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
Mountain-Plains Consortium, North Dakota State University
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Upper Great Plains Transportation Institute
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1. Accomplishments: What was done? What was learned?

a. What are the major goals of the program?

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

b. What was accomplished under these goals?

i. Project Selection

Sixty research projects were selected for the 2014-2015. Projects have been selected for the original grant, while projects are still being submitted for the Modification 2 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, 451 (Year 2), MPC-446 through MPC-502.

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-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory
7. MPC-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges

8. MPC-467: Self-Regulation and Distraction
9. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
10. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
11. MPC-472: Developing an Optimization Model for Managing County Paved Roads
12. MPC-473: Bicycle and Pedestrian Design for Rural Communities
13. MPC-474: Highway Safety Manual Part D: Validation and Application in Wyoming
14. MPC-475: Analysis of the Relationship of Roadside Inspections on Large Truck Crashes
15. MPC-476: Highway-Rail Grade Crossing Traffic Hazard Forecasting Model
16. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
17. MPC-480: A Comprehensive Safety Assessment Methodology for Innovative Geometric Designs
18. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
19. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
20. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges
21. MPC-491: Self-Centering Buckling Restrained Braces for Curved Bridges
22. MPC-495: Safety Effects of Protected and Protected/Permitted Left-Turn Phases
23. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders

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-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory
12. MPC-463: Rehabilitation Project Selection and Scheduling in Transportation Networks
13. MPC-464: Development of Network-Based Measures and Computational Methods for Evaluating the Redundancy of Transportation Networks
14. MPC-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges
15. MPC-468: Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance)
16. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit

17. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
18. MPC-472: Developing an Optimization Model for Managing County Paved Roads
19. MPC-477: Characterizing the ductility of Portland cement stabilized soil
20. MPC-478: Long-Term Behavior of Precast Concrete Bridges
21. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
22. MPC-481: Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure
23. MPC-482: Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems
24. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
25. MPC-484: Effect of Service Temperature on Joint Removal in Steel Bridges
26. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
27. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges
28. MPC-492: Early-Age Fiber-Reinforced Concrete Properties for Overlays
29. MPC-493: Incorporating Maintenance Costs and Considerations into Highway Design Decisions
30. MPC-494: Statistical Analysis and Sampling Standards for Maintenance Management Quality Assurance (MMQA)
31. MPC-496: Prevention of Low Temperature Cracking of Pavements
32. MPC-497: Compaction Testing of Granular Materials
33. MPC-500: Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
34. MPC-501: Development of an Alternative to the Double Tee Bridge System
35. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders

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-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
13. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic

Competiveness
14. MPC-488: Effects of Infill Development and Regional Growth on At-Risk Populations' Exposure to Traffic Density
15. MPC-494: Statistical Analysis and Sampling Standards for Maintenance Management Quality Assurance (MMQA)

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

ii. Programmatic Milestones

In addition to the programmatic milestones described below, several milestones embedded within individual projects have been achieved. Most of the research projects call for literature reviews. The literature reviews for those projects with the earliest starts are substantially complete. Interim reports are not required after the literature review stage. At this time, all projects are on schedule to be completed as planned during the program period.

Table 6: Program Milestones

Milestone Event	Description	Start Date	End Date
Development of Proposal Guidelines	Proposal guidelines were developed by the director, in consultation with other consortium members, to ensure a consistent solicitation and project selection process that facilitates peer review and links program activities to the Secretary's strategic goals. Similar but different guidelines were developed for education, workforce development, and technology transfer projects, to reflect the differences in tasks and outcomes associated with these projects. The proposal guidelines and related information have been posted on the Center's webpage.	09/1/2013	09/15/2013
Call for Proposals	The solicitation of proposals occurred on each university campus, using proposal guidelines developed by the director. Modification 1 call for proposals. Modification 2 call for proposals	09/15/2013 05/19/2014 04/01/2015	11/15/2013 09/19/2014 12/30/2015
Execution of Grant Agreement	The grant was received from RITA and executed by NDSU's Sponsored Programs office. All of the necessary internal accounting and financial procedures were established, including subcontract agreements with consortium universities. Modification 1 execution Modification 2 execution	11/08/2013 05/19/2014 04/01/2015	11/08/2013 05/19/2014 04/01/2015
Center Directory	A directory of key center personnel was completed and published on the center's web page. Updated		12/15/2013 12/15/2014 12/15/2015

