

**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,  
Director [Denver.tolliver@ndsu.edu](mailto:Denver.tolliver@ndsu.edu)  
(701)231-7190**

**Dec 31, 2015**

**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: Dec 31, 2015  
Semi-Annual PPR#8**

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## **1. Accomplishments: What was done? What was learned?**

### **a. What are the major goals of the program?**

The overall objectives are to: (1) conduct basic and applied research, the products of which are judged by peers or other experts in the field of transportation to advance the body of knowledge in transportation; (2) offer an education program in transportation that includes multidisciplinary course work and participation in research; (3) conduct workforce development activities and programs to expand the workforce of transportation professionals; (4) provide an ongoing program of technology transfer to make transportation research results available to potential users in a form that can be readily used; and (5) provide planning and technical assistance to Native American tribes, especially those heavily impacted by energy development. Other program goals are to select projects and activities using peer review principles and procedures and client input that: (1) address the Secretary's strategic goals, and (2) leverage UTC funds with matching funds from state and local governments and private industry. The chief operational goals for grant DTRT12-G-UTC08 is to make important contributions to research and technology transfer in key areas related to the Secretary's goals of State of Good Repair, Safety, and Economic Competitiveness, while addressing critical issues of the region and stakeholder groups—especially issues in the rapidly growing Bakken oil production region.

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

#### **i. Project Selection and Peer Review**

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

#### **Table 1: MPC Research Projects Most Directly Correlated with Sustainability**

1. MPC-390: Design and Construction Monitoring of Surcharged Embankment
2. MPC-392: Evaluation of Spliced Sleeve Connections for Precast Reinforced Concrete Bridge Piers
3. MPC-393: Traffic Modeling of Transit Oriented Development
4. 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-367: Developing Statistical Models for Crash Severity Comparing Statewide, County and Indian Reservation Roads
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-397: Evaluation and Mitigation of Vehicle Impact Hazard for Overpass Bridges in South Dakota
6. MPC-402: Seismic Performance of SCC Bridge Columns
7. MPC-406: Risk- and Reliability-Based Approaches to Analyzing Road Geometric Design Criteria
8. MPC-407: The Effect of Multi-tasking on Self-Assessments of Driving Performance Center for the Prevention of Distracted Driving
9. MPC-408: Exploring Unique Plastic-Reinforced Bridge Decks: Phase I
10. MPC-409: Identification of Low-Risk Adjusted Work Schedules Designed to Manage Fatigue During Peak Service Demand Periods in the Shortline Railroad Industry
11. MPC-416: Development and Testing of Crashworthy Ipe Bridge Rails

12. MPC-418: 400 South Corridor Assessment
13. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
14. MPC-431: Connected Vehicle Weather Data for Operation of Rural Variable Speed Limit Corridors
15. MPC-432: Finding Innovative Solutions to Prevent Wildlife Access to Highways at Wildlife Guards
16. MPC-438: Calibration of HSM Predictive Methods on Rural State and Local Highways
17. MPC-445: A Sensor Fusion Approach to Assess Pavement Condition and Maintenance

