

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

**Grant No. DTRT12-G-UTC08
Mountain-Plains Consortium, North Dakota State University Denver Tolliver,
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**North Dakota State University
Upper Great Plains Transportation Institute
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Grant period: January 1, 2012 – June 30, 2016

**Reporting Period End Date: June 30, 2016
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1. Accomplishments: What was done? What was learned?

a. What are the major goals of the program?

The overall objectives are to: (1) conduct basic and applied research, the products of which are judged by peers or other experts in the field of transportation to advance the body of knowledge in transportation; (2) offer an education program in transportation that includes multidisciplinary course work and participation in research; (3) conduct workforce development activities and programs to expand the workforce of transportation professionals; (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; and (5) provide planning and technical assistance to Native American tribes, especially those heavily impacted by energy development. Other program goals are to select projects and activities using peer review principles and procedures and client input that: (1) address the Secretary's strategic goals, and (2) leverage UTC funds with matching funds from state and local governments and private industry. The chief operational goals for grant DTRT12-G-UTC08 is 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—especially issues in the rapidly growing Bakken oil production region.

b. What was accomplished under these goals?

i. Project Selection and Peer Review

Under grant DTRT12-G-UTC08, 87 research projects have been selected from federal fiscal year (FY) 2012 and 2013 funds. All projects have been selected through a peer review process that reflects substantial input and matching resources from state departments of transportation and other transportation agencies in the region. The projects selected under grant DTRT12-G-UTC08 are listed in Tables 1-7, under the primary strategic goal addressed by the project. Please note that many of the projects address several goals simultaneously. In particular, many projects that address State of Good Repair have potential Safety and Economic Competitiveness benefits.

Table 1: MPC Research Projects Most Directly Correlated with Sustainability

1. MPC-390: Design and Construction Monitoring of Surcharged Embankment
2. MPC-392: Evaluation of Spliced Sleeve Connections for Precast Reinforced Concrete Bridge Piers
3. MPC-396: Extent, Severity, and Location of Chip Seal Loss on the South Dakota State Road Network

Table 2: MPC Research Projects Most Directly Correlated with Safety

1. MPC-366: Structural Health Monitoring of Highway Bridges Subjected to Overweight Trucks, Phase I – Instrumentation Development and Validation
2. MPC-371: Decision Support for Strategic Truck Safety and Weight Enforcement Planning
3. MPC-375: Small Railroad Capital Investment Needs and Financial Options
4. MPC-378: MEMS Sensors for Transportation Structures
5. MPC-381: Performance-based Interaction Analysis of Damage on Bridge Expansion Joints and Heavy Traffic
6. MPC-397: Evaluation and Mitigation of Vehicle Impact Hazard for Overpass Bridges in South Dakota
7. MPC-402: Seismic Performance of SCC Bridge Columns
8. MPC-406: Risk- and Reliability-Based Approaches to Analyzing Road Geometric Design Criteria
9. MPC-407: The Effect of Multi-tasking on Self-Assessments of Driving Performance Center for the Prevention of Distracted Driving
10. MPC-408: Exploring Unique Plastic-Reinforced Bridge Decks: Phase I
11. MPC-409: Identification of Low-Risk Adjusted Work Schedules Designed to Manage Fatigue During Peak Service Demand Periods in the Shortline Railroad Industry
12. MPC-416: Development and Testing of Crashworthy Ipe Bridge Rails

13. MPC-418: 400 South Corridor Assessment
14. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
15. MPC-432: Finding Innovative Solutions to Prevent Wildlife Access to Highways at Wildlife Guards
16. MPC-438: Calibration of HSM Predictive Methods on Rural State and Local Highways
17. MPC-445: A Sensor Fusion Approach to Assess Pavement Condition and Maintenance

Table 3: MPC Research Projects Most Directly Correlated with State of Good Repair

1. MPC-366: Structural Health Monitoring of Highway Bridges Subjected to Overweight Trucks, Phase I – Instrumentation Development and Validation
2. MPC-375: Small Railroad Capital Investment Needs and Financial Options
3. MPC-378: MEMS Sensors for Transportation Structures
4. MPC-379: Plastic-Aluminum Composites in Transportation Infrastructure
5. MPC-387: Comprehensive GIS-Based Rural Regional Transportation Planning Models
6. MPC-390: Design and Construction Monitoring of Surcharged Embankment
7. MPC-395: Accelerated Bridge Construction in South Dakota: Pilot Study for Implementation Strategy
8. MPC-396: Extent, Severity, and Location of Chip Seal Loss on the South Dakota State Road Network
9. MPC-397: Evaluation and Mitigation of Vehicle Impact Hazard for Overpass Bridges in South Dakota
10. MPC-400: Evaluation of Ice Loads on Bridge Piers in South Dakota (Years 2 & 3)
11. MPC-402: Seismic Performance of SCC Bridge Columns
12. MPC-405: Seismic Retrofit of Spliced Sleeve Connections for Precast Bridge Piers
13. MPC-406: Risk- and Reliability-Based Approaches to Analyzing Road Geometric Design Criteria
14. MPC-411: Re-Use of Mine Waste Materials Amended with Fly Ash in Transportation Earthwork Projects
15. MPC-414: Quantifying Sustainability Metrics for Trunkline Bridges in the Mountain Plains Region
16. MPC-415: Framework of Performance-Based Earthquake Design of Curved and Skewed Bridges
17. MPC-421: Seismic Rehabilitation of Skewed and Curved Bridges Using a New Generation of Bulking Restrained Braces
18. MPC-422: Highway Structures Supported on Expanded Polystyrene (EPS) Embankment without Deep Foundations
19. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
20. MPC-427: Fire Performance of Bridge Members Retrofitted with Near-Surface-Mounted Carbon Fiber Reinforced Polymer Composites
21. MPC-432: Finding Innovative Solutions to Prevent Wildlife Access to Highways at Wildlife Guards
22. MPC-437: Fiber Reinforced Concrete for Structure Component
23. MPC-439: Precast Bridge Girder Details for Improved Performance
24. MPC-440: Tolerances for Placement of Tie Bars in Portland Cement Concrete Pavements
25. MPC-441: Developing a Pavement Management System for Small Communities
26. MPC-442: Improving Rural Emergency Medical Services (EMS) through Transportation System Enhancements, Phase II
27. MPC-443: Bridge Structure Alternatives for Local Roads
28. MPC-444: Data-driven Freeway Performance Evaluation Framework for Project Prioritization and Decision Making
29. MPC-445: A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness

Table 4: MPC Research Projects Most Directly Correlated with Economic Competitiveness

1. MPC-366: Structural Health Monitoring of Highway Bridges Subjected to Overweight Trucks, Phase I – Instrumentation Development and Validation
2. MPC-375: Small Railroad Capital Investment Needs and Financial Options
3. MPC-379: Plastic-Aluminum Composites in Transportation Infrastructure
4. MPC-381: Performance-based Interaction Analysis of Damage on Bridge Expansion Joints and Heavy Traffic
5. MPC-387: Comprehensive GIS-Based Rural Regional Transportation Planning Models
6. MPC-395: Accelerated Bridge Construction in South Dakota: Pilot Study for Implementation Strategy

7. MPC-396: Extent, Severity, and Location of Chip Seal Loss on the South Dakota State Road Network
8. MPC-397: Evaluation and Mitigation of Vehicle Impact Hazard for Overpass Bridges in South Dakota
9. MPC-402: Seismic Performance of SCC Bridge Columns
10. MPC-408: Exploring Unique Plastic-Reinforced Bridge Decks: Phase I
11. MPC-409: Identification of Low-Risk Adjusted Work Schedules Designed to Manage Fatigue During Peak Service Demand Periods in the Shortline Railroad Industry
12. MPC-418: 400 South Corridor Assessment
13. MPC-422: Highway Structures Supported on Expanded Polystyrene (EPS) Embankment without Deep Foundations
14. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
15. MPC-426: Does the Livability of a Residential Street Depend on the Characteristics of the Neighboring Street Network?
16. MPC-427: Fire Performance of Bridge Members Retrofitted with Near-Surface-Mounted Carbon Fiber Reinforced Polymer Composites
17. MPC-437: Fiber Reinforced Concrete for Structure Component
18. MPC-439: Precast Bridge Girder Details for Improved Performance
19. MPC-440: Tolerances for Placement of Tie Bars in Portland Cement Concrete Pavements
20. MPC-443: Bridge Structure Alternatives for Local Roads
21. MPC-445: A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness

Table 5: MPC Research Projects Most Directly Correlated with Livable Communities

1. MPC-379: Plastic-Aluminum Composites in Transportation Infrastructure
2. MPC-381: Performance-based Interaction Analysis of Damage on Bridge Expansion Joints and Heavy Traffic
3. MPC-387: Comprehensive GIS-Based Rural Regional Transportation Planning Models
4. MPC-392: Evaluation of Spliced Sleeve Connections for Precast Reinforced Concrete Bridge Piers
5. MPC-408: Exploring Unique Plastic-Reinforced Bridge Decks: Phase I
6. MPC-418: 400 South Corridor Assessment
7. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
8. MPC-426: Does the Livability of a Residential Street Depend on the Characteristics of the Neighboring Street Network?
9. MPC-436: Using Flocculation to Reduce Turbidity of Construction Site Runoff
10. MPC-438: Calibration of HSM Predictive Methods on Rural State and Local Highways
11. MPC-444: Data-driven Freeway Performance Evaluation Framework for Project Prioritization and Decision Making

Table 6: MPC Research Projects Most Directly Correlated with Environmental Sustainability

1. MPC-411: Re-Use of Mine Waste Materials Amended with Fly Ash in Transportation Earthwork Projects
2. MPC-414: Quantifying Sustainability Metrics for Trunkline Bridges in the Mountain Plains Region
3. MPC-416: Development and Testing of Crashworthy Ipe Bridge Rails
4. MPC-418: 400 South Corridor Assessment
5. MPC-421: Seismic Rehabilitation of Skewed and Curved Bridges Using a New Generation of Bulking Restrained Braces
6. MPC-436: Using Flocculation to Reduce Turbidity of Construction Site Runoff
7. MPC-441: Developing a Pavement Management System for Small Communities
8. MPC-442: Improving Rural Emergency Medical Services (EMS) through Transportation System Enhancements, Phase II

Table 7: MPC Education Projects

1. MPC-385: Educational and Workforce Development Proposal: STEM Outreach at Colorado State University
2. MPC-403: Web-based Decision Support Tool for Traffic Management and Work Zone Analysis
3. MPC-424: Educational and Workforce Development Proposal: Ethics and Academic Conduct

ii. Educational Accomplishments

The transportation and transportation-related courses offered during Spring and Summer 2016 are listed in Table 8, 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 8: Transportation and Transportation-Related Courses Offered This Reporting Period