Center Webpage	The MPC webpage was updated and is fully functional for the current grant period Updated		12/15/2013 12/15/2014 12/15/2015
UTC/CUTC Meeting	The director and administrative staff attended the UTC/CUTC meeting at TRB and received guidance from RITA regarding the forthcoming grant.	01/11/2014 06/02/2014 01/11/2015 06/1/2015 1/10/2016	01/16/2014 06/05/2014 01/11/2015 06/4/2015 01/14/2016
Peer Review of Proposals	All project proposals were subjected to external and internal peer review.	01/15/2014 05/19/2014 04/01/2015	03/15/2014 12/30/2014 12/30/2015
Primary Focus	MPC's proposal targets the following MAP-21 research and technology deployment objectives under the goal of Improving Infrastructure Integrity: A) increase the reliability of life-cycle performance predictions used in infrastructure design, construction, and management; B) improve the ability of transportation agencies to deliver projects that meet expectations for timeliness, quality, and cost; C) reduce user delay attributable to infrastructure system performance, maintenance, rehabilitation, and construction; D) improve highway condition and performance through increased use of design, materials, construction, and maintenance innovations; and E) study vulnerabilities of the transportation system to seismic activities and extreme events and methods to reduce those vulnerabilities.	03/15/2014	12/31/2015
Selection of Projects	Projects were selected from the proposals received and awards were made to principal investigators, based on the peer reviews of proposals, stakeholder commitments, and the overall availability of funds.	03/15/2014 09/19/2014 04/01/2015	06/15/2014 12/30/2014 12/30/2015
Posting of Projects	The selected projects were posted on the MPC webpage and added to the Research in Progress database.	05/15/2014 09/19/2014 04/01/2015	08/15/2014 12/30/2014 12/30/2015
Site Visit	A site visit to all MPC Universities.		Annually

iii. Educational Accomplishments

The transportation and transportation-related courses offered during Spring, Summer, and Fall 2015 are listed in Table 7, 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 7: Transportation and Transportation-Related Courses Offered This Period

Major Subject Area	Course Title
Engineering & Design	CIVE 302 Evaluation of Civil Engineering Materials
	CIVE 355 Introduction to Geotechnical Engineering
	CIVE 466 Design and Behavior of Steel Structures
	CIVE 367 Structural Analysis
	CIVE 563 Structural Reliability
	CIVE 566 Intermediate Structural Analysis
	CIVE 576 Engineering Applications of GIS and GPS
	CIVE 664 Mechanics of Fatigue and Fracture
	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 455: Steel Design
	CEE 769: Bridge Design
	CEE 755: Advanced Reinforced Concrete
	CEE 447/547: Foundation Engineering
	CEE 363: Highway and Traffic Engineering
	CEE 346: Geotechnical Engineering
	CEE 749: Geotechnical Testing
	CVEN 3602 - Transportation Engineering
	CVEN 4602 - Highway Engineering
	CVEN 5602 - Advanced Street & Highway Design
	CVEN 5682 - Pavement Design
	CvEEN 5510 Highway Design Undergraduate
	CvEEN 5920 Sustainable Materials Undergraduate
	CvEEN 5220 Concrete Design II Undergraduate
	CvEEN 6225 Concrete Science Graduate
	CvEEN 6330 Soil Dynamics Graduate
	CvEEN 2130 Statistics and Economics Undergraduate
	CvEEN 5420 Open Channel Flow Undergraduate
	CvEEN 5570 Pavement Design Undergraduate
	CE 3500 Transportation Engineering
	CE 4510 Pavement Engineering
	CE 5510 Pavement Engineering

