

**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: December 31, 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-396: Extent, Severity, and Location of Chip Seal Loss on the South Dakota State Road Network
2. MPC-411: Re-Use of Mine Waste Materials Amended with Fly Ash in Transportation Earthwork Projects
3. MPC-414: Quantifying Sustainability Metrics for Trunkline Bridges in the Mountain Plains Region
4. MPC-416: Development and Testing of Crashworthy Ipe Bridge Rails
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-390: Design and Construction Monitoring of Surcharged Embankment
9. MPC-392: Evaluation of Spliced Sleeve Connections for Precast Reinforced Concrete Bridge Piers
10. MPC-418: 400 South Corridor Assessment

Table 2: MPC Research Projects Most Directly Correlated with Safety

1. MPC-378: MEMS Sensors for Transportation Structures
2. MPC-381: Performance-based Interaction Analysis of Damage on Bridge Expansion Joints and Heavy Traffic
3. MPC-397: Evaluation and Mitigation of Vehicle Impact Hazard for Overpass Bridges in South Dakota
4. MPC-402: Seismic Performance of SCC Bridge Columns
5. MPC-409: Identification of Low-Risk Adjusted Work Schedules Designed to Manage Fatigue During Peak Service Demand Periods in the Short line Railroad Industry
6. MPC-416: Development and Testing of Crashworthy Ipe Bridge Rails

7. MPC-418: 400 South Corridor Assessment
8. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
9. MPC-438: Calibration of HSM Predictive Methods on Rural State and Local Highways

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

1. MPC-378: MEMS Sensors for Transportation Structures
2. MPC-379: Plastic-Aluminum Composites in Transportation Infrastructure
3. MPC-387: Comprehensive GIS-Based Rural Regional Transportation Planning Models
4. MPC-390: Design and Construction Monitoring of Surcharged Embankment
5. MPC-395: Accelerated Bridge Construction in South Dakota: Pilot Study for Implementation Strategy
6. MPC-396: Extent, Severity, and Location of Chip Seal Loss on the South Dakota State Road Network
7. MPC-397: Evaluation and Mitigation of Vehicle Impact Hazard for Overpass Bridges in South Dakota
8. MPC-400: Evaluation of Ice Loads on Bridge Piers in South Dakota (Years 2 & 3)
9. MPC-402: Seismic Performance of SCC Bridge Columns
10. MPC-405: Seismic Retrofit of Spliced Sleeve Connections for Precast Bridge Piers
11. MPC-411: Re-Use of Mine Waste Materials Amended with Fly Ash in Transportation Earthwork Projects
12. MPC-414: Quantifying Sustainability Metrics for Trunkline Bridges in the Mountain Plains Region
13. MPC-415: Framework of Performance-Based Earthquake Design of Curved and Skewed Bridges
14. MPC-421: Seismic Rehabilitation of Skewed and Curved Bridges Using a New Generation of Bulking Restrained Braces
15. MPC-422: Highway Structures Supported on Expanded Polystyrene (EPS) Embankment without Deep Foundations
16. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
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-441: Developing a Pavement Management System for Small Communities
21. MPC-443: Bridge Structure Alternatives for Local Roads
22. MPC-444: Data-driven Freeway Performance Evaluation Framework for Project Prioritization and Decision Making

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

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-395: Accelerated Bridge Construction in South Dakota: Pilot Study for Implementation Strategy
5. MPC-396: Extent, Severity, and Location of Chip Seal Loss on the South Dakota State Road Network
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-409: Identification of Low-Risk Adjusted Work Schedules Designed to Manage Fatigue During Peak Service Demand Periods in the Shortline Railroad Industry
9. MPC-418: 400 South Corridor Assessment
10. MPC-422: Highway Structures Supported on Expanded Polystyrene (EPS) Embankment without Deep Foundations
11. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
12. MPC-437: Fiber Reinforced Concrete for Structure Component
13. MPC-439: Precast Bridge Girder Details for Improved Performance
14. MPC-440: Tolerances for Placement of Tie Bars in Portland Cement Concrete Pavements
15. MPC-443: Bridge Structure Alternatives for Local Roads