Major Subject Area	Course Title
Engineering & Design	CIVE 303 Infrastructure and Transportation Systems
	CIVE 355 Introduction to Geotechnical Engineering
	CIVE 455 Applications in Geotechnical Engineering
	CIVE 467 Design of Reinforced Concrete Structures
	CIVE 553 Slope Stability and Retaining Structures
	CIVE 561 Advanced Steel Behavior and Design
	CIVE 565 Finite Element Method
	CIVE 567 Advanced Concrete Design
	CIVE 577 GIS in Civil and Environmental Engineering
	CIVE 581 Bridge Engineering and Hazard
	CEE 363: Highway and Traffic Engineering
	CEE 452/552: Prestressed Concrete
	CEE 346: Geotechnical Engineering
	CEE 455: Steel Design
	CEE 754: Advanced Design of Steel Structures
	CEE 732: Advanced Foundation Engineering
	EM 741: Finite Element Analysis
	CVEN 4602 - Highway Engineering
	CVEN 5602 - Advanced Street & Highway Design
	CvEEN 3510 Civil Engineering Materials Undergraduate
	CvEEN 5220 Concrete Design II Undergraduate
	CvEEN 5500 Sustainable Materials Undergraduate
	CvEEN 5510 Highway Design Undergraduate
	CvEEN 6225 Concrete Science Graduate
	CE 3500 Highway Engineering
	CE 4510 Pavement Design
	CE 5510 Pavement Design
	CEE 3080 Reinforced Concrete Design
	CEE 5380 Earthquake Engineering
	CEE Geotechnical Lab and Field Methods
Freight & Logistics	TRAN 4010 Introduction to Transportation Systems
	TRAN 4330 Principles of Supply Chain: Management and
Planning & Environment	URPL 5040 - Natural and Built Environments

	URPL 5050 - Urban Development
	URPL 6300 - Planning for Healthy Communities
	URPL 6350 - Form and Formation of Cities
	URPL 6555 - Transportation and Land Use
	TRAIN 4710 Transportation Finance (Module 1 of 2)
	TRAN 4020 Transportation Economics (Module 2 of 2)
	TRAN 4060 Transportation Marketing and Sales Tools
	TRAIN 4330 Principles of Supply Chain: Management and
	TRAIN 4320 Transportation Management, Leadership, and Values
	CvEEN 5560 Transportation Planning Undergraduate
	CEE 5190 GIS for Civil Engineers Technologies
Traffic & Operations	CVEN 5612 - Traffic Impact Assessment
	CvEEN 3520 Transportation Engineering Undergraduate
	CEE 3210 Introduction to Transportation Engineering
Transportation Safety	CVEN 5662 Transportation System Safety
	CVEN 5611 - Traffic and Safety Data Analysis
	CvEEN 7520 Transportation Safety Graduate
	CE 5560 Traffic Safety
	CEE 6250 Transport Data/Safety
Transportation Systems	TRAN 4010 Introduction to Transportation Systems
	CEE 6210 Transportation Systems Analysis
	CVEN/URPL 5633 - Sustainable Transportation Systems
Public Transportation	CVEN 5800 Transit Construction
	TRAN 4080 Transportation Law and Regulation: Domestic and

Altogether, 57 transportation and transportation-related courses have been offered during this reporting period. Altogether, 496 transportation courses have been offered during the grant period thus far. In addition to the courses listed in Table 8, foundational courses in engineering materials, mechanics, structural analysis, and geotechnical engineering have been offered at most of the MPC universities.

iii. Workforce Development Accomplishments

Training events provided for transportation professionals during this reporting period are listed below.

1. AGC Private Course
2. Asphalt Maintenance: Crack Sealing/Pouring & Spot Surface Repairs
3. Asphalt paving Maintenance 1
4. Asphalt Paving Maintenance 2
5. ATSSA Flagger Certification
6. ATSSA Traffic Control Supervisor (TCS)
7. ATSSA Traffic Control Technician (TCT)
8. ATSSA Truck Mounted Attenuators
9. Basic Construction Survey
10. Basic Sign Installation
11. Basics of a Good Road
12. Communication Skills for Supervisors
13. Construction Project Management: Contract Administration
14. Design, Layout, Inspection and Construction
15. Electrical Plan Reading - Inspection & Installation
16. Ethics Awareness for the Transportation Industry

17. Evaluation of Grouted Spliced Sleeve Connections Reinforced Precast Concrete Bridge Piers -MPC Research Project
18. Fundamental of PROW ADA Ramp
19. Fundamentals of Geometric Design: Exploring the Green Book
20. Gravel Roads Maintenance - New Manual Review
21. Guardrail Installation & Inspection
22. Guardrail Maintenance
23. Heavy Equipment Operation (Hands on)
24. Heavy Equipment Safety Operations
25. Highway Capacity Manual Overview & Related Software Changes 6th Edition 2015
26. Highway Pipe Installation
27. John Maxwell: 15 Invaluable Laws of Growth
28. John Maxwell: Today Matters
29. John Maxwell's Becoming A Person of Influence: How to Positively Impact the Lives of Others
30. Keyhole Technology for Urban Utility Excavations to Reduce the Impact of Pavement Cuts
31. Leadership - Developing a Presence
32. Leading a Successful Change Initiative
33. Negotiation Strategies & Techniques to Improve Construction Project Mgmt.
34. PE Exam for Civil Engineers
35. Pedestrian and Bicycle Safety
36. Practical Bridge Scour Analysis, Methods & Countermeasures
37. Preventing Runners and Backovers
38. Reducing Roadway Departure Crashes
39. Registered Storm Water Inspector
40. Results Based Performance Mgmt.
41. Roadway Drainage
42. Roadway Materials
43. Seal Coat Workshop
44. Storm Water Detention & Design
45. The Balancing Act: Stress and Productivity
46. Tier IV Regeneration & Digital Multi-Meter Principles
47. Tractor Mower Safety Training
48. Traffic Data Collection
49. Transportation Safety Congress
50. Trenching Safety Practices
51. Truck Rodeo
52. Understanding Linear Scheduling for Roadway Construction Projects
53. Utah Continuing Education Conference
54. Workplace, Equipment and Jobsite Safety
55. Workzone