	CE 4555 Geometric Design of Highways
	CE 4900 CDE in Transportation
	CEE 6120 Bridge Design
	CEE 5070 Steel Design
	CEE 6130 Structural Dynamics and Seismic Design
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
	URPL 5010 - Planning Methods
	URPL 6650 - Planning in the Developing World
	URPL 6565 - Pedestrian and Bike Planning
	CvEEN 5560 Transportation Planning Undergraduate
	CEE 5240/6220 Urban and Regional Transportation Planning
Traffic & Operations	CVEN 5621 - Highway Capacity Analysis
	CVEN 5622 - Traffic Operations and Control
	CvEEN 3520 Transportation Engineering Undergraduate
	CvEEN 6525 Highway and Traffic Engineering Graduate
	CEE 5220/6220 Traffic Engineering
Transportation Safety	CVEN 5611 - Traffic and Safety Data Analysis
	CVEN 5622 - Transportation System Safety
	CE 5560 Traffic Safety
Transportation Systems	URPL 6555 - Transportation and Land Use
	CVEN 5633 - Case Studies in Sustainable Transportation
	CvEEN 7920 Statistical and Econometric Analysis Graduate
	CvEEN 7540 Intelligent Transportation Systems
	CEE 6210 Transportation Systems Analysis

Altogether, 69 transportation and transportation-related courses have been offered this reporting period, for a total of 279 total transportation courses offered this grant period. In addition to the courses listed in Table 7, 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. Aggregate Certification
2. Asphalt Certification
3. Asphalt Paving Maintenance 1 and 2
4. ATSSA Flag Certification
5. ATSSA Flagger Instructor Training
6. ATSSA Traffic Control
7. ATSSA Traffic Control Supervisor
8. Basics of good Roads
9. Communication Skills for Supervisors
10. Concrete Certification
11. Flagger Certification
12. Heavy Equipment Safety Operations
13. Preventing Runners and Backovers
14. Registered Stormwater Inspector
15. Retroreflectivity for signs
16. Road and Safety Fundamentals
17. Roadway Drainage
18. Roadway Materials
19. Street Lighting
20. Street Sweeper
21. Transportation and Safety Congress
22. Case Studies in Performance-Based Analysis of Geometric Design, Transportation Research Board Webinar
23. Future Directions in Highway and Street Design and Analysis, Workshop at the 5th International Symposium on Highway Geometric Design
24. Welding
25. Winter Road Maintenance
26. Workplace, Equipment and Jobsite Safety
27. Work-zone Safety

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.
370	Anticipatory Guidance Provision Related to Driving Safety/Cessation for Older Drivers: A Rural-Urban Comparison	Dec 2014	MPC 14-277

373	Damage Assessment, Characterization, and Modeling for Enhanced Design of Concrete Bridge Decks in Cold Regions	Jul 2015	MPC 15-286
394	Using Expert Opinion to Quantify Accuracy and Reliability of Nondestructive Evaluation of Bridges	Aug 2015	MPC 15-288

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

- 18th Annual National Transportation Conference; September 21-24, 2015; Myrtle Beach, South Carolina
- 2015 American Society of Engineering Education Annual Conference and Exposition, Seattle, WA
- 20th International Conference on Composite Materials, Copenhagen, Denmark
- 21st International Symposium on Transportation and Traffic Theory (ISTTT21), Kobe, Japan
- 3rd International Conference on Human Factors in Transportation, Las Vegas, NV
- 55th Annual ITE Intermountain Section Meeting, May 14 – 16, 2015, Jackson, WY
- 5th International Symposium on Highway Geometric Design, Vancouver, Canada
- ACI Spring 2015 Convention. Kansas City, MO
- American Concrete Institute: Spring convention, Kansas City, MO
- Associated Schools of Construction 51st Annual International Conference, College Station, TX
- Congress for the New Urbanism Annual Conference, Dallas, TX