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-418: 400 South Corridor Assessment
5. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
6. MPC-436: Using Flocculation to Reduce Turbidity of Construction Site Runoff
7. MPC-438: Calibration of HSM Predictive Methods on Rural State and Local Highways
8. 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-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
4. MPC-411: Re-Use of Mine Waste Materials Amended with Fly Ash in Transportation Earthwork Projects
5. MPC-414: Quantifying Sustainability Metrics for Trunkline Bridges in the Mountain Plains Region
6. MPC-416: Development and Testing of Crashworthy Ipe Bridge Rails
7. MPC-418: 400 South Corridor Assessment
8. MPC-421: Seismic Rehabilitation of Skewed and Curved Bridges Using a New Generation of Bulking Restrained Braces
9. MPC-436: Using Flocculation to Reduce Turbidity of Construction Site Runoff
10. MPC-441: Developing a Pavement Management System for Small Communities

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

ii. Educational Accomplishments

The transportation and transportation-related courses offered during Summer and Fall 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 302 Evaluation of Civil Engineering Materials
	CIVE 466 Design and Behavior of Steel Structures
	CIVE 355 Introduction to Geotechnical Engineering
	CIVE 367 Structural Analysis and Intermediate Structural Analysis
	CIVE 576 Engineering Applications of GIS and GPS
	CIVE 580 Coastal Engineering - Processes and Infrastructure Design
	CEE 106 Elementary Surveying and Lab
	CEE 456 Concrete Theory and Design
	CEE 443 Matrix Analysis of Structures
	CEE 446 Advanced Geotechnical Engineering
	CEE 792 Topics-Advanced Topics in Reinforced Concrete
	CEE 769 Bridge Design
	CEE 765 Pavement Design
	CVEN 3602 Transportation Engineering

	URPL 6565 Pedestrian & Bicycle Planning
	CEE 6120 Bridge Design
	CEE 5070 Steel Design
	CEE 6130 Structural Dynamics and Seismic Design
	CEE 5010 Matrix Analysis
	CEE 3160 Civil Engineering Materials
	CE 4555 Geometric Design
	CE 3600 Soils
	CE 5555 Geometric Design
	CE 5590 Pavement Materials
	TRAN 4010 Introduction to Transportation System
	TRAN 4300 Principles of Supply Chain
	CVEEN 3510 Civil Engineering Materials
	CVEEN 5110 GIS in Civil Engineering
	CVEEN 5220 Concrete Design II
	CVEEN 5500 Sustainable Materials
	CVEEN 5570 Pavement Design
	CVEEN 6225 Concrete Science
	CVEEN 7235 Bridge Design
	CVEEN 7920 Advanced Material Testing
Freight & Logistics	TRAN 4010 Introduction to Transportation Systems
	TRAN 4330 Principles of Supply Chain: Management and technologies
	TRAN 4080 Transportation Law and Regulation: Domestic and International
Planning & Environment	URPL 6410 Social Justice in Planning URPL 6600 - Regional
	TRAN 4710 Transportation Finance
	TRAN 4020 Transportation Economics
	TRAN 4060 Transportation Marketing and Sales Tools
	TRAN 4330 Principles of Supply Chain: Management and
	TRAN 4320 Transportation Management, Leadership, and Values
	CVEEN 5560 Transportation Planning, Undergraduate
	URPL 6645 Disaster/Climate Change Planning
	URPL 6650 Planning in the Dev. World
	URPL 6405 Urban Housing
	CEE 5240 Urban and Regional Transportation Planning
Traffic & Operations	CEE 5220 Traffic Engineering
	CVEEN 7545 Transportation Modeling
	CVEEN 3520 Transportation Engineering
Public Transportation	TRAN 4080 Transportation Law and Regulation
	CE 5570 Transportation Planning
Transportation Safety	CVEN 5662 Transportation System Safety
	CVEEN 7520 Transportation Safety
Transportation Systems	CVEN 5460 Introduction to Sustainable Urban Infrastructure
	CVEEN 7920 Statistics and Econometrics
	CEE 6210 Transportation Systems Analysis