iv. Research accomplishments

The following peer reviewed research reports/presentations were published during the period of January- June 2016 from grant DTRT12-G-UTC08 or previous grants.

Project #	Title	Date	Report No.
470	Guidelines for Effective LTAP Course Evaluation	January 2016	MPC-16-305

408	Evaluation of New Reactive FRP Reinforcement Assemblies for Reinforced Concrete Transportation Structures	January 2016	MPC-16-304
445	A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness	February 2016	MPC-16-306
366	Structural Health Monitoring of Highway Bridges Subjected to Overweight Trucks, Phase I - Instrumentation Development and Validation	March 2016	MPC-16-307
371	Analysis of Risk Factors in Severity of Rural Truck Crashes	April 2016	MPC-16-308

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. These accomplishments are summarized under the products section of this report.

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

(1) Continue to offer the multidisciplinary multimodal catalogue of courses described in the prospectus and teach those courses scheduled during the academic year (2) Continue to deliver extensive programs of technical training, similar to the programs illustrated in b.iii. (3) Continue the strong MPC research programs, which will result in many new publications and journal papers. (4) Participate in conferences and workshops on transportation and energy development. (5) Collaborate with other UTCs to promote greater exchange of information and explore partnering possibilities in railway and waterway transportation. (6) Continue to involve graduate students in MPC research projects.

2. Products: What has the program produced?

a. Publications, conference papers, presentations

i. Participation in key conferences and workshops

- 95th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan 10-14, 2016
- 95th Transportation Research Board, Washington D.C., January 2016.
- A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness, International Society for Asphalt Pavements 53rd Annual Petersen Asphalt Research Conference, July 18-21, 2016, Jackson Hole, WY
- Accelerated Bridge Construction in South Dakota: Pilot Study for Implementation Strategy South Dakota State University: TRB 95th Annual Meeting, January 10-14, Washington, D.C.
- ASCE Geotechnical and Structural Engineering Congress, Phoenix, AZ.
- ASCE International Conference on Transportation & Development, Houston, TX
- ASCE Structures Congress. Phoenix, AZ. February, 2016.
- Calibration of HSM Predictive Methods on Rural State and Local Highways 2016 Transportation Research Board Annual Meeting, Washington DC.
- Evaluating Rural Emergency Medical Service (EMS) Performance. Presented at the Lifesavers Conference on Highway Safety Priorities
- Evaluation and Mitigation of Vehicle Impact Hazard for Overpass Bridges in South Dakota South Dakota State University: TRB 95th Annual Meeting, January 10-14, Washington, D.C.

- Evaluation of Ice Loads on Bridge Piers in South Dakota (Years 2 & 3) South Dakota State University: TRB 95th Annual Meeting, January 10-14, Washington, D.C.
- Fiber Reinforced Concrete for Structure Component South Dakota State University: TRB 95th Annual Meeting, January 10-14, Washington, D.C.
- Global Waste Management Symposium, Jan. 31 - Feb. 3, Indian Wells, California
- International Health and Transport Conference
- PCI Annual Convention and National Bridge Conference, Nashville, TN.
- Second Serbian Road Congress, Belgrade, Serbia.
- Seismic Performance of SCC Bridge Columns South Dakota State University: TRB 95th Annual Meeting, January 10-14, Washington, D.C.
- Sensors Expo and Conference 2016, San Jose, CA, June 22, 2016
- SHRP2 NDS Data Issues Resolution Workshop, Washington, DC.
- Society for the Advancement of Material and Process Engineering: conference, Long Beach, CA
- SPIE Smart Structures/NDE 2016, Las Vegas, NV, March 24, 2016
- Transportation Research Board 95th Annual Meeting, Washington, DC.
- Transportation Research Board Highway Safety Performance Committee Midyear Meeting, Irvine, CA
- UDOT Automated Traffic Signal Performance Measures Workshop, Salt Lake City, UT.
- Utah Society of Professional Engineers Continuing Education Conference.

