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, & 3
Mountain-Plains Consortium, North Dakota State University
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North Dakota State University
Upper Great Plains Transportation Institute
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Grant period: October 1, 2013 – September 30, 2018

Reporting Period End Date: September 30, 2017
Semi-Annual PPPR#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; 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

Eighty-nine research projects were selected from 2013 to present under this grant. Projects have been selected for the original grant, Modification 1, 2, and 3. 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-409, MPC-446 to MPC-532.

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-461: Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards
6. MPC-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory
7. MPC-467: Self-Regulation and Distraction
8. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
9. MPC-472: Developing an Optimization Model for Managing County Paved Roads
10. MPC-473: Bicycle and Pedestrian Design for Rural Communities
11. MPC-474: Highway Safety Manual Part D: Validation and Application in Wyoming
12. MPC-475: Analysis of the Relationship of Roadside Inspections on Large Truck Crashes
13. MPC-476: Highway-Rail Grade Crossing Traffic Hazard Forecasting Model
14. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
15. MPC-480: A Comprehensive Safety Assessment Methodology for Innovative Geometric Designs
16. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes

17. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
18. MPC-491: Self-Centering Buckling Restrained Braces for Curved Bridges
19. MPC-495: Safety Effects of Protected and Protected/Permitted Left-Turn Phases
20. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
21. MPC-503: Characterization of Crushed Bases in Wyoming
22. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
23. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation
24. MPC-507: Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging
25. MPC-515: Redefining the Child Pedestrian Safety Paradigm
26. MPC-517: Route Planning for Enhanced Transportation Network Utilization: A System Optimization Approach for Route Planning in Advanced Traveler Information Systems
27. MPC-518: Tribal Crash Reporting in ND: Practices, Perceptions, and Systematic Implementation
28. MPC-519: Operational and Safety Analysis with Mitigation Strategies for Freeway Truck Traffic in WY
29. MPC-520: Financial Benefits of Proposed Access Management Treatments
30. MPC-521: Evaluating Relationships between Perception-Reaction Times, Emergency Deceleration Rates, and Crash Outcomes using Naturalistic Driving Data
31. MPC-524: Development of Next Generation Liquefaction (NGL) Database for Liquefaction-Induced Lateral Spread
32. MPC-525: Does Cell Phone Use Impair Learning and Improvement in Driving Performance?
33. MPC-526: Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement
34. MPC-531: Flood Hydrograph Generation for Predicting Bridge Scour in Cohesive Soils

Table 2: MPC Research Projects Most Directly Correlated with State of Good Repair

1. MPC-447: Post-Fire Ground Treatments for Protection of Critical Transportation Structures
2. MPC-449: Determining the Uncertainty in the Current Condition of Bridges for Use in Risk Based Inspection and Management
3. MPC-451: Assessing the Cost-Effectiveness of Wyoming's CMAQ Unpaved Road Dust Suppression Program
4. MPC-452: Updating the Highway Safety Manual 2010 - Part C: Regional Consideration of the Rocky Mountains and Plain Regions
5. MPC-456: Performance of Steel Girders Repaired with Advanced Composite Sheets in a Corrosive Environment: A Multi-Physics Approach Leading to Practical Design Recommendations
6. MPC-458: Application of a Multi-Agent System with the Large-Scale Agent-Based Model for Freight Demand Modeling
7. MPC-461: Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards
8. MPC-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory
9. MPC-463: Rehabilitation Project Selection and Scheduling in Transportation Networks
10. MPC-464: Development of Network-Based Measures and Computational Methods for Evaluating the Redundancy of Transportation Networks

