Grant No. DTRT12-G-UTC08
Mountain-Plains Consortium, North Dakota State University Denver Tolliver,
Director Denver.tolliver@ndsu.edu
(701)231-7190
June 30, 2016

DUNS: 803882299 and EIN: 45-6002439

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

Grant period: January 1, 2012 – June 30, 2016

Reporting Period End Date: June 30, 2016
Semi-Annual PPPR#9

Denver D. Tolliver
Director, Mountain-Plains Consortium North Dakota State University
1. Accomplishments: What was done? What was learned?

a. What are the major goals of the program?

The overall objectives are to: (1) conduct basic and applied research, the products of which are judged by peers or other experts in the field of transportation to advance the body of knowledge in transportation; (2) offer an education program in transportation that includes multidisciplinary course work and participation in research; (3) conduct workforce development activities and programs to expand the workforce of transportation professionals; (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
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
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

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

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

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Project Description</th>
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<tbody>
<tr>
<td>MPC-366</td>
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<tr>
<td>MPC-387</td>
<td>Comprehensive GIS-Based Rural Regional Transportation Planning Models</td>
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<td>MPC-395</td>
<td>Accelerated Bridge Construction in South Dakota: Pilot Study for Implementation Strategy</td>
</tr>
</tbody>
</table>
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
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 Retrofit 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

### 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

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

<table>
<thead>
<tr>
<th>Project #</th>
<th>Title</th>
<th>Date</th>
<th>Report No</th>
</tr>
</thead>
<tbody>
<tr>
<td>470</td>
<td>Guidelines for Effective LTAP Course Evaluation</td>
<td>January 2016</td>
<td>MPC-16-305</td>
</tr>
</tbody>
</table>
c. How have the results been disseminated?

The results are being disseminated in a variety of ways, including: (1) workshops and conferences, (2) videoconferences, (3) online modules, (4) presentations at conferences, (5) publications, (6) webpage postings and displays, and (7) Internet-based dissemination media, including broadcast emails and webinars. 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
- ASCE Geotechnical and Structural Engineering Congress, Phoenix, AZ.
- ASCE International Conference on Transportation & Development, Houston, TX
- Calibration of HSM Predictive Methods on Rural State and Local Highways 2016 Transportation Research Board Annual Meeting, Washington DC.
- 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
- 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.
• 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.


• 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


• 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


• 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


• 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.


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.


iv. Key Presentations

• 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]
• 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]
• 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.

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

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 Upadhay; 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 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, twelve graduate students are working on MPC research projects at South Dakota State University: Masters Students - Brittney Ahrenstorff, Todd Pauly, Jacob Humbug, 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 Ndemebe, 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
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.