Altogether, 58 transportation and transportation-related courses have been offered during this reporting period. Altogether, 554 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. ATSSA Flagger Certification
2. ATSSA Traffic Control Technician (TCT)
3. ATSSA Traffic Control Supervision (TCS)
4. Attended Administrative Assist Training Seminar in Fargo
5. Be Safe At Home
6. Crashworthiness of Work Zone Devices Cancelled
7. Design, Layout, Inspection and Construction
8. Fundamentals of PROW ADA Tamp
9. Heavy Equipment Operation
10. Heavy Equipment Safety Operations
11. High Friction Surface Treatment
12. How Do I Respond to That? - A Practical Approach to Conflict
13. Implementation of Intelligent Compaction Technologies for Road Construction in Wyoming
14. John Maxwell's "Everyone Communicates, Few Connect"
15. John Maxwell's "How to be a Real Success"
16. Killdeer Roundtable Meeting
17. Leveraging Diversity
18. Local Roads Corrugated Metal Pipe - Devils Lake
19. Local Roads Corrugated Metal Pipe - Mandan
20. Local Roadway Snow & Ice Control On-site Bottineau
21. Local Roadway Snow & Ice Control On-site Carrington
22. Local Roadway Snow & Ice Control On-site Killdeer
23. Manager-Led Team Building: Developing Teams with Vision
24. Managing Priorities Through Time Management
25. Mobile & Terrestrial LiDAR & Effective Use of Point Cloud Data
26. NDDOT/UGPTI Regional Meeting - Devils Lake
27. NDDOT/UGPTI Regional Meeting - Dickinson
28. NDDOT/UGPTI Regional Meeting - Mandan
29. NDDOT/UGPTI Regional Meeting - Stanley
30. NDDOT/UGPTI Regional Meeting - Valley City
31. Negotiation Strategies & Techniques to Improve Construction Project
32. Overview of NEPA & Section 4(f)
33. Preventing Runners and Backovers
34. Regional Local Roads Conference On-Site Rapid City SD
35. Registered Stormwater Inspector
36. Roadway Drainage
37. Slip lining & Other Culvert Repair Options
38. State of the Practice & the Future of GPR & NDT for Pavement & Deck Surveys
39. TC3 PCC Pavement Preservation Series - Joint Sealing & Crack Sealing

- 40. TC3 Personal Protective Equipment (PPE)
- 41. Tier IV Emissions, Regeneration & Diesel Exhaust Fluid
- 42. Transfer The Knowledge Before It Walks Out The Door
- 43. Truck Rodeo
- 44. Use of Travel Time, Travel Time Reliability, & Winter Condition Index Info for Improved Operation of Rural Interstates
- 45. Workplace, Equipment and Jobsite Safety
- 46. Writing & Grammar Skills for Today's Work Environment

iv. Research accomplishments

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

Project #	Title	Date	Report No.
426	Does the Livability of a Residential Street Depend on the Characteristics of the Neighboring Street Network?	July 2016	MPC 16-309
450	Using Building Information Modeling to Track and Assess the Structural Condition of Bridges	August 2016	MPC 16-310
380	Investigation of Interaction between Traffic Safety, Law Enforcement and Environment	September 2016	MPC 16-311
415	Earthquake Fragility Assessment of Curved and Skewed Bridges in Mountain West Region	September 2016	MPC 16-312
460	Remote Sensing of Multimodal Transportation Systems	September 2016	MPC 16-313
441	Pavement Management System for City of Madison	November 2016	MPC 16-314
421	Seismic Rehabilitation of Skewed and Curved Bridges Using A New Generation of Buckling Restrained Braces	December 2016	MPC 16-315

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

- 16th World Conference on Earthquake Engineering, Santiago, Chile
- 2016 PCI Annual Convention and National Bridge Conference, Nashville, TN
- 2017 Tailings and Mine Waste, Keystone, Colorado, USA
- ACI Fall Convention. October 23-26, 2016. Philadelphia, PA.
- ASCE International Conference on Transportation & Development, Houston, TX
- Association of Collegiate Schools of Planning Annual Conference; Portland, OR; November 2016.
- ITE Western District Annual Meeting; Albuquerque, NM; July 2016.
- Pro Walk/Pro Bike/Pro Place; Vancouver, BC, Canada; September 2016.
- Proceedings of Geotechnical and Structural Engineering Congress, Phoenix, AZ
- SHRP2 NDS Data Issues Resolution Workshop, Washington, DC
- 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
- University Transportation Center Spotlight Conference on Pedestrian and Bicycle Safety, Washington, DC; December 2016.
- Utah Society of Professional Engineers Continuing Education Conference
Second Serbian Road Congress, Belgrade, Serbia