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

1. MPC-365: Improved Understanding of Pavement Impacts and Cost-Effective Designs Based on Mechanistic Empirical Methods
2. MPC-375: Small Railroad Capital Investment Needs and Financial Options
3. MPC-378: MEMS Sensors for Transportation Structures
4. MPC-379: Plastic-Aluminum Composites in Transportation Infrastructure
5. MPC-387: Comprehensive GIS-Based Rural Regional Transportation Planning Models
6. MPC-390: Design and Construction Monitoring of Surcharged Embankment
7. MPC-394: Quantifying Uncertainty in Nondestructive Bridge Inspection Methods for use in Performance Based Inspection
8. MPC-395: Accelerated Bridge Construction in South Dakota: Pilot Study for Implementation Strategy
9. MPC-396: Extent, Severity, and Location of Chip Seal Loss on the South Dakota State Road Network
10. MPC-397: Evaluation and Mitigation of Vehicle Impact Hazard for Overpass Bridges in South Dakota
11. MPC-400: Evaluation of Ice Loads on Bridge Piers in South Dakota (Years 2 & 3)
12. MPC-402: Seismic Performance of SCC Bridge Columns
13. MPC-404: Seismic Performance of Concrete Filled Steel Tube (CFST) Bridge Columns For Accelerated Bridge Construction
14. MPC-405: Seismic Retrofit of Spliced Sleeve Connections for Precast Bridge Piers
15. MPC-406: Risk- and Reliability-Based Approaches to Analyzing Road Geometric Design Criteria
16. MPC-410: Predicting Fatigue Service Life Extension of RC Bridges with Externally Bonded CFRP Repairs
17. MPC-411: Re-Use of Mine Waste Materials Amended with Fly Ash in Transportation Earthwork Projects
18. MPC-414: Quantifying Sustainability Metrics for Trunkline Bridges in the Mountain Plains Region
19. MPC-419: Experimental and Numerical Study for the Debonding Interface Between an Existing Pavement and a New Concrete Overlay
20. MPC-421: Seismic Rehabilitation of Skewed and Curved Bridges Using a New Generation of Bulking Restrained Braces
21. MPC-422: Highway Structures Supported on Expanded Polystyrene (EPS) Embankment without Deep Foundations
22. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
23. MPC-427: Fire Performance of Bridge Members Retrofitted with Near-Surface-Mounted Carbon Fiber Reinforced Polymer Composites
24. MPC-428: Using Recycled Concrete Aggregate in New Concrete Construction
25. MPC-429: A Methodology for Developing a Replacement Strategy for County/City Owned Bridges
26. MPC-432: Finding Innovative Solutions to Prevent Wildlife Access to Highways at Wildlife Guards
27. MPC-437: Fiber Reinforced Concrete for Structure Component
28. MPC-439: Precast Bridge Girder Details for Improved Performance
29. MPC-440: Tolerances for Placement of Tie Bars in Portland Cement Concrete Pavements
30. MPC-441: Developing a Pavement Management System for Small Communities
31. MPC-442: Improving Rural Emergency Medical Services (EMS) through Transportation System Enhancements, Phase II
32. MPC-443: Bridge Structure Alternatives for Local Roads
33. MPC-444: Data-driven Freeway Performance Evaluation Framework for Project Prioritization and Decision Making
34. MPC-445: A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness

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

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1. MPC-375: Small Railroad Capital Investment Needs and Financial Options
2. MPC-379: Plastic-Aluminum Composites in Transportation Infrastructure
3. MPC-384: Understanding Public Perceptions of Different Revenue Generation Systems for Highway Construction and Maintenance
4. MPC-387: Comprehensive GIS-Based Rural Regional Transportation Planning Models
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-402: Seismic Performance of SCC Bridge Columns
9. MPC-408: Exploring Unique Plastic-Reinforced Bridge Decks: Phase I
10. MPC-409: Identification of Low-Risk Adjusted Work Schedules Designed to Manage Fatigue During Peak Service Demand Periods in the Shortline Railroad Industry
11. MPC-418: 400 South Corridor Assessment
12. MPC-422: Highway Structures Supported on Expanded Polystyrene (EPS) Embankment without Deep Foundations
13. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
14. MPC-426: Does the Livability of a Residential Street Depend on the Characteristics of the Neighboring Street Network?
15. MPC-427: Fire Performance of Bridge Members Retrofitted with Near-Surface-Mounted Carbon Fiber Reinforced Polymer Composites
16. MPC-437: Fiber Reinforced Concrete for Structure Component
17. MPC-439: Precast Bridge Girder Details for Improved Performance
18. MPC-440: Tolerances for Placement of Tie Bars in Portland Cement Concrete Pavements
19. MPC-443: Bridge Structure Alternatives for Local Roads
20. MPC-445: A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness

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

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1. MPC-379: Plastic-Aluminum Composites in Transportation Infrastructure
2. MPC-387: Comprehensive GIS-Based Rural Regional Transportation Planning Models
3. MPC-392: Evaluation of Spliced Sleeve Connections for Precast Reinforced Concrete Bridge Piers
4. MPC-393: Traffic Modeling of Transit Oriented Development
5. MPC-408: Exploring Unique Plastic-Reinforced Bridge Decks: Phase I
6. MPC-417: Evaluation and Development of Livability and Sustainability Programs for Indian Reservations
7. MPC-418: 400 South Corridor Assessment
8. MPC-425: Building a Sustainable GIS Framework for Supporting a Tribal Transportation Program
9. MPC-426: Does the Livability of a Residential Street Depend on the Characteristics of the Neighboring Street Network?
10. MPC-436: Using Flocculation to Reduce Turbidity of Construction Site Runoff
11. MPC-438: Calibration of HSM Predictive Methods on Rural State and Local Highways
12. 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**

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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-417: Evaluation and Development of Livability and Sustainability Programs for Indian Reservations
5. MPC-418: 400 South Corridor Assessment
6. MPC-421: Seismic Rehabilitation of Skewed and Curved Bridges Using a New Generation of Bulking