ii. Key Journal Articles or Conference Publications

- Alhomair, S.A., Gorakhki, M.H., and Bareither, C.A. Hydraulic conductivity of fly ash-amended mine tailings, *Geotechnical and Geological Engineering*, In Review, submitted 23 May 2016.
- Bridgelall, R., Huang, Y., Zhang, Z., and Tolliver, D., "A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness," MPC-16-306, North Dakota State University - Upper Great Plains Transportation Institute, Fargo: Mountain-Plains Consortium, March 23, 2016.
- Bridgelall, R., Huang, Y., Zhang, Z., Deng, F., "Precision enhancement of pavement roughness localization with connected vehicles," *Measurement Science and Technology*, 27(2016) 025012 (9pp), January 4, 2016.
- Bridgelall, R., Rahman, T., Daleiden, J. F., Tolliver, D., "Error sensitivity of the connected vehicle approach to pavement performance evaluations," *International Journal of Pavement Engineering*, pp. 1-6, March 28, 2016.
- Bridgelall, R., Tolliver, D., "Accuracy enhancement of roadway anomaly localization using connected vehicles," *International Journal of Pavement Engineering*, pp. 1-7, March 18, 2016.
- Bridgelall, R., Tolliver, D., Rahman, T., Daleiden, J. F., "Use of Connected Vehicles to Characterize Ride Quality," *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2589, DOI: 10.3141/2589-13 (in press)
- Brown, D.N., Parks, J.E., Ameli, M.J., and Pantelides, C.P. (2016). "Strut-and-tie models of repaired precast concrete bridge substructures with CFRP shell." *Composite Structures*, 138, 161-171.
- Chen, Luke and Chen, Suren (2016), "Seismic fragility analysis of curved and skewed bridges in low-to-moderate seismic region", *Earthquake and Structures*, 10(4), 789-810.
- Chen, Z., X. Liu, and G. Zhang. Non-recurrent Congestion Analysis using Data-driven Spatiotemporal Approach for Information Construction. *Transportation Research Part C: Emerging Technologies*. Vol 71, pp 19-31, 2016.
- 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.
- Gorakhki, M.H. and Bareither, C.A. Unconfined compressive strength of mine tailings amended with fly ash, *Journal of Geotechnical and Geoenvironmental Engineering*, In Review, submitted 4 April 2016.
- 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

- Md R. R. Shaon, Xiao Qin (2016), Quantifying Safety Effects of Rural Roadway Features Using Mixed Distribution Generalized Linear Models, Transportation Research Record, accepted for publication, 2583, DOI 10.3141/2583-17.
- Namrou, A. and Kim, Y.J. 2016. Residual performance of concrete-adhesive interface at elevated temperatures, Construction and Building Materials, Elsevier, 105, 113-122
- Parks, J.E., Brown, D.N., Ameli, M.J., and Pantelides, C.P. (2016). “Seismic repair of severely damaged precast reinforced concrete bridge columns connected with grouted splice sleeves.” ACI Structural J., May-Jun., 113(3), 615-626.
- Parks, J.E., Papulak, T., and Pantelides, C.P. (2016). “Acoustic emission monitoring of grouted splice sleeve connectors and reinforced precast concrete assemblies.” Construction and Building Materials, 122, 537–547.
- Pettigrew, C.P., Barr, P.J., Maguire, M. and Halling, M.W. “Behavior of 48-Year Old, Double-Tee Bridge Girders, made with Lightweight Concrete.” Accepted to the ASCE Journal of Bridge Engineering. January 2016.
- Qin, Xiao, Shen, Zhao, and Wehbe, N., “Predicting Collision Risk between Trucks and Interstate Overpasses.” ASCE Journal of Transportation Engineering. 2016. In print.
- Siriwardanage, T. and Kim, Y.J. 2016. Thermomechanical behavior of NSM CFRP-concrete interface, ACI Structural Journal, American Concrete Institute (ACI), 113(3), 567-576
- 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.
- 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.
- 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.
- Taylor, J. Liu, X.C., and Porter, R.J. “Using Bikeshare Trajectory Data to Explore Roadway Characterization,” submitted to Transportation Research Part C: Emerging Technologies, May 2016.
- Vachal, Kimberly, 2016, Factors in Rural Truck Crashes, Journal of Law, Logistics, and Policy, In Publication.
- Wang, Y., L. Ibarra, and C. Pantelides, Seismic Retrofit of a Three-Span RC Bridge with Buckling-Restrained Braces, Journal of Bridge Engineering, 10.1061/(ASCE)BE.1943-5592.0000937.04016073
- Wehbe, N., Konrad, M., and Breyfogle, A., “Joint Detailing Between Double Tee Bridge Girders for Improved Serviceability and Strength.” Transportation Research Record. 2016. In print.
- Xiao Qin, Md. R. R. Shaon, Zhi Chen (2016), Developing Analytical Procedures for Calibrating the HSM Predictive Methods, Transportation Research Record 2583, DOI 10.3141/2583-12.
- Xiao Qin, Zhaoxiang He, Haifa Sarma (2015), Rural Emergency Medical Service Needs Assessment, Transportation Research Record 2513, pp 30–39.

iii. Key Conference Papers

- Ameli, M.J., Parks, J.E., Brown, D. N., and Pantelides, C.P. (2016). “Seismic evaluation of grouted splice sleeve connection alternatives for reinforced precast concrete bridge piers in accelerated bridge construction.” Paper ID-20, Proc. The 2016 PCI Annual Convention and National Bridge Conference, Mar. 1-5, 2016, Nashville, TN, pp. 19.
- Bridgelall, R., Tolliver, D., “Participatory Sensing of Road Roughness Using Connected Vehicles,” Sensors Expo and Conference 2016, San Jose, CA, June 22, 2016.
- Bridgelall, R., Tolliver, D., Rahman, T., Daleiden, J. F., “Ride Quality Characterizations Using Connected Vehicles,” in Proc. Transportation Research Board, Washington, D.C., Jan 10-14, 2016.
- 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.