- European Association for Signal Processing (EUSIPCO 2015): Hyperspectral Applications in the Global Transportation Infrastructure, Nice, France, August 31, 2015
- ITE Western District Meeting, Las Vegas, NV
- Pavement Performance of Typical UDOT Surface Mixtures, Salt Lake City, UT
- Sensors Expo and Conference 2015: Emerging Applications of Hyperspectral Image Sensing in Transportation, Long Beach, CA, June 9, 2015
- The Canadian Society for Civil Engineering 5th International/11th Construction Specialty Conference, University of British Columbia, Vancouver, Canada

ii. Key Publications

- Bogutyn, S., Catalina A., Bordelon, A., and Tikalsky, P. "Rejuvenation Techniques For Concrete Containing Photocatalytic TiO2 Material," Construction and Building Materials, Vol. 96, 2015 pp. 96-101.
- Clevenger, C.M., Ozbek, M.E., Fanning, B., and VonFeldt, S. (2015). "Case Study of Work-based Learning Involving BIM for Infrastructure in Support of Graduate Construction Research." International Journal of Construction Education and Research 11 (3), 163-178.
- 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," Transportation Research Record: Journal of the Transportation Research Board, 2015, submitted.
- Kim, M.O. and Bordelon, A. "Fiber Effect on Interfacial Bond Between Concrete and Fiber Reinforced Mortar," Transportation Research Record: Journal of the Transportation Research Board, 2015, submitted.
- McGuire, B., Atadero, R.A., Clevenger, C., and Ozbek, M. Bridge Information Modeling for Inspection and Evaluation, ASCE Journal of Bridge Engineering, Accepted August 2015.
- Pan Lu, and Denver Tolliver. Accident Prediction Model for Public Highway-Rail Grade Crossings, Accident Analysis & Prevention,2015 (under review)
- Parks, J.E. Brown, D.N., Ameli, M.J., and Pantelides, C.P. "Seismic Repair of Severely Damaged Precast RC Bridge Columns Connected with Grouted Splice Sleeves," ACI Structural Journal, 2015 accepted.
- Song, Y., Zlatkovic, M., and Porter, R.J. "GPS-Based Transit Signal Priority for Mixed-Traffic Bus Rapid Transit," Transportation Research Record: Journal of the Transportation Research Board, 2015, submitted.
- Tasic, I. and Porter, R.J. "Modeling Spatial Relationships between Access to Multimodal Transportation and Traffic Safety Outcomes," Safety Science, 2015, accepted.
- 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," Transportation Research Record: Journal of the Transportation Research Board, 2015, submitted.

- Zijian Zheng, Pan Lu, and Denver Tolliver. Accident Prediction for Highway-Rail Grade Crossings using Decision Tree Approach: An Empirical Analysis, Transportation Research Record, 2015 (under review)