Restrained Braces

7. MPC-428: Using Recycled Concrete Aggregate in New Concrete Construction
8. MPC-436: Using Flocculation to Reduce Turbidity of Construction Site Runoff
9. MPC-441: Developing a Pavement Management System for Small Communities
10. 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

**ii. Educational Accomplishments**

The transportation and transportation-related courses offered during Summer 2015 and Fall 2015 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
<b>Engineering &amp; Design</b>	CIVE 302 Evaluation of Civil Engineering Materials
	CIVE 367 Structural Analysis
	CIVE 466 Design and Behavior of Steel Structures
	CIVE 566 Intermediate Structural Analysis
	CIVE 562 Structural Reliability
	CIVE 564 Mechanics of Fatigue and Fracture
	CEE 106-106/L Elementary Surveying and Lab
	CEE 792 Topics-Advanced Topics in Reinforced Concrete
	CEE 759 Structural Dynamics
	CEE 458/558 Timber Design
	CEE 456 Theory and Design of Reinforced Concrete
	CEE 447/547 Foundation Engineering
	CVEN 3602 Transportation Engineering
	CVEN 5682 Pavement Design
	CvEEN 2130 Statistics and Economics Undergraduate
	CvEEN 5420 Open Channel Flow Undergraduate
	CvEEN 5570 Pavement Design Undergraduate
	CE 3500 Highway Engineering
	CEE 6120 Bridge Design
	CEE 5070 Steel Design
CEE 6130 Structural Dynamics and Seismic Design	
TRAN 4310 Freight Transportation Systems	
TRAN 4610 Passenger Transportation Systems	
TRAN 4010 Introduction to Transportation Systems	
<b>Freight &amp; Logistics</b>	TRAN 4010 Introduction to Transportation Systems
	TRAN 4330 Principles of Supply Chain: Management and
	TRAN 4080 Transportation Law and Regulation: Domestic and International
	TL 711 Logistics Systems

<b>Freight &amp; Logistics</b>	TL 733 Case Studies in Logistics
	TL 811 Modeling for Logistics Research
	TL 831 Modeling for Transportation and Logistics Decision Analysis
<b>Planning &amp; Environment</b>	CVEN 5460 Introduction to Sustainable Urban Infrastructure
	URPL 6399 Introduction to Sustainable Urban Infrastructure
	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
	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
	CEE 5240/6220 Urban and Regional Transportation Planning
	TL 752 Transportation Planning and Environmental Compliance
<b>Traffic &amp; Operations</b>	CVEN 5621 Highway Capacity Analysis
	CvEEN 3520 Transportation Engineering Undergraduate
	CvEEN 6525 Highway and Traffic Engineering Graduate
	CE 5530 Traffic Operation
	CEE 5220/6220 Traffic Engineering
<b>Transportation Safety</b>	CVEN 5662 Transportation System Safety
<b>Transportation Systems</b>	URPL 6555 Transportation and Land Use
	TRAN 4010 Introduction to Transportation Systems
	TRAN 4050 Intermodal Transportation Systems
	CvEEN 7540 Intelligent Transportation Systems
	CE 5585v Pavement Management System
	CEE 6210 Transportation Systems Analysis
	TL 751 Transportation System Security
	TL 754 Urban Transportation Systems Analysis
TL 782 Transportation Systems I	
<b>Public Transportation</b>	TL 786 Public Transportation
	CVEN 5800 Transit Design
	TRAN 4080 Transportation Law and Regulation: Domestic and International

Altogether, 64 transportation and transportation-related courses have been offered during this reporting period. Altogether, 439 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. Asphalt Paving Maintenance 1
2. Asphalt Paving Maintenance 2