- Kim, Y.J. and Namrou, A. 2016. Tolerance of Bond in Composite-concrete Interface with Various Adhesives Subjected to High Temperatures, Society for the Advancement of Material and Process Engineering (SAMPE 2016), Long Beach, CA, USA
- Md R. R. Shaon, Xiao Qin (2016), Quantifying Safety Effects of Rural Roadway Features Using Mixed Distribution Generalized Linear Models, 2016 Transportation Research Board Annual Meeting, Washington, DC.
- Parks, J.E., Brown, D. N., Ameli, M.J., and Pantelides, C.P. (2016). “Seismic repair of precast RC bridge columns connected with grouted splice sleeves.” Paper ID-52, Proc. The 2016 PCI Annual Convention and National Bridge Conference, Mar. 1-5, 2016, Nashville, TN, pp. 17.
- Sherry, P. (2016) “Fatigue Calibration Models in Rail Transportation.” A paper presented at the ICTH, San Jose California. June 2016.
- Song, Y., Zlatkovic, M., and Porter, R.J. “A Corridor-Level Evaluation of GPS-Based Transit Signal Priority,” Proceedings of the International Conference on Transportation and Development 2016, Houston, TX, June 26-29, 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.
- Xiao Qin, Md. R. R. Shaon, Zhi Chen (2016), Developing Analytical Procedures for Calibrating the HSM Predictive Methods, 2016 Transportation Research Board Annual Meeting, Washington DC.
- Xiao Qin, Zhi Chen, Md. R. R. Shaon (2016), New Insights on the Role of SPF and Proportional Severity Levels in the Highway Safety Manual Predictive Methods, 2016 Transportation Research Board Annual Meeting, Washington DC.
- Zhang, Z., Deng, F., Huang, Y., Bridgelall, R., “Field validation of road roughness evaluation using in-pavement strain sensors,” in Proc. SPIE Smart Structures/NDE 2016, Las Vegas, NV, March 24, 2016.
- Zhang, Z., Huang, Y., Bridgelall, R., Deng, F., “Optimization of Sampling Facilities for Weigh-in-Motion Measurements,” in Proc. SPIE Smart Structures/NDE 2016, Las Vegas, NV, March 24, 2016.

iv. Key Presentations

- Bridgelall, R., Tolliver D. D, “Next Generation Intelligent Transportation Systems for Smart Cities,” Seminar on Emerging Transportation Issues, North Dakota State University, Fargo, March 1, 2016.
- Bridgelall, R., Tolliver, D., “Participatory Sensing of Road Roughness Using Connected Vehicles,” Sensors Expo and Conference 2016, San Jose, CA, June 22, 2016.
- Bridgelall, R., Tolliver, D., Rahman, T., Daleiden, J. F., “Ride Quality Characterizations Using Connected Vehicles,” 95th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan 10-14, 2016.
- Chen, Luke, Chen, Suren (2015). “Seismic fragility performance of skewed and curved bridges in mountain west region”, The 2nd International Symposium on Life-cycle Performance of Bridges and Structures, Dec 18-20 2015, Changsha, 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. [refereed paper – presented in poster session]
- Kim, Y.J. and Namrou, A. 2016. Tolerance of Bond in Composite-concrete Interface with Various Adhesives Subjected to High Temperatures, Society for the Advancement of Material and Process Engineering (SAMPE 2016), Long Beach, CA, USA
- Md R. R. Shaon, Xiao Qin (2016), Quantifying Safety Effects of Rural Roadway Features Using Mixed Distribution Generalized Linear Models, 2016 Transportation Research Board Annual Meeting, Washington DC.

- Porter, R.J. “Substantive Safety Analysis: Tools for Practitioners,” Opening Keynote Speaker for the 2nd Serbian Road Congress, Belgrade, Serbia, June 9, 2016. [invited presentation]
- Sherry, P. (2016) “Fatigue Calibration Models in Rail Transportation.” A paper presented at the ICTH, San Jose California. June 2016.
- Song, Y., Zlatkovic, M., and Porter, R.J. “A Corridor-Level Evaluation of GPS-Based Transit Signal Priority,” Session 6A: Bus Transit, of the International Conference on Transportation and Development 2016, Houston, TX, June 28, 2016. [refereed paper]
- 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. [refereed paper – presented in poster session]
- Tasic, I., and Porter, R.J. "Multimodal Transportation Safety in Major U.S. Cities," Session 8D of the 3rd International Conference on Transportation and Development of the American Society of Civil Engineers, Houston, TX, June 26-29, 2016 [refereed abstract]
- 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. [refereed paper – presented in poster session]
- USU. Flower, J. P. and Cramer, P.C. (2015). International Conference on Ecology and Transportation. September 20-24, 2015. Raleigh, North Carolina
- Wehbe, N., Breyfogle, A., Huft, D., Mingo, M., Konrad, M., "Precast Bridge Girder Details for Improved Performance," Poster Presentation, 95th Annual Meeting, Washington, D.C., January 11, 2016.
- Wehbe, N., Konrad, M., and Breyfogle, A., “Joint Detailing Between Double Tee Bridge Girders for Improved Serviceability and Strength.” Podium Presentation. TRB 95th Annual Meeting, Washington, D.C., January 11, 2016.
- Xiao Qin, Md. R. R. Shaon, Zhi Chen (2016), Developing Analytical Procedures for Calibrating the HSM Predictive Methods, 2016 Transportation Research Board Annual Meeting, Washington DC.
- Xiao Qin, Zhi Chen, Md. R. R. Shaon (2016), New Insights on the Role of SPF and Proportional Severity Levels in the Highway Safety Manual Predictive Methods, 2016 Transportation Research Board Annual Meeting, Washington DC.
- Zhang, Z., Deng, F., Huang, Y., Bridgelall, R., “Field validation of road roughness evaluation using in-pavement strain sensors,” SPIE Smart Structures/NDE 2016, Las Vegas, NV, March 24, 2016.
- Zhang, Z., Huang, Y., Bridgelall, R., Deng, F., “Optimization of Sampling Facilities for Weigh-in-Motion Measurements,” SPIE Smart Structures/NDE 2016, Las Vegas, NV, March 24, 2016.