iii. Key Conference Papers

- Bridgelall, R., Rafert, J. B., Tolliver, D., "Emerging Applications of Hyperspectral Image Sensing in Transportation," In: Proc. Sensors Magazine, Long Beach, CA, June 9, 2015.
- Bridgelall, R., Rafert, J. B., Tolliver, D., "Hyperspectral Applications in the Global Transportation Infrastructure," In: Proc. European Association for Signal Processing (EUSIPCO 2015), Nice, France, August 31, 2015.
- Kim, Min Ook, and Amanda Bordelon. "Age-Dependent Properties of Fiber Reinforced Concrete Used in Thin Overlays". Accepted to 11th ICCP 2016 Conference in San Antonio 6/25/2015.
- Li, Y., Romero, P., Sudbury, D., and Allen, C.: "Repeatability and Reproducibility of Low-Temperature Testing of Asphalt Mixtures Using the Bending Beam Rheometer." Proceedings ASCE 16th International Conference on Cold Regions Engineering. Salt Lake City, UT. ISBN (PDF): 978-0-7844-7931-5, Salt Lake City, UT. W.S. Guthrie, ed. Pp 217-228 (July, 2015)
- Li, Y., Sudbury, D., and Romero, P.: "Use of the Bending Beam Rheometer as a Low-Temperature Performance Tests for Asphalt Mixtures." Paper 16-4994. Submitted to the 2016 Meeting of the Transportation Research Board. Washington DC. (2016)
- Marshall, W. and Ferenchak, N. The American Story of Inequitable Road Safety Outcomes. Congress for the New Urbanism Annual Meeting, Dallas, TX, April 2015.
- Musunuru, A, Porter, R.J., Fyfe, M., and Sayed, T. "Risk and Reliability Analysis of Geometric Design Criteria: A Critical Synthesis," Compendium of Papers from the 5th International Symposium on Highway Geometric Design, Vancouver, Canada, June 22-24, 2015.
- Pan Lu, and Denver Tolliver. Accident Prediction Model for Public Highway-Rail Grade Crossings 2015 (under review)
- Parks, J.E., Brown, D.N., Ameli, M.J., and Pantelides, C.P. (2015). "Repair of damaged precast bridge columns with grouted splice sleeve connections using CFRP shells and plastic hinge relocation." 20th Intern. Conf. on Composite Materials, Paper 3319-2, Copenhagen, Denmark.
- Sudbury, D., Romero, P., Li, Y., and Gong, X.: "Evaluating the Effect of Air Voids and Binder Content in Cold Temperature Testing of Asphalt Mixtures Using the Bending Beam Rheometer." Proceedings ASCE 16th International Conference on Cold Regions Engineering. Salt Lake City, UT. ISBN (PDF): 978-0-7844-7931-5, Salt Lake City, UT. W.S. Guthrie, ed. Pp 229-240 (July, 2015)

- Xu, Xiangdong, Anthony Chen, Sarawut Jansuwan, Kevin Heaslip, Chao Yang. "Modeling transportation network redundancy." Transportation Research Procedia of the 21st International Symposium on Transportation and Traffic Theory (ISTTT21), Kobe, Japan, 2015.
- Zijian Zheng, Pan Lu, and Denver Tolliver. Accident Prediction for Highway-Rail Grade Crossings using Decision Tree Approach: An Empirical Analysis 2015 (under review)

iv. Key Presentations

- Bumadian, I. and Kim, Y.J. 2015. Galvanic corrosion of steel-composite interface bonded with a polymeric adhesive, ASCE Structures Congress 2015, Portland, OR, USA
- Marshall, W. and Ferenchak, N. The American Story of Inequitable Road Safety Outcomes. Congress for the New Urbanism Annual Meeting, Dallas, TX, April 2015.
- MPC-497: Compaction Testing of Granular Materials - A presentation was made to the SDDOT as part of project kickoff.
- MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders - A kickoff presentation was made to the WisDOT.
- Musunuru, A, Porter, R.J., Fyfe, M., and Sayed, T.* “Risk and Reliability Analysis of Geometric Design Criteria: A Critical Synthesis,” Poster Session 2 of the 5th International Symposium on Highway Geometric Design, Vancouver, Canada, June 23, 2015.
- Parks, J.E., Brown, D.N., Ameli, M.J., and Pantelides, C.P. “Repair of damaged precast bridge columns with grouted splice sleeve connections using CFRP shells and plastic hinge relocation.” 20th International Confercent on Composite Materials, Copenhagen, Denmark, 2015.
- Porter, R.J. “Geometric Design, Speed, and Safety,” TREC Seminar Series, Portland State University, Portland, Oregon, April 10, 2015.
- Porter, R.J. “Past, Current, and Future Roles of Speed in Highway and Street Design,” Workshop 2 of the 5th International Symposium on Highway Geometric Design, Vancouver, Canada, June 21, 2015.
- Porter, R.J. “Performance-Based Geometric Design Analysis,” Workshop 2 of the 5th International Symposium on Highway Geometric Design, Vancouver, Canada, June 21, 2015.
- Romero, P. Prevention of Low Temperature Cracking of Pavements, AASHTO Subcommittee on Materials (SOM) meeting. Pittsburgh, PA, August 2015.
- Siriwardanage, T. and Kim, Y.J. 2015. Thermal-conduction modeling of a composite material embedded in a concrete substrate, 4th International Conference on Material Modeling, Berkley, CA, USA
- Taylor, J. and X. Liu. Big Data Analytic of Bike Share Program. Salt Lake City Transportation Advisory Board. Salt Lake City, UT, May 4, 2015.