3. ATSSA Flagger Certification
4. ATSSA Flagger Instructor Training
5. ATSSA Traffic Control Supervisor
6. ATSSA Traffic Control Technician - Video Conference
7. ATSSA Certification
8. Basics of a Good Road
9. Chip Seal Best Practices
10. Communication Skills for Supervisors
11. Confined Space Training
12. Designing for Pedestrian and Bicycle Safety
13. Erosion & Sediment Control: Construction Cert Training - Onsite Bismarck
14. Erosion Control Options - Video Conference
15. Heavy Equipment Operation (Hands On)
16. Heavy Equipment Safety Operations
17. Integrated Roadside Vegetation Management
18. John Maxwell: Sometime You Win, Sometimes You Learn - Video Conference
19. Joint Detailing for Improved Performance of Double Tee Bridge Systems, Transportation Learning Network (TLN) webinar
20. Joint Detailing for Improved Performance of Double Tee Bridge System – Webinar
21. Local Roadway - Signing 101 - On Site Bottineau
22. Local Roadway - Signing 101 - On Site Grafton
23. Local Roadway - Signing 101 - On Site Minot
24. Local Roadway - Snow & Ice Control - On-site - Grand Forks
25. Local Roadway - Snow & Ice Control - On-site – Jamestown
26. Local Roadway - Snow & Ice Control - On-site – Killdeer
27. Local Roadway - Snow & Ice Control - On-site – Wahpeton
28. Math for Survey and Construction - Video Conference
29. Motor Grader Training Classroom Adams County
30. Motor Grader Training Classroom Barnes County
31. Motor Grader Training Classroom Bottineau
32. Motor Grader Training Classroom Burleigh County
33. Motor Grader Training Classroom Grand Forks County
34. Motor Grader Training Classroom Mountrail County
35. Motor Grader Training Field Adams County
36. Motor Grader Training Field Barnes County
37. Motor Grader Training Field Bottineau County
38. Motor Grader Training Field Bowman County
39. Motor Grader Training Field Burke County
40. Motor Grader Training Field Burleigh County
41. Motor Grader Training Field Divide County
42. Motor Grader Training Field Emmons County
43. Motor Grader Training Field Foster County
44. Motor Grader Training Field Golden Valley County
45. Motor Grader Training Field Grand Forks County
46. Motor Grader Training Field Griggs County
47. Motor Grader Training Field Kidder County
48. Motor Grader Training Field LaMoure County
49. Motor Grader Training Field McHenry County
50. Motor Grader Training Field Mountrail County
51. Motor Grader Training Field Rolette County
52. Motor Grader Training Field Slope County

53. Motor Grader Training Field Steele County
54. Motor Grader Training Field Stutsman County
55. Motor Grader Training Field Trail County
56. Motor Grader Training Field Ward County
57. MUTCD Training
58. OSHA 10-Hr Training Specifically of Roadway Construction -Onsite - Jamestown
59. Pipe Jacking for Culverts and Storm Sewers - Video Conference
60. Presenting the Story of Your Data Webinar
61. Preventing Runovers & Backovers / Road Safety - Onsite West Fargo
62. Preventing Runovers & Backovers / Road Safety - Video Conference
63. Registered Stormwater Inspector
64. Research Presentation - Implementation of Low Temperature Tests for Asphalt Mixtures – Webinar
65. Retroreflectivity for Signs
66. Retroreflectivity for Signs
67. Roadway Foundation Demonstration Workshop - Onsite - Crosby
68. Roadway Materials
69. Route, Preliminary Survey & LiDar 3-D Modeling Video Conference
70. Street Lighting
71. Street Sweeper
72. The Future of Transportation in Denver Summit
73. Tree Trimming
74. Welding
75. Workplace, Equipment and Job Site Safety
76. WYDOT certification classes in Aggregate, Asphalt, and Concrete

#### iv. Research accomplishments

The following peer reviewed research reports/presentations were published during the period of July – December 2015 from grant DTRT12-G-UTC08 or previous grants.

Project #	Title	Date	Report No.
373	Damage Assessment, Characterization, and Modeling for Enhanced Design of Concrete Bridge Decks in Cold Regions	July 2015	MPC-286
394	Using Expert Opinion to Quantify Accuracy and Reliability of Nondestructive Evaluation of Bridges	August 2015	MPC-288
423	Impact of Energy Sector Growth on Perceived Transportation Safety in the 17-County Oil Region of Western North Dakota: A Three-Year Case Study	October 2015	MPC-289
367	Indian Reservation Safety Improvement Program: A Methodology and Case Study	November 2015	MPC-291
386	Use of Travel Time, Travel Time Reliability, and Winter Condition Index Information for Improved Operation of Rural Interstates	December 2015	MPC-295
327	Seismic Risk Assessment for the I-25/I-70 Corridor in the Mountain Plains Region of the U.S.	December 2015	MPC-296
410	Predicting Fatigue Service Life Extension of RC Bridges with Externally Bonded CFRP Repairs	December 2015	MPC-292
429	Developing A Methodology to Inspect and Assess Conditions of Short Span Structures on County Roads	December 2015	MPC-290



	in Wyoming		
432	Could Cattle Guards Augmented with Electrified Pavement Prevent Mule Deer and Elk Access to Highways?	December 2015	MPC-297
365	Calibration of the Mechanistic-Empirical Pavement Design Guide for Local Paved Roads in Wyoming	December 2015	MPC-294

