of Papers from the 95th Annual Meeting of the Transportation Research Board, Washington, D.C., January 10-14, 2016.
- Tasic, I., Porter, R.J., and Brewer, S.C. "Applications of Generalized Additive Models and Bayesian Hierarchical Models for Areal Safety Analysis of Urban Multimodal Transportation Systems," Compendium of Papers from the 95th Annual Meeting of the Transportation Research Board, Washington, D.C., January 10-14, 2016.
- Taylor, J., Liu, X., and Wei, R. Bike-sharing Facility Expansion Planning with Location-Allocation Modeling. Proceedings for the Western Regional Science Association Annual Meeting, Big Island of Hawai'i, February 14-17, 2016.
- Terrill, T.; Shinstine, D.; and Ksaibati, K.; "Methodology to Assess and Compare the State Highway System with the Local Roadway System on the Wind River Indian Reservation"; Transportation Research Board Meeting, Washington D.C., 2016.
- Upadhyay, A., Pantelides, C.P., and Ibarra, L. (2016). "Seismic performance of curved bridges on soft soils retrofitted with buckling restrained braces." Geotechnical and Structural Engineering Congress 2016, ASCE, 118-137.
- Wehbe, Nadim and Walker Olson. Experimental Evaluation Of Misaligned Tie Bar Effects On PCC Pavement Longitudinal Joints. Proceedings of the 8th International Structural Engineering and Construction Conference: Implementing Innovative Ideas in Structural Engineering and Project Management, Sydney, Australia, November 23-28, 2015. pp. 1159-1164. MPC support is acknowledged.
- Wehbe, Nadim, Michael Konrad, and Aaron Breyfogle. Precast Bridge Girder Details for Improved Performance. TRB 95th Annual Meeting, Washington, D.C., 2016. MPC support is acknowledged.
- Xingyu Wang, Xiaoning Qi, Zhibin Lin, Na Gong and Jinhui Wang, Electrochemical Characterization of Soils Surrounding Buried or Embedded Steel Elements (accepted), ASCE's Pipelines 2016 Conference, July 17-20 in Kansas City, MO.
- Xu, X., A. Chen, L. Cheng, and C. Yang. "A link-based mean-excess traffic equilibrium model under uncertainty." 95th Transportation Research Board Annual Meeting, Washington D.C., 2016.
- Zlatkovic, Milan, and Cameron Kergaye. "Performance Matrices for Evaluating Innovative Intersections and Interchanges," Compendium of Papers from the 95th Annual Meeting of the Transportation Research Board, Washington, D.C., January 10-14, 2016.