- Wehbe, N., Tazarv, M., Bohn, L. "Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders." South Dakota Department of Transportation, Oct. 08, 2015.
- Wehbe, N., Tazarv, M., Mingo, M., Carnahan, Z. "Development of an Alternative to the Double Tee Bridge System." South Dakota Department of Transportation, Oct. 08, 2015.
- Xu, Xiangdong, Anthony Chen, Sarawut Jansuwan, Kevin Heaslip, Chao Yang. "Modeling transportation network redundancy." 21st International Symposium on Transportation and Traffic Theory (ISTTT21), Kobe, Japan, August 5-7, 2015.
- Zlatkovic, M. "Deterministic Tool for Operational and Safety Assessment of Innovative Intersection/ Interchange Design Alternatives" 55th Annual ITE Intermountain Section Meeting, May 14–16, 2015, Jackson, WY.

v. Other Items Produced During this Period

- Bridgelall, R., Rafert, J. B., Tolliver, D., Lee, E., “Resolution Agile Remote Sensing for Transportation Safety,” Transportation Research Record: Journal of the Transportation Research Board, (submitted 6-8-15; in peer review)
- Bridgelall, R., Rafert, J. B., Tolliver, D., “Hyperspectral image acquisition with unmanned aircraft swarms,” International Journal of Remote Sensing, (re-submitted on 9-7-15; awaiting review response)
- Bridgelall, R., Rafert, J. B., Atwood, D., “Hyperspectral Range Imaging for Transportation Systems Evaluation,” SPIE Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems 2016, (submitted 7-19-15; in peer review)
- Bridgelall, R., Rafert, J. B., Tolliver, D., “Concepts to Guide Hyperspectral Data Use in Transportation Systems,” SPIE Journal of Applied Remote Sensing, (submitted 6-11-15; in peer review)
- Bridgelall, R., Rafert, J. B., Tolliver, D., Lee, E., “Rapid hyperspectral image classification to enable autonomous search systems,” International Journal of Remote Sensing, (submitted on 9-22-15; 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)
- Grant Award (NDSU Foundation Centennial Endowment): Rafert, J. B., “Remote Sensing of ND Roads and Pipelines Using Unmanned Airborne Systems (UAS)”, May, 2015 ($4945). Used to purchase a Bergen Hexacopter. Currently, the Hexacopter is undergoing integration with its radio and power supply.
- Sensor Acquisition and Evaluation: XIMEA Hyperspectral Camera. Installed Matlab, ENVI, and the sensor software to evaluate the image quality.
- Draft Masters Thesis of Locquiao, J. Multifaceted Analysis of Transit Station Accessibility Characteristics Based on First Mile Last Mile. University of Utah, October, 2015.

- Draft Report for Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance)
- MPC-453: Speed Selection Behavior during Winter Road Conditions - Draft report chapters.
- MPC-473: Bicycle and Pedestrian Design for Rural Communities - Survey of stakeholders was developed and administered to local agencies in Wyoming.
- MPC-470: Evaluating Transportation Professional Development and Continuing Education Courses - The draft copy of the final report.
- MPC-477: Characterizing the ductility of Portland cement stabilized soil - We have primarily been working with the students on the literature review and the preparation for the testing.
- MPC-478: Long-Term Behavior of Precast Concrete Bridges - One student has been working on his MS thesis for this project.