**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) With the guidance of the recently established North Dakota Transportation Safety Advisory Group, identify a two-year work plan to conduct safety research and technical training that addresses key Bakken-related issues, including motor carrier, railway, and pipeline safety. (4) In conjunction with tribal partners, develop a two-year plan for tribal transportation research and technical assistance to include: a) the development of an emergency management/response guidebook, b) GIS modeling and technical assistance in traffic forecasting; and c) help in implementing road safety procedures and countermeasures on tribal roads. (5) Continue the strong MPC research programs, which will result in many new publications and journal papers. (6) Participate in conferences and workshops on transportation and energy development. (7) Collaborate with other UTCs to promote greater exchange of information and explore partnering possibilities in railway and waterway transportation. (9) 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**

- 20<sup>th</sup> International Conference on Composite Materials, Copenhagen, Denmark
- 6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015, 2450-2457, July 26-30, Las Vegas, NV
- Accelerated Bridge Construction Conference in Miami, FL
- American Concrete Institute, Fall 2015 Convention, Denver, CO
- American Concrete Institute, Fall Convention, Denver, CO
- American Short Line Conference in April of 2015 in Orlando, FL
- Connected and Autonomous Vehicles: The 9th University Transportation Centers Spotlight Conference, USDOT, Washington, D.C., Dec 15, 2015
- Disrupting Mobility Conference, Cambridge, MA
- Joint 6th International Conference on Advances in Experimental Structural Engineering (6AESE) and 11th International Workshop on Advanced Smart Materials and Smart Structures Technology (11ANCRiSST)
- Smart Cities Forum, USDOT, Washington, D.C., Dec 15, 2015
- Tailings and Mine Waste 2015, Vancouver, British Columbia, Canada
- The 8th International Engineering and Construction Conference (ISEC-8), Sydney, Australia

- Utah Department of Transportation 2015 Annual Conference, Salt Lake City, UT

## ii. Key Journal Articles or Conference Publications

- Bright, Christopher, Rebecca Atadero and John van de Lindt. Concept Development and Evaluation of a New GFRP Reinforcement Geometry for Concrete Beams. *Journal of Composites for Construction*. doi: 10.1061/(ASCE)CC.1943-5614.0000615.
- Brown, D.N., Parks, J.E., Ameli, M.J., and Pantelides, C.P. "Strut-and-tie models of repaired precast concrete bridge substructures with CFRP shell." *Composite Structures*, 138, 161-171, 2016.
- Fanning, B., Clevenger, C.M., Ozbek, M.E., and Mahmoud, H. (2015). "Implementing BIM on Infrastructure: Comparison of Two Bridge Construction Projects." *ASCE Practice Periodical on Structural Design and Construction* 20 (4) 04014044, 1-8.
- 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.
- Hasanbas, E. and L. Ibarra. (2015) "Effects of Screen Machines on the Structural Dynamic Response of Steel Frame Buildings." *ASCE Journal of Performance of Constructed Facilities*, 2015.
- Hesse, A., Atadero, R., and Ozbek, M.E. (2015). "Uncertainty in Common NDE Techniques for Use in Risk-Based Bridge Inspection Planning: Existing Data." *ASCE Journal of Bridge Engineering* 20 (11) 04015004, 1-8.
- Ibarra, L. and B. Birhanu. "High Strength Fiber Reinforced Concrete Beam-Columns with High Strength Steel." *ACI Structural Journal*, 2015.
- Kim, Min Ook, Amanda Bordelon. "Fiber Effect on Interfacial Bond Between Concrete and Fiber Reinforced Mortar" *Transportation Research Record: Journal of the Transportation Research Board*, 2015.
- Kim, Y.J. and Namrou, A. Interface between near-surface-mounted CFRP-concrete interface in thermal distress *ACI Structural Journal*, American Concrete Institute (ACI)
- Namrou, A. and Kim, Y.J. Residual performance of concrete-adhesive interface at elevated temperatures, *Construction and Building Materials*, Elsevier
- Sanbonmatsu, D. M., Strayer, D. L., Behrends, A. A., Medeiros-Ward, N., and Watson, J. M. (under review). Why drivers use cell phones and support legislation to restrict this practice.
- Sanbonmatsu, D. M., Strayer, D. L., Biondi, F., Behrends, A. A., & Moore, S. M. (2015). Cell phone use diminishes self-awareness of impaired driving. *Psychonomic Bulletin and Review*. doi: 10.3758/s13423-015-0922-4.
- Siriwardanage, T. and Kim, Y.J. Thermomechanical behavior of NSM CFRP-concrete interface, *ACI Structural Journal*, American Concrete Institute (ACI)
- 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.
- 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*, August 2015.
- Tasic, I., Zlatkovic, M., Martin, P. T., and Porter, R. J. "Street Connectivity vs. Street Widening: Impact of Enhanced Street Connectivity on Traffic Operations in Transit Supportive Environments." *Transportation Research Record, Journal of the Transportation Research Board*, No. 2494 (2015) 57-68.
- Tucker, C. and L. Ibarra. "Effects of Partial Design Strength Concrete on the Seismic Performance of Concrete Filled Tube Columns in Accelerated Bridge Construction." *ASCE Journal of Bridge Engineering*, 2015.
- Wang, Y., Ibarra, L., and Pantelides, C.P. "Seismic Retrofit of a Three Span Reinforced Concrete Bridge with Buckling Restrained Braces." *J. Bridge Engineering*, ASCE, 2015.
- Wehbe, Nadim, Aaron Breyfogle, Dave Huft, Michael Mingo, and Michael Konrad. Precast Bridge Girder Details for Improved Performance. TRB 95th Annual Meeting poster session. TRB 95th Annual Meeting, Washington, D.C., 2016.