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

- Bridgelall, R., Rahman, M. T., Daleiden, J. F., “Pavement Performance Evaluations Using Connected Vehicles,” International Society for Asphalt Pavements 53rd Annual Petersen Asphalt Research Conference, July 18-21, 2016, Jackson Hole, WY (abstract invited, manuscript in peer review).
- Bridgelall, R., Rahman, M. T., Tolliver, D. D., Daleiden, J. F., “A Connected Vehicle Method of Estimating the International Roughness Index,” Transportation Research Record: Journal of the Transportation Research Board, (submitted for peer-review June 2016).

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

Nothing to report at this time.

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

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 project:

Two principal investigators, faculty, and administrators participating in MPC projects at **Utah State University** are: Paul Barr, University Program Coordinator; and Patricia Cramer, PI. In addition, one student is participating in MPC research projects at **Utah State University**: Masters Students – Joseph Flower.

Six principal investigators, faculty, and administrators participating in MPC projects at the **University of Wyoming** are: Khaled Ksaibati, University Program Coordinator and PI; Debbie Shinstine, PI; Wendy Perkins, Administrator; Shaun Wulff, Statistics Professor; Jennifer Tanner, PI; and Rhonda Young, PI. In addition, nine students are participating in MPC research projects at the **University of Wyoming**: Doctorate Students: Edward Offei; Masters Students - Taylor Kasperick, Rebecca Franke, Sanjay Pokharel, Darby Hacker, Bryce Fiore, Wes Werbelow, Britton Hammit, and Sandeep Thapa.

Sixteen principal investigators, faculty, and administrators participating in MPC projects at the **University of Utah**: Richard J. Porter, University Program Coordinator and PI; Steven Bartlett, PI; Evert Lawton, Co-PI; Chris P. Pantelides, PI; Lawrence D. Reaveley, Co-PI; Xuesong Zhou, PI; Peter Martin, PI; Milan Zlatkovic, PI; Muhammad Farhan, Co-PI; Jinjin Tang, Researcher and Visiting Professor; Luis Ibarra, PI and Co-PI; Dave Strayer, PI; David Sanbonmatsu, Co-PI; Amanda Bordelon, PI; Jan Vaslestad, Co-PI; and Cathy Liu, PI. In addition, eighteen graduate students are working on MPC research projects at the **University of Utah**: Doctorate Students – M.J. Ameli, Ivana Tasic, Jeffrey Taylor, Tie Shiate (Visiting Student), M. Scott Shea, Anusha Musunuru, Arwen Behrends, Shannon Moore, Min Ook Kim, Yuandong Wang, Ramesh Neupane, and Zhuo Chen; Masters Students - Zachary Gibbs, Joel Parks, Dylan Brown, Catherine Tucker, and Anurag Upadhyay; and Francesco Biondi, visiting student scholar.

Thirteen principal investigators, faculty, and administrators are participating in MPC projects at **South Dakota State University**: Nadim Wehbe, University Program Coordinator, PI, and Co-PI; Shiling Pei, PI; Aaron Breyfogle, Project Manager; Allen Jones, PI; Xiao Qin, PI and Co-PI; Daris Ormesher, Project Manager; Guanghui Hua, PI; Beverly Klein, Lab Staff; Dave Huft, Project Manager; Junwon Seo, Co-PI; Hao Wang, Subcontractor; Chad A. Comes, Project Manager; and Haifa Samra, Co-PI. In addition, twelve graduate students are working on MPC research projects at **South Dakota State University**: Masters Students - Brittney Ahrenstorff, Todd Pauly, Jacob Humburg, Micah Underberg, Zhi Chen, Md. Razaur Rahman Shaon, Michael Konrad, Walker Olson, Kofi Oppong, Zhaoxiang He, Melissa Tracy, and Nicole Campbell.

Eight principal investigators, faculty, and administrators are participating in selected projects from **Colorado State University**: Rebecca Atadero, University Program Coordinator and PI; Mehmet Ozbek, PI; Chris Bareither, PI; John van de Lindt, PI; Bolivar Senior, Co-PI; Suren Chen, PI; Paul Heyliger, PI; and Hussam Mahmoud, PI. In addition, six graduate students are working on MPC research projects at **Colorado State University**: Doctorate Student- Mohammad Reza Hassanzadeh Gorakhki; Masters Students – Nasser Albeiruti, Chris Bright, Tyler Sobieck, Sultan Abdulaziz Alhomair, and Vaishak Gopi.

Ten principal investigators, faculty, and administrators are participating in selected projects at **North Dakota State University**: Kimberly Vachal, University Program Coordinator and PI; Brenda Lantz, PI; Doug Benson, PI; Denver Tolliver, PI and Co-PI; Pan Lu, PI; Alan Dybing, Co-PI; EunSu Lee, PI; Raj Bridgelall, PI; and

Ying Huang, Co-PI. In addition, six graduate students are working on MPC projects at **North Dakota State University**: Doctorate Students- Poyraz Kayabas, Anne Campbell, Elvis Ndembe, Chijioke Ifepe, Zhiming Zhang, and Fodan Deng.