### iv. Key Presentations

- Bordelon, A. “Age-Dependent Properties of Fiber Reinforced Concrete Used in Concrete Overlays” 95th Annual Meeting of the Transportation Research Board (#16-6248), Washington DC, Jan 2016.
- Bordelon, A. “C is for Concrete, It’s Good Enough for Me” Women in Architecture Pecha Kucha Night, Salt Lake City, March 18, 2016.
- Bordelon, A. “Fiber Effect on Interfacial Bond Between Concrete and Fiber-Reinforced Mortar” 95th Annual Meeting of the Transportation Research Board (presentation #16-3895), Washington DC, Jan 2016.
- Bordelon, A. “Smog-Eating Concrete with TiO2” Global Change and Sustainability Center Think Tank Mixer, Salt Lake City, January 20, 2016.
- Bridgelall, R., Rafert, J. B., Atwood, D., Tolliver, D., “Hyperspectral Range Imaging for Transportation Systems Evaluation,” SPIE Smart Structures/NDE 2016, Las Vegas, NV, March 24, 2016.
- Bridgelall, R., Rafert, J. B., Tolliver, D., Lee, E., “Resolution Agile Remote Sensing for Transportation Safety,” 95th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan 10-14, 2016.
- Bumadian, I. Kim, Y.J., and Ji. Y 2015. Electrode potentials deteriorating behavior of CFRP-strengthened steel beams, 12th International Symposium on Fiber Reinforced Polymers for Reinforced Concrete Structures, Nanjing, China
- Fayyaz S., S.K., Liu, X.C., and Porter, R.J. “A Genetic-Algorithm and Regression-Based Model for Analyzing Fare Payment Structure and Transit Dwell Time,” Session 304 of the 95th Annual Meeting of the Transportation Research Board, Washington, D.C., January 11, 2016.
- Ferenchak, N. and Wesley E. Marshall. Relative (In)Effectiveness of Bicycle Sharrows on Ridership and Safety Outcomes. Transportation Research Board Annual Meeting, Washington, D.C., January, 2016.
- Jansuwan, S., A. Chen, K. Subprasom, K. Pinthong, N. Indra-Payoong. "Development of a Decision Support System for Assessing Vulnerability of National Highway Networks: Case Study of 2011 Mega Flood in Thailand." 20th Hong Kong Society of Transportation Studies Conference: Urban Transport Analytics, Hong Kong, P.R. China, December 12-14, 2015.
- SEAU Northern Chapter Monthly meeting. March. Logan, UT.
- Seminar -- A New Model for Predicting Ductile Fracture in Metal Alloys (October 2015) Department of Civil and Environmental Engineering, University of Waterloo, Waterloo, Canada
- Seminar -- Fatigue and Fracture Assessment and Repair of Civil Infrastructure (October 2015)
  American Society of Civil Engineering (ASCE) Northern Colorado Branch
  Fort Collins, CO
- Song, Y., Zlatkovic, M., and Porter, R.J. “GPS-Based Transit Signal Priority for Mixed-Traffic Bus Rapid Transit,” Session 451 of the 95th Annual Meeting of the Transportation Research Board, Washington, D.C., January 11, 2016.
- Song, Z. "Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory." International LiDAR Mapping Forum, Denver, CO, Feb 23, 2016.
- Tasic, I., Porter, R.J., and Brewer, S.C. “Applications of Generalized Additive Models and Bayesian Hierarchical Models for Areal Safety Analysis of Urban Multimodal Transportation Systems,” Session 448 of the 95th Annual Meeting of the Transportation Research Board, Washington, D.C., January 11, 2016.

- Taylor, J., Liu, X., and Wei, R. Bike-sharing Facility Expansion Planning with Location-Allocation Modeling. Western Regional Science Association Annual Meeting, February 2016.
- Terrill, T.; Shinstine, D.; and Ksaibati, K.; “Methodology to Assess and Compare the State Highway System with the Local Roadway System on the Wind River Indian Reservation”; Transportation Research Board Meeting, Washington D.C., 2016.
- Transportation 101, Wyoming Engineering Society Annual Meeting, Sheridan, WY Feb. 2016
- Wehbe, Nadim and Walker Olson. Experimental Evaluation Of Misaligned Tie Bar Effects On PCC Pavement Longitudinal Joints. proceedings of the 8th International Structural Engineering and Construction Conference: Implementing Innovative Ideas in Structural Engineering and Project Management, Sydney, Australia, November 23-28, 2015.
- Wehbe, Nadim, Michael Konrad, and Aaron Breyfogle. Precast Bridge Girder Details for Improved Performance. TRB 95th Annual Meeting, Washington, D.C., 2016. MPC support is acknowledged.
- Wehbe, Nadim. Joint Detailing for Improved Performance of Double Tee Bridge Systems. Transportation Learning Network (TLN) webinar. December 17, 2015.
- Xu, X., A. Chen, L. Cheng, and C. Yang. "A link-based mean-excess traffic equilibrium model under uncertainty." 95th Transportation Research Board Annual Meeting, Washington D.C., Jan. 10-14, 2016.
- Zlatkovic, M. "Performance Matrices for Evaluating Innovative Intersection and Interchange Designs." UDOT Annual Conference, Sandy, UT, October 2015.
- Zlatkovic, M., and Cameron Kergaye. "Performance Matrices for Evaluating Innovative Intersections and Interchanges." TRB 95th Annual Meeting, Washington D.C., January 2016.