- Wehbe, Nadim, Michael Konrad, Aaron Breyfogle. Joint Detailing between Double Tee Bridge Girders for Improved Serviceability and Strength. TRB 95th Annual Meeting, Washington, D.C., 2016
- Xiao, Qin, Zhao Shen, and Nadim Wehbe. Predicting Collision Risk between Trucks and Interstate Overpasses. Journal of Transportation Engineering (submitted revised paper-Editor review only).
- Yang, Mijia. An Integrated Real-Time Health Monitoring and Impact/Collision Detection System for Bridges in Cold Remote Regions. (Mar 2015, MPC-15-282)
- Yazdani, Frank. Damage Assessment, Characterization, and Modeling for Enhanced Design of Concrete Bridge Decks in Cold Regions, (Jul 2015, MPC-15-286)
- Zhang, Z., Deng, F., Huang, Y., Bridgelall, R., Strommen, R., "Road Roughness Evaluation Using In-Pavement Strain Sensors," Smart Materials and Structures, 24 (11), October 15, 2015.
- Zhuo Chen and Xiaoyue Liu. "Nonrecurrent Congestion Analysis Using Data-Driven Spatiotemporal Approach for Information Construction." Transportation Research Part C, 2015.

### iii. Key Conference Papers

- Bridgelall, R., Daleiden, J. F., "Assessing Pavement Roughness in Urban Environments," The 27th Annual Road Profile Users' Group Meeting, Raleigh, NC, Nov 2-5, 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," 95th Annual Meeting of the Transportation Research Board, Washington D.C.
- Gorakhki, M. H. and Bareither, C. A. (2016). Compressibility Behavior of Synthetic Mine Tailings Amended with Fly Ash, Geo-Chicago 2016: Sustainability, Energy, and the Geoenvironment, ASCE.
- Hammit, Britton, Mohamed Ahmed, and Rhonda Young. "Feasibility of Using Connected Vehicle Data for Rural Roadway Weather Conditions in Wyoming. Accepted for publication in the Proceedings from the 95th Annual Meeting of the Transportation Research Board, Washington, D.C., January 2016.
- Parks J.E., C.P. Pantelides, L. Ibarra, and D. Sanders (2015) "Seismic Anchorage of Dry Storage Casks." Structural Mechanics in Reactor Technology, SMiRT 23rd. Manchester, UK, 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 Intern. Conf. on Composite Materials, Paper 3319-2, Copenhagen, Denmark.
- Ramasamy U., R. Medina, J. Coleman, and L. Ibarra. "Buckling Behavior of Spent Nuclear Fuel Rods under Impact Loading." Structural Mechanics in Reactor Technology, SMiRT 23rd. Manchester, UK, 2015.
- Song, Y., Zlatkovic, M., and Porter, R.J. "GPS-Based Transit Signal Priority for Mixed-Traffic Bus Rapid Transit," 95th Annual Meeting of the Transportation Research Board, Washington D.C.)
- 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," 95th Annual Meeting of the Transportation Research Board, Washington D.C.
- Upadhyay, A., Pantelides, C.P., and Ibarra, L. "Seismic Performance of Curved Bridges on Soft Soils with BRB retrofit." Paper to be presented at the Geotechnical and Structural Engineering Congress, Feb. 14-17, 2016, Phoenix, Arizona.
- Wang Y. and L. Ibarra. "Optimization of Modified Base-isolated Systems for Next Generation Nuclear Structures." Structural Mechanics in Reactor Technology, SMiRT 23rd. Manchester, UK, 2015.
- Wehbe, Nadim and Walker Olson. Experimental Evaluation Of Misaligned Tie Bar Effects On PCC Pavement Longitudinal Joints. proceedings of the 8th International Structural Engineering and Construction Conference: Implementing Innovative Ideas in Structural Engineering and

Project Management, Sydney, Australia, November 23-28, 2015. pp. 1159-1164.