One principal investigator, faculty, and administrator are participating in MPC projects at the **University of Denver** include: Patrick Sherry, University Program Coordinator and PI. In addition, three graduate students working on MPC projects at **University of Denver**: Doctoral Students - Keaton Zucker and Jessica Mantia; Masters Student- Rachel Mulholland.

Three principal investigator, faculty, and administrator participating in MPC projects at the **University of Colorado Denver** include: Wesley Marshall, University Program Coordinator and PI; Carolyn McAndrews, PI; and Jimmy Kim, PI. In addition, two graduate students working on MPC projects at **University of Colorado Denver**: Doctoral Student - Thushara Siriwardanage; Masters Student- Abdulaziz Alqurashi.

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. National Institute of Standards and Technology, Boulder
2. Tegracore, Industrial partner
3. Tailings and Mine Waste (TMW) Conference Committee
4. NDDOT is providing crash data and WIM data.
5. NDHP is providing officer log and CAD data and inspection data.
6. NDHP provided access to inspection and crash data via the FMSCA portal data.
7. FRA Administrators
8. AAR John Gray, Frank Hardesty, Shannon Stare
9. ASLRRRA Scott Sullivan, Elizabeth Petty, Richard Timmons
10. Fort Berthold Reservation
11. MnROAD research facility
12. South Dakota State University
13. South Dakota Department of Transportation
14. Minnesota Department of Transportation
15. South Dakota Office of EMS
16. Bridge Structure Alternatives for Local Roads
17. South Dakota Department of Transportation
18. Association of General Contractors of South Dakota
19. TRB Task Force on Aterials and Public Health
20. City and County of Denver
21. American Short Line Railroad Association
22. Wasatch Front Regional Council
23. National Cooperative Highway Research Program
24. Kittelson & Associates, Inc.
25. AAA Foundation for Traffic Safety
26. Florida Atlantic University
27. Utah Transit Authority
28. Utah Department of Transportation
29. City of Salt Lake Transportation Division
30. Norwegian Public Roads Administration
31. Utah Department of Transportation
32. Utah Division of Wildlife Resources

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

The impacts of the program will become clearer in future years. The implementation of research findings often lags project selection and completion. However, certain impacts are emerging. The benefits of the program are already being felt in many respects.

1. Graduate Education. Collectively, the MPC universities offer one of the most diverse and comprehensive multimodal multidisciplinary graduate education programs in the nation. As shown earlier, 57 courses were offered in the Spring and Summer 2016 and 496 courses have been offered since the inception of the program. The impact of the educational program will increase in future years, as the MPC universities expand the number of courses offered through their existing exchange program, in which students from any MPC university can take courses from other universities. These courses must be placed online for the collaborative exchange to work most effectively. Considerable progress has been made, thus far, in converting classroom courses to online courses and increasing the reach of the program.

2. Workforce Development. MPC's technical training program is having a major impact in the region. Online modules, short courses, webinars, and on site/videoconferencing events are reaching state and local transportation department employees and tribal transportation planners. By harnessing the capabilities of the four LTAP centers located at the MPC universities and the multimedia capabilities of the Transportation Learning Network (which was founded and is partly funded by MPC) more than 55 technical training events were offered in the second half of 2016. These training modules and short courses are critical to transportation agencies that need to improve or renew the skills of engineering technicians and other frontline workers. Many MPC courses or training events result in the certification of workers. Even when certification is not required, TLN's online learning management systems allow employees and employers to set learning goals and monitor progress towards these goals.

MPC is making another major impact in workforce development. Altogether, 57 graduate students are working on MPC research projects under the tutelage of faculty researchers. These graduate students represent the researchers and technical analysts of tomorrow. Without the MPC program and the stipend funds that it provides, these students may not be specializing in transportation; but, instead would be seeking career opportunities in other fields. The MPC research program allows faculty to mentor graduate students while allowing the students to work on projects for federal and state transportation agencies—thereby, gaining valuable practical experience.

3. Tribal Transportation Technical Assistance. The program is already having a major impact in terms of providing tools and assistance for Native American tribes in the region, especially those impacted by energy development in Wyoming and North Dakota. To better coordinate and plan tribal-related activities, NDSU has designated a tribal transportation program coordinator to help the director identify critical needs and leverage resources to meet those needs. Technical assistance is already being provided in road safety, GIS transportation model building, forecasting heavy truck traffic attributable to energy development, and facilities planning. An emergency response planning guidebook (to help tribes plan for and respond to natural disasters that impact the transportation system and the delivery of life-saving services) has been disseminated within the region and the western United States.

4. Research. During this rating period five research projects have been completed and final reports published that address critical regional and national issues. Multiple journal articles and conference papers have

been derived from each project, increasing their reach and impact. MPC's strategy of requiring journal articles and presentations at national conferences (such as TRB and the Transportation Research Forum) is greatly magnifying the impacts of the research projects and MPC reports.

5. Leadership. MPC researchers and program administrators are having a major impact through participation in TRB, TRF, ITE, and other national organizations and conferences. Moreover, MPC is a leader in responding to the dynamic and sometimes unprecedented transportation demands and issues posed by shale energy development. MPC research projects in Wyoming and North Dakota are helping impacted states and local/tribal governments develop long-term road and bridge investment strategies. Even though MPC's primary focus is State of Good Repair, MPC has responded quickly to urgent requests for safety training and research in light of the unprecedented issues associated with the transportation in the region.

5. Changes/Problems - Nothing to report 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.