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: Christopher Bareither, PI; Paul Heyliger, Co-PI; John W. van de Lindt, PI; Bolivar Senior, Co-PI; Rebecca Atadero, MPC Director and PI; Mehmet Ozbek, Co-PI; Caroline Clevenger, Co-PI; Jeffrey D. Niemann, PI; Hussam Mahmoud, Co-PI; Suren Chen,

PI; Kelly Strong, Co-PI; and Scott Glick, Co-PI. In addition, eleven students are working on MPC research projects at **Colorado State University**: Doctorate Students- Kirsten Peterson, Yufen Zhou, and Luke Chen; Masters Students- Taylor Ray, David Turner, Patrick Sanders, Almotasem Maamon, Aliena Debelak, and Avi Sharma; Undergraduate Students- Kole Van Trese and Kayla Moden.

Five principle investigators, faculty, and administrators participating in MPC projects at **North Dakota State University** are: Bruce J. Rafert, PI; Raj Bridgelall, Co-PI; Pan Lu, PI; Brenda Lantz, PI; Kimberly Vachal, PI; EunSu Lee, PI; Alan Dybing, PI; and Denver Tolliver, MPC Director and PI. In addition, twenty four graduate students are working on MPC projects at **North Dakota State University**: Doctorate Students- Poyraz Kayabas, Christopher DeHaan, Neeraj Dhingra, Kathryn Ferguson, Mingwei Guo, Luke Holt, Amin Keramati, Osama Khan, Babak Mirzazadeh, Dilip Mistry, Yong Shin Park, Yuan Xu, Fangzheng Yuan, Anne Campbell, Elvis Ndembe, Chijioke Ifepe, Ali Rahim Talegani, Zijian Zheng, Zhiming Zhang, Asif Arshid, and Keshab Thapa; Masters Students- Ashkan Saboori, Sara Mamani, and Liuqing Hu.

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

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

Ten principle investigators, faculty, and administrators participating in MPC projects at the **University of Utah** are: Richard J. Porter, MPC Director and PI; Milan Zlatkovic, PI and Co-PI; 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; and Daniel Fagnant, Technical Advisor. In addition, twenty-one students are working on MPC research projects at the **University of Utah**: Doctorate Students- Ivana Tasic, Jeff Taylor, Arwen Behrends, Yu Song, Anusha Musunuru, Zhuo Chen, M. Scott Shea, Kiavash Fayyaz, Catalina Arboleda, Joel Parks, MJ Ameli, Anurag Upadhyay, Ruoyang Wu, and Min Ook Kim; Masters Students- Jem Locquaio, Daniel Sudbury, Yang Li, Dillon Li, and Siddartha Rayaprolu; Undergraduate Students- Ryan Betz and Ariel Froerer.

Five principle investigators, faculty, and administrators participating in MPC projects at the **University of Wyoming** are: Khaled Ksaibati, MPC Director, PI, and Co-PI; Mohamed Ahmed, PI; Rhonda Young, Associate Professor and PI; Kam Ng, PI; and Bart Evans, Administration. In addition, seven students are working on MPC research projects at the **University of Wyoming**: Masters Students- Chris Chamberlin, Rameshwor Chalise, Sandeep Thapa, Trenna Terrell, Dawit

Mebrahtom, and Sadia Sharmin; Undergraduate Student- Nicole Peterson. Others participating in MPC projects at the **University of Wyoming** include Dennis Trusty, Director NP TTAP.

Six principle investigators, faculty, and administrators participating in MPC projects at **Utah State University** are: Ziqi Song, PI and Co-PI; Anthony Chen, PI and Co-PI; James Dorward, PI; Jim Bay, PI; John Rice, PI; and Paul Barr, MPC Director and PI. In addition, seven students are working on MPC research projects at **Utah State University**: Doctorate Students- Majid Khalilikhah, Seungkyu Ryu, and Ann Heaslip; Masters Students- Jen Ostrowski, Phillip Powelson, Yi He, and Holly Lloyd. Others participating in MPC projects at the **Utah State University** include Xiangdong Xu, Collaborator; Sarawut Jansuwan, Collaborator; and Keechoo Choi, Collaborator.