- Zargar S., R.A. Medina, L. Ibarra, and J. Coleman. "Numerical and experimental assessment of fuel rods exposed to vibration loads during transportation." Structural Mechanics in Reactor Technology, SMiRT 23rd. Manchester, UK, 2015.
- Zhiming, Z., Deng, F., Huang, Y., Bridgelall, R., Strommen, R., "Road Roughness Evaluation With In-Pavement Sensors," Joint 6th International Conference on Advances in Experimental Structural Engineering (6AESE) and 11th International Workshop on Advanced Smart Materials and Smart Structures Technology (11ANCRiSST), Champaign, IL, Aug 3, 2015.
- Zhuo Chen and Xiaoyue Liu. "Nonrecurrent Congestion Analysis Using Data-Driven Spatiotemporal Approach for Information Construction." 95th Annual Meeting of the Transportation Research Board, Washington D.C.

#### iv. Key Presentations

- Ameli, M.J. "Grouted Splice Sleeve Connections for Bridge Piers in Seismic Regions: Experiments and Analysis." Accelerated Bridge Construction Conference, Miami, Florida, Dec. 7-8, 2015.
- Bridgelall, R., Daleiden, J. F., "Assessing Pavement Roughness in Urban Environments," The 27th Annual Road Profile Users' Group Meeting, Raleigh, NC, Nov 2-5, 2015.
- Bridgelall, R., Tolliver, D., "Internet of Everything Enables Smart Infrastructure Management," USDOT Smart Cities Forum, Washington, D.C., Dec 15, 2015.
- MPC-409: Identification of Low-Risk Adjusted Work Schedules Designed to Manage Fatigue During Peak Service Demand Periods in the Shortline Railroad Industry. We delivered a progress report on the problematic work schedules and proposed countermeasures to the American Short Line Conference in April of 2015 in Orlando FL. Approximately 15 people attended the presentation.
- MPC-409: Identification of Low-Risk Adjusted Work Schedules Designed to Manage Fatigue During Peak Service Demand Periods in the Shortline Railroad Industry. We delivered a presentation on the importance of safety culture at the International Rail Safety Conference in South Africa.
- MPC-432: Finding Innovative Solutions to Prevent Wildlife Access to Highways at Wildlife Guards. There have been two progress presentations made to UDOT on this work. Both was well received. Patricia is currently talking with other DOTs to see interest in similar projects in other states.
- Pantelides, C. "Experimental Evaluation and Analytical Simulation of Bridge Column to Footing Joints Connected Using Grouted Splice Sleeves in Seismic Regions," ABC Connections for Seismic-Resistant Design, special session of ACI Committee 341, Earthquake Resistant Concrete Bridges, Denver, CO, November 8, 2015.
- Qin, X. "Beyond HSM Calibration: Finding the discrepancies", Highway Safety Performance Committee Midyear Meeting, June 2015, Arnold and Mabel Beckman Conference Center, Irvine, California, June 10, 2015.
- Sherry, P. & Philbrick, K. (2015). "Efficacy and Factor Structure of the Safety Culture Survey in the Transportation Industry: The Relationship between Safety Culture and Employee Accidents". A Presentation at the International Rail Safety Conference, Johannesburg, SA, October 5, 2015.
- Wehbe, Nadim. Joint Detailing for Improved Performance of Double Tee Bridge Systems. Transportation Learning Network (TLN) webinar. December 17, 2015.
- Young, Rhonda. "A Connected Vehicle Road Weather Data Collection System" Presented at the National Rural Intelligent Transportation System (NRITS) Conferee, Snowbird, UT, August 2015.
- Zhiming, Z., Deng, F., Huang, Y., Bridgelall, R., Strommen, R., "Road Roughness Evaluation

With In-Pavement Sensors,” Joint 6th International Conference on Advances in Experimental Structural Engineering (6AESE) and 11th International Workshop on Advanced Smart Materials and Smart Structures Technology (11ANCRiSST), Champaign, IL, Aug 3, 2015.

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

Nothing to report at this time.