### v. Other Items Produced During this Period

- AASHTO TP-125 has been voted as a provisional specification. This is the result of MPC-496.
- Bridgelall, R., Rafert, J. B., Tolliver, D., “Performance of hyperspectral imaging with unmanned aircraft swarms,” Journal of Spectral Imaging, (submitted on 10-29-15; awaiting review response).
- Bridgelall, R., Rafert, J. B., Tolliver, D., Lee, E., “Rapid hyperspectral image classification to enable autonomous search systems,” Journal of Spectral Imaging, (submitted on 11-21-15; in peer review).
- Grant Proposal (Defense University Research Instrumentation Program -- DURIP): Rafert, J. B., Bridgelall, R., “Dynamic Data Driven Hyperspectral Structure from Motion”, September 25, 2015 ($603,562).
- http://news.hjnews.com/logan_hj/new-nibley-bridge-gets-cutting-edge-instruments/article_a3fbcfb4-a7b6-5f76-a6c2-1140662e8234.html
- MPC-472: Developing an Optimization Model for Managing County Paved Roads
  * Developed a pavement performance model.
- MPC-478: Long-Term Behavior of Precast Concrete Bridges
  The project was highlighted in the local newspaper and a collaborative project
- Porter, R.J., Zlatkovic, M.T., and Musunuru, A. Incorporating Maintenance Costs and Considerations into Highway Design Decisions: Interim Report. Prepared for Utah Department of Transportation, November 2015.
- Sensor Acquisition and Evaluation: XIMEA Hyperspectral Camera. Installed Matlab, ENVI, and the sensor software to evaluate the image quality.

### 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/resources/downloads/KeyCenterDirectory.pdf?year=2014

### 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 principle investigators, faculty, and administrators participating in MPC projects:

Twelve principle investigators, faculty, and administrators participating in MPC projects at **Colorado State University** are: Rebecca Atadero, MPC Program Director and PI; Hussam Mahmoud, PI; Christopher Bareither, PI; Paul Heyliger, Co-PI; John W. van de Lindt, PI; Bolivar Senior, Co-PI; Mehmet Ozbek, Co-PI; Caroline Clevenger, Co-PI; Suren Chen, PI; Jeffrey D. Niemann, PI; Kelly Strong, Co-PI; and Scott Glick, Co-PI. In addition, sixteen students are working on MPC research projects at **Colorado State University**: Doctorate Students - Guangyang Hou, Luke Chen, Huajie Wen, Yufen Zhou and Kirsten Peterson; Masters Students - Aliena Debelak, Almotasem Maamon, Aura Lee Harper-Smith, Avi Sharma, David Turner, Karly Rager, Patrick Sanders, Taylor Ray and Trai Nguyen; Undergraduate Students - Kayla Moden and Kole Van Trese.

Six principle investigators, faculty, and administrators participating in MPC projects at **North Dakota State University** are: Denver Tolliver, MPC Program Director and PI; Bruce J. Rafert, PI; Raj Bridgelall, Co-PI; Pan Lu, PI; Brenda Lantz, PI; and Zhibin Lin, PI. In addition, five students are working on MPC projects at **North Dakota State University**: Doctorate Students - Ali Rahim Talegani, Fei Yan, Mingli Li, Mohsen Azimi, and Zijian Zheng.

Seven principle investigators, faculty, and administrators participating in MPC projects at **South Dakota State University** are: Nadim Wehbe, MPC Program Director, PI, and Co-PI; Allen L. Jones, PI; Guanghui Hua, PI; Christopher Schmit, Co-PI; Kyungnan Min, Co-PI; Mostafa Tazarv, Co-PI; and Junwon Seo, PI. In addition, eight students are working in MPC research projects at **South Dakota State University**: Masters Students - Eduardo Torres, Ghaem Hooshyari, Gregory Hansen, Lucas Bohn, Michael Mingo, Suraiya Akter, and Zachary Carnahan; Undergraduate Student - Jason Weber.