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. East Dakota Water Development District
10. Federal Highway Administration, Wyoming Division
11. Fehr & Peers
12. Inberg Miller Engineers, Casper WY
13. James River Water Development District
14. Key Laboratory of Road and Traffic Engineering, Tongji University, Shanghai, China.
15. Lincoln County Road and Bridge Department
16. Michigan Technological Research Institute
17. National Institute of Development Administration (NIDA), Bangkok, Thailand.
18. Sisseton Wahpeton Oyate Reservation
19. South Dakota Department of Environment and Natural Resources
20. South Dakota Department of Transportation
21. Standing Rock Sioux Tribe Indian Reservation
22. StarSeismic LLC
23. Teton County Road and Bridge Department
24. Utah Department of Transportation
25. Utah State University College of Education
26. Utah Transit Authority
27. Virginia Tech
28. Wasatch Front Regional Council
29. Wisconsin Department of Transportation
30. Wyoming Department of Transportation
31. 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's projects are having an impact by helping to support the transportation education of undergraduate, masters, and doctoral students. The projects have had some impact on their respective research disciplines, although it is still early for many projects.

The **University of Colorado Denver** projects listed under this reporting period represent emerging and innovative research topics that will impact the research community and broader society. The impact of these MPC efforts (via both research and workforce development) is being felt in Transportation Engineering, Planning, and Structural Engineering. The MPC work had facilitated the workforce development of multiple students in research methods and skill development (particularly with respect to GIS, statistical approaches/software, and structural steel girder corrosion investigations). All of this work is combining to improve the reputation of CU Denver as a research university with strengths in transportation, which assists both the University as well as the students in the workforce. These MPC projects have led to multiple popular press articles and a broader discussion of these research topics in society.

Implementation of the **University of Utah's** program is still in early stages, and measurable research impacts are difficult to quantify at this point in time. One project PI has noted that early ideas generated from the initial tasks of one project has already been incorporated into a graduate-level highway engineering class at the University of Utah. The program already shows substantial support in the area of workforce development, with 22 undergraduate and graduate students heavily involved in the research projects. Two of these students were recognized as the 2015 American Road & Transportation Builders Association (ARTBA) Future Industry Leader Spotlight Award, recognizing women who have achieved outstanding academic records and demonstrated extraordinary leadership skills within and outside of the academic environment.

The **University of Wyoming's** projects have impacts in the following ways; The tribal safety projects are enhancing the safety on Indian reservations and the infrastructural projects are helping DOTs implement more cost effective designs for infrastructures.

b. Expected Impacts

Colorado State University's projects are expected to have impacts on their disciplines by contributing to ongoing advances in various transportation related fields.

South Dakota State University's projects have the following expected impacts. Identify and select modern techniques for verifying target compaction levels in the field for granular materials. Develop a low-maintenance, low-cost mixed-media filtration system for storm water treatment. Produce guidance for evaluating the suitability of aqueous waste streams for transportation-related applications in South Dakota. Develop rehabilitation techniques for

longitudinal joint in double tee bridge girder bridge systems on local roads. Develop new economically competitive alternative systems to double tee bridge girders. Develop SCC mix designs for use in prestressed bridge girders in Wisconsin.

The **University of Colorado Denver's** projects have the following expected impacts. While difficult to quantify, we expect the work under investigation to set the stage for continued growth of the UTC program at CU Denver with respect to both future research projects that will leave a positive impact on society as well as the careers and the students and faculty that work on these projects. The outcomes of these projects will be of particular benefit to cities serious about providing a safe transportation system for all road users and reducing fatalities on the roadway.

Results of the ongoing projects for the **University of Utah** 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. An example is 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.

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