ii. Key Journal Articles or Conference Publications

- Ameli, M.J., and Pantelides, C.P. (2016). "Seismic analysis of precast concrete bridge columns connected with grouted splice sleeve connectors." *J. Structural Engineering, ASCE*, 10.1061/(ASCE)ST.1943-541X.0001678, 04016176.
- Ameli, M.J., Brown, D.N., Parks, J.E., and Pantelides, C.P. (2016). "Seismic column-to-footing connections using grouted splice sleeves." *ACI Structural J.*, May-Jun., 113(5), 1021-1030.
- 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.
- Choi, Jaesung, EunSu Lee, David C. Roberts. Reshaping Tribal Road Network using Public Information. *Journal of Geographic Information System*, Vol 6. No.6, pp.594-604.
- 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
- Kim, Min Ook, Amanda Bordelon. "Fiber Effect on Interfacial Bond Between Concrete and Fiber Reinforced Mortar" In the *Journal of the Transportation Research Board: Transportation Research Record*, No. 2591, 2016, pp. 11-18.
- Lee, EunSu, Building a Sustainable GIS Framework for Supporting a Tribal Transportation Problem. MPC15-287, North Dakota State University, Fargo: Mountain-Plains Consortium, 2016
- EunSu, Revamping Tribal Road Networks from Various Sources and Improving Quality. *Transportation Research Board*, 2017
- Wehbe, Nadim, Michael Konrad, and Aaron Breyfogle. Joint Detailing Between Double Tee Bridge Girders for Improved Serviceability and Strength. *Transportation Research Record*, No. 2592. 2016.
- Wehbe, Nadim, Michael Konrad. Precast Bridge Girder Detail for Improved Performance, Study SD2013-01, DRAFT Final Report.

- Wehbe, Nadim, Xiao Qin, Brett Tigges, Zhao Shen, and Abdullah Boudaqa. Evaluation and Mitigation of Vehicle Impact Hazards for Overpasses Study SD2012-02, DRAFT Final Report.
- Marshall, W. and McAndrews, C. Understanding Livable Streets in the Context of the Arterials that Surround Them. Transportation Research Record (doi: 10.3141/2605-01).
- 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.
- 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
- 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.
- 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. <http://dx.doi.org/10.1016/j.aap.2016.03.010>
- 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., 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
- Tasic, Ivana, Xuesong Zhou, and Milan Zlatkovic. "Use of spatiotemporal constraints to quantify transit accessibility: case study of potential transit-oriented development in West Valley City, Utah." *Transportation Research Record: Journal of the Transportation Research Board* 2417 (2014): 130-138.
- 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
- Tucker, C. and Ibarra, L. "Effects of Partial Design Strength Concrete on the Seismic Performance of Concrete Filled Tube Columns in Accelerated Bridge Construction." was published in the *ASCE Journal of Bridge Engineering* on Vo. 21, Issue 6,(ASCE)BE.1943-5592.0000812, 2016.
- Upadhyay, A., Pantelides, C.P., and Ibarra, L. "Seismic Pounding Mitigation using BRBs for Curved Bridges on Soft Soils," *Journal of Bridge Engineering*, Sept. 2016
- Wang, Y., Ibarra, L., and Pantelides, C. (2016). "Seismic Retrofit of a Three-Span RC Bridge with Buckling-Restrained Braces." *Journal of Bridge Engineering*, 21(11), 04016073.
- Zhuo Chen, Xiaoyue Liu, and Guohui 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.

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
- 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, Min Ook, Amanda Bordelon. "Fiber Effect on Interfacial Bond Between Concrete and Fiber Reinforced Mortar" 95th Annual Meeting of the Transportation Research Board (#16-3895).
- Marshall, W. and McAndrews, C. Understanding Livable Streets in the Context of the Arterials that Surround Them. Transportation Research Board; Washington, D.C.; January 2017.
- 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.
- 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.
- 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.
- Upadhyay, A., Pantelides, C. P. & Ibarra, L. (2016). "Seismic Performance of Curved Bridges on Soft Soils Retrofitted with Buckling Restrained Braces." Proceedings of Geotechnical and Structural Engineering Congress 118-137.
- Zhuo Chen and Xiaoyue Liu. "Nonrecurrent Congestion Analysis Using Data-Driven Spatiotemporal Approach for Information Construction."