Seven principle investigators, faculty, and administrators participating in MPC projects at the **University of Colorado Denver** are: Wesley Marshall, MPC Director and PI; Carolyn McAndrews, PI and Co-PI; Bruce Janson, Co-PI; Jimmy Kim, PI; Krista Nordback Postdoctoral student and Co-PI; Austin Troy, Faculty; and Matthew Cross, Faculty. In addition, five students are working on MPC research projects at the **University of Colorado Denver**: Doctorate Students - Ibrahim Bumadian, and Nick Ferenchak; Masters Students - Nick Coppola, Evan Rosenlieb, and Yufei Chai.

Twelve principle investigators, faculty, and administrators participating in MPC projects at the **University of Utah** are: Richard J. Porter, MPC Director, PI, and Co-PI; Milan Zlatkovic, PI and Co-PI; Tiffany Hortin, Administration; Cathy Liu, PI and Co-PI; David Sanbonmatsu, PI; David Strayer, Co-PI; Joel Cooper, Technical Advisor; Pedro Romero, PI; Amanda Bordelon, PI; Chris P. Pantelides, PI; Juan Medina, Researcher; and Brendan Duffy, Data Information Specialist. In addition, twenty-four students are working on MPC research projects at the **University of Utah**: Doctorate Students - Anurag Upadhyay, Anusha Musunuru, Arwen Behrends, Catalina Arboleda, Ivana Tasic, Jeff Taylor, Joel Parks, Kiavash Fayyaz, M. Scott Shea, Min Ook Kim, MJ Ameli, Ruoyang Wu, Yu Song, and Zhuo Chen; Masters Students - Daniel Sudbury, Dillon Li, Jem Locquaio, Lingkun Li, Siddartha Rayaprolu, and Yang Li; Undergraduate Students - Ariel Froerer, James Holt, Martin Dinsmore, and Ryan Betz.

Seven principle investigators, faculty, and administrators participating in MPC projects at the **University of Wyoming** are: Khaled Ksaibati, MPC Director, PI, and Co-PI; Bart Evans, Faculty; Mohamed Ahmed, PI; Rhonda Young, Associate Professor and PI; Dennis Trusty, Director NP TTAP; Kam Ng, PI; and Promothes Saha, PI. In addition, ten 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, and Dawit Mebrahtom; Undergraduate Student - Nicole Peterson.

Eleven principle investigators, faculty, and administrators participating in MPC projects at **Utah State University** are: Paul Barr, MPC Director and PI; Ziqi Song, PI and Co-PI; Anthony Chen, PI; Xiangdong Xu, Collaborator; Sarawut Jansuwan, Collaborator; James Dorward, PI; Jim Bay, PI; John Rice, PI; Marv Halling, Faculty; Seungkyu Ryu, Collaborator; and Keechoo Choi, Collaborator. In addition, ten students are working on MPC research projects at **Utah State University**: Doctorate Students - Majid Khalilikhah, Seungkyu Ryu, and Ann Heaslip; Masters Students - Yi He, Holly Lloyd, 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. AAA Foundation for Traffic Safety
2. Ajou University, Korea
3. Campbell County Road and Bridge Department
4. Campbell's Scientific
5. City of Watertown, SD
6. Colorado Department of Transportation
7. Converse County Road and Bridge Department
8. Crook County Road and Bridge Department
9. Denver Regional Transportation District
10. Digital Glove Foundation
11. East Dakota Water Development District
12. Fehr & Peers

13. FHWA, Wyoming Division
14. Inberg Miller Engineers, Casper WY
15. James River Water Development District
16. Key Laboratory of Road and Traffic Engineering, Tongji University, Shanghai, China
17. Lincoln County Road and Bridge Department
18. Michigan Technological Research Institute
19. National Institute of Development Administration (NIDA), Bangkok, Thailand
20. Utah State University College of Education
21. Roaring Fork Transportation Authority
22. Rocky Mountains and Plain Regions
23. Sisseton Wahpeton Oyate Reservation
24. South Dakota Department of Environment and Natural Resources
25. South Dakota Department of Transportation
26. Standing Rock Sioux Tribe Indian Reservation
27. StarSeismic LLC
28. Teton County Road and Bridge Department
29. Utah Department of Transportation (UDOT)
30. Utah Transit Authority (UTA)
31. Virginia Tech
32. Wasatch Front Regional Council (WFRC)
33. Wisconsin Department of Transportation
34. Wyoming Department of Transportation
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

**Colorado State University:**
Impacts to date are most related to advancing the state of knowledge within specific areas of research focus.