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

- Prospectus for Technology Transfer: Pavement Analysis Via Vehicle Electronic Telemetry (PAVVET): <http://ugpti.org/research/downloads/PAVVETProspectus.pdf>
- Prospectus for Technology Transfer: Railway Analysis by Integrated Logic systems (RAILs): <http://ugpti.org/research/downloads/RAILsProspectus.pdf>
- Prospectus for Technology Transfer: Pipeline Infrastructure Performance Enhancement Solutions (PIPES): <http://ugpti.org/research/downloads/PIPESProspectus.pdf>

**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**

- Liu, X. and Chen, Z. "Framework for Project Prioritization and Decision Making." Final Report. UT-15.05. Utah Department of Transportation. 2015.
- MPC-432: Finding Innovative Solutions to Prevent Wildlife Access to Highways at Wildlife Guards  
There has been interest from some cities. It has primarily been UDOT that has been interested since the last reporting period.
- MPC-445: A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness  
Poster: Connected Vehicle Research to Enable Smart Cities
- MPC-445: A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness  
Poster: Smart Trains Research to Enable Smart Cities
- MPC-445: A Sensor Fusion Approach to Assess Pavement Condition and Maintenance Effectiveness  
Poster: Smart Pipes Research to Enable Smart Cities

**3. Participants and Other Collaborating Organizations: Who has been involved?**

**a. What individuals have worked on the program?**

The principal investigators, faculty, and administrators participating in MPC project:

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

Six principal investigators, faculty, and administrators participating in MPC projects at the **University of Wyoming** are: Khaled Ksaibati, University Program Coordinator and PI; Debbie Shinstine, PI; Wendy Perkins, Administrator; Shaun Wulff, Statistics Professor; Jennifer Tanner, PI; and Rhonda Young, PI. In

addition, nine students are participating in MPC research projects at the **University of Wyoming**: Doctorate Students: Edward Offei; Masters Students - Taylor Kasperick, Rebecca Franke, Sanjay Pokharel, Darby Hacker, Bryce Fiore, Wes Werbelow, Britton Hammit, and Sandeep Thapa.

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

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

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

Ten principal investigators, faculty, and administrators are participating in selected projects at **North Dakota State University**: Kimberly Vachal, University Program Coordinator and PI; Brenda Lantz, PI; Doug Benson, PI; Denver Tolliver, PI and Co-PI; Pan Lu, PI; Alan Dybing, Co-PI; EunSu Lee, PI; Raj Bridgelall, PI; and Ying Huang, Co-PI. In addition, six graduate students are working on MPC projects at **North Dakota State University**: Doctorate Students- Poyraz Kayabas, Anne Campbell, Elvis Ndembe, Chijioke Ifepe, Zhiming Zhang, and Fodan Deng.

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

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

#### **b. What other organizations have been involved as partners?**

The timing of match funding and the commitments of collaborators vary widely throughout the life of the grant.

During this period, we have the following committed collaborators.

1. AAA Foundation for Traffic Safety
2. AAR John Gray, Frank Hardesty, Shannon Stare
3. ASLRRRA Scott Sullivan, Elizabeth Petty, Richard Timmons
4. Association of General Contractors of South Dakota
5. City and County of Denver
6. City of Salt Lake Transportation Division
7. Florida Atlantic University
8. Fort Berthold Reservation
9. FRA Administrators
10. Kittelson & Associates, Inc.
11. Minnesota Department of Transportation
12. MnROAD Research Facility
13. National Cooperative Highway Research Program
14. NCAR
15. NDDOT
16. NDHP
17. Northern Plain TTAP Center
18. Norwegian Public Roads Administration
19. South Dakota Department of Transportation
20. South Dakota Office of EMS
21. Tom Streicher, Vice President of American Short Line Railroad Association
22. Utah Department of Transportation
23. Utah Division of Wildlife Resources
24. Utah Transit Authority
25. WACERS
26. Wasatch Front Regional Council
27. WCCA
28. Wind River Indian Reservation
29. WYDOT
30. Wyoming Division of FHWA

**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, 64 courses were offered in the Summer and Fall 2015 and 439 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 76 technical training events were offered in the second half of 2015. 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) is currently under development and will be disseminated within the region and the western United States when completed.

- 4. Research.** During this rating period ten 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. The newly formed North Dakota Transportation Safety Advisory Group (which includes representation from NDDOT, North Dakota Highway Patrol, FRA, PHMSA, and FMCSA) is identifying critical research projects for 2015-2016 and leveraging technical assistance and training for transportation operators, emergency responders, and state and local planners. 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 of Bakken crude oil via rail, pipeline, and truck.

## **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.