iv. Key Presentations

- 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.
- Choi, J. "Integration of Road Information on the Fort Berthold Indian Reservation at the state of North Dakota using a GIS framework," 2014 Intermountain GIS Conference, Billings, MT, April 19, 2014
- Choi, J., Lee, E., Roberts, D.C., "Reshaping Tribal Road Network using Public Information." Transportation Research Board Annual Meeting, Washington D.C., January, 2015.
- 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.
- Gorakhki, M. and Bareither, C. A. "Reuse of Mine Tailings Amended with Fly Ash as Cemented Paste Backfill." 2016 Tailings and Mine Waste Conference, Keystone, Colorado, Oct. 3-5, 2016.
- Kim, Min Ook, Amanda Bordelon. "Fiber Effect on Interfacial Bond Between Concrete and Fiber Reinforced Mortar" 95th Annual Meeting of the Transportation Research Board (#16-3895). Jan 2016.
- Lee, E., "Revamping Tribal Road Networks from Various Sources and Improving Quality of the Networks." Transportation Research Board Annual Meeting, Washington D.C. January 2017.
- Marshall, W. and McAndrews, C. Understanding Livable Streets in the Context of the Arterials that Surround Them. Transportation Research Board; Washington, D.C.; January 2017.

- 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.
- Porter, R.J. “Substantive Safety Analysis: Tools for Practitioners,” Opening Keynote Speaker for the 2nd Serbian Road Congress, Belgrade, Serbia, June 9, 2016.
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, Y., M. Zlatkovic, and R.J. Porter. “Evaluation of GPS-based Transit Signal Priority for Mixed-Traffic Bus Rapid Transit.” Transportation Research Board (TRB) 95th Annual Meeting, Washington D.C., January 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.
- 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.
- 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.
- Upadhyay, A., Pantelides, C. P. & Ibarra, L. (2016). “Seismic Performance of Curved Bridges on Soft Soils Retrofitted with Buckling Restrained Braces.” Proceedings of Geotechnical and Structural Engineering Congress 2016 118-137.
- Wehbe, N. and Michael Konrad. "Precast Bridge Girder Detail for Improved Performance." Presentation to the SDDOT Research Review Board, September 7, 2016. Pierre, SD.
- Wehbe, N. Xiao Qin, Brett Tigges, Zhao Shen, and Abdullah Boudaqa. "Evaluation and Mitigation of Vehicle Impact Hazard for Overpasses." Presentation to the SDDOT Research Review Board, September 7, 2016. Pierre, SD.

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

Nothing to report at this time.

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:

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.

Seven principal investigators, faculty, and administrators are participating in selected projects from **Colorado State University**: Suren Chen, PI, Rebecca Atadero, MPC Director and PI, Christopher Bareither, PI, Paul Heyliger, PI, Hussam Mahmoud, PI, John van de Lindt, PI, Mehmet Ozbek, PI. In addition, four graduate students are working on MPC research projects at **Colorado State University**: Doctorate Student- Luke Chen and Yufen Zhou; Masters Students- Mohammad Reza Hassanzadeh Gorakhki and Sultan Abdulaziz Alhomair.

Nine 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, twenty-four graduate students are working on MPC projects at **North Dakota State University**: Doctorate Students- Bhavana Bhardwaj, Leonard Chia, Christopher Dehaan, Neeraj Dhingra, Kenechukwa Ezekwem, Kathryn Ferguson, Fesseha Gebremikael, Mingwei Guo, Seyed Ali Haji Esmaeili, Md Daulat Hossain, Luke Holt, Chijoke Ifepe, Fecri Karanki, Poyraz Kayabas, Amin Keramati, Narendra Malalgoda, Dilip Mistry, Yong Shin Park, Ali Rahim Taleqani, Jinat Rehana, Yuan Xu, Fangzheng Yuan, Zijian Zheng and Asif Arshid.

One principal investigator, faculty, and administrator is participating in MPC projects at the **University of Denver** including: Patrick Sherry. In addition, two graduate students working on MPC projects at **University of Denver**: Doctoral Students – Keaton Zucker; Masters Student-Jessica Mantia.

Twelve principal investigator, faculty, and administrator is participating in MPC projects at the **University of Utah** including: Richard J. Porter, Steve F. Bartlett, Evert C. Lawton, Amanda Bordelon, David Sanbonmatsu, David Strayer, Luis Ibarra, P. Pantelides, Lawrence D. Reaveley, Xiaoyue Cathy Liu, Xuesong Zhou, and Milan Zlatkovic. In addition, six graduate students working on MPC projects at **University of Utah**: Doctoral Students Joel Cooper, Juan Medina, Duffy, Muhammad Farhan, Jinjin Tang, Tiffany Hortin.

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. ASLRRA 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, 58 courses were offered in the summer and Fall 2016 and 554 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 46 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, 48 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 seven 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.