**South Dakota State University:** The projects provided research and learning experience for eight 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:** Our MPC affiliation has been a great benefit to the continued building of a transportation program at CU Denver, both in terms of supporting our faculty and innovative research and also in terms of education and workforce development. The MPC has also been helpful in promoting multi-disciplinary research and teaching. Civil Engineering and Urban Planning now have multiple shared research projects with several over-lapping students. These efforts are helping create a transportation workforce that not only has the technical skills and expertise but also has the ability to understand the larger context of their work. One impact of our affiliation with the MPC worth noting is the improving

national reputation of CU Denver's research and education work with respect to the field of transportation. The research activities actively transfer state-of-the-art technologies via conference presentation and journal publication. The MPC research has also been the subject of numerous popular press articles, radio interviews, and television appearances by Dr. Marshall. These outreach efforts are positively impacting the transfer of these research ideas into practice. The research activities also address three important national issues - infrastructure deterioration, safety, and sustainability.

**University of Utah:** One of the biggest, early impacts of the program comes from MPC-496: Prevention of Low Temperature Cracking of Pavements. Results from this project have led to a new specification for testing asphalt mixtures has been developed and will be an AASHTO provisional standard. Another project PI has noted that early ideas generated from the initial tasks of MPC 493 has already been incorporated into a graduate-level highway engineering class at the University of Utah. MPC 495 has already resulted in expanded real-time connections between Utah DOT's Traffic Operations Center and the Utah Traffic Lab to support data collection for the project, which includes an interface to detailed information on all traffic signals throughout Salt Lake City. This interface will likely be incorporated into the University of Utah's Introduction to Transportation Engineering course during signal timing lectures and homework problems. This will allow undergraduate students to more readily "visualize" traffic signal operations. MPC-490 has helped to create and revise a physical NOx photocatalytic analysis system at the University of Utah Civil Engineering Concrete Lab. This analysis box can be used for all types of materials to measure their NO and NO2 photocatalytic efficiency. The new MS student on MPC-490 has been trained on using SEM as a tool for measuring chemistry and microstructure topography. The prototype system was used for a middle-school student science fair project in Spring 2016. The technology was also incorporated into CVEEN 6225 in Spring 2016. As part of MPC-492, the University of Utah was able to build a wedge-splitting test apparatus for fracture testing and a ring shrinkage concrete test apparatus at the Utah Department of Transportation. The program already shows substantial support in the area of workforce development, with 25 undergraduate and graduate students heavily involved in the research projects.

**Utah State University:** We have direct impacts in terms of the workforce development with the students that we are advising and mentoring. The UTC projects allow exposure to real life projects and professionals that these students would not have otherwise. We also impact the technology transfer with the conferences we attend and the journal papers.

## b. Expected Impacts

**Colorado State University:** Our projects have a range of expected impacts including enhanced design and analysis tools for use in practice, and analysis that helps decision makers have better information in areas such as transit oriented development and bridge management.

**South Dakota State University:** Development of a low-maintenance, low-cost mixed-media filtration system for stormwater 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**: We expect the work under investigation to set the stage for continued growth of the UTC program at CU Denver in terms of future research projects that will leave a positive

impact on society and the careers of the students and faculty that work on these projects. 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 expected impacts of the projects are mainly in terms of design and long-term behavior. How can we design the infrastructure system to be more efficient and safe. We will have recommendations in both of these areas. We will also have impacts on the long-term behavior. The more data that we have of actual behavior will allow a better understanding of how to make our infrastructure investment last longer and perform better. We anticipate recommendations to the code for design and best practice procedures for construction.

## 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