11. MPC-468: Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance)
12. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
13. MPC-472: Developing an Optimization Model for Managing County Paved Roads
14. MPC-477: Characterizing the ductility of Portland cement stabilized soil
15. MPC-478: Long-Term Behavior of Precast Concrete Bridges
16. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
17. MPC-481: Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure
18. MPC-482: Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems
19. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
20. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
21. MPC-492: Early-Age Fiber-Reinforced Concrete Properties for Overlays
22. MPC-493: Incorporating Maintenance Costs and Considerations into Highway Design Decisions
23. MPC-494: Statistical Analysis and Sampling Standards for Maintenance Management Quality Assurance (MMQA)
24. MPC-496: Prevention of Low Temperature Cracking of Pavements
25. MPC-497: Compaction Testing of Granular Materials
26. MPC-500: Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
27. MPC-501: Development of an Alternative to the Double Tee Bridge System
28. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
29. MPC-503: Characterization of Crushed Bases in Wyoming
30. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
31. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation
32. MPC-506: Reliable Prediction of Shear Strength of Swelling Clays
33. MPC-507: Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging
34. MPC-511: Mechanical Bar Splices for Accelerated Bridge Construction of Columns
35. MPC-512: Pre-stress Losses and Development of Short-Term Data Acquisition System for Bridge Monitoring
36. MPC-516: Innovative Strengthening for Deteriorated Concrete Bridges Using Embedded Composite Sheets Bonded with Polyester-silica
37. MPC-519: Operational and Safety Analysis with Mitigation Strategies for Freeway Truck Traffic in WY
38. MPC-522: Development of a Guideline for Selection of Tack Coats in South Dakota
39. MPC-523: Methodology for Load Rating Double-Tee Bridges
40. MPC-526: Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement
41. MPC-528: Hotspot and Sampling Analysis for Effective Maintenance Management and Performance Monitoring
42. MPC-529: Alternative in-situ Water-Cement Meter Using a Parallel-Plate Capacitor Concept

43. MPC-530: Screening of South Dakota Asphalt Mixes for Moisture Damage using Conventional and Innovative Approaches
44. MPC-531: Flood Hydrograph Generation for Predicting Bridge Scour in Cohesive Soils

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-463: Rehabilitation Project Selection and Scheduling in Transportation Networks
4. MPC-464: Development of Network-Based Measures and Computational Methods for Evaluating the Redundancy of Transportation Networks
5. MPC-466: First and Last Mile Strategies for Transit Systems
6. MPC-468: Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance)
7. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
8. MPC-472: Developing an Optimization Model for Managing County Paved Roads
9. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
10. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
11. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
12. MPC-488: Effects of Infill Development and Regional Growth on At-Risk Populations' Exposure to Traffic Density
13. MPC-494: Statistical Analysis and Sampling Standards for Maintenance Management Quality Assurance (MMQA)
14. MPC-497: Compaction Testing of Granular Materials
15. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
16. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
17. MPC-500: Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
18. MPC-501: Development of an Alternative to the Double Tee Bridge System
19. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
20. MPC-503: Characterization of Crushed Bases in Wyoming
21. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
22. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation
23. MPC-509: Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment
24. MPC-511: Mechanical Bar Splices for Accelerated Bridge Construction of Columns
25. MPC-513: Optimal Deployment of Wireless Charging Facilities for an Electric Bus System
26. MPC-514: Impacts of Ridesourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior
27. MPC-516: Innovative Strengthening for Deteriorated Concrete Bridges Using Embedded Composite Sheets Bonded with Polyester-silica

28. MPC-517: Route Planning for Enhanced Transportation Network Utilization: A System Optimization Approach for Route Planning in Advanced Traveler Information Systems
29. MPC-519: Operational and Safety Analysis with Mitigation Strategies for Freeway Truck Traffic in WY
30. MPC-522: Development of a Guideline for Selection of Tack Coats in South Dakota
31. MPC-523: Methodology for Load Rating Double-Tee Bridges
32. MPC-528: Hotspot and Sampling Analysis for Effective Maintenance Management and Performance Monitoring
33. MPC-530: Screening of South Dakota Asphalt Mixes for Moisture Damage using Conventional and Innovative Approaches
34. MPC-531: Flood Hydrograph Generation for Predicting Bridge Scour in Cohesive

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-466: First and Last Mile Strategies for Transit Systems
4. MPC-473: Bicycle and Pedestrian Design for Rural Communities
5. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
6. MPC-485: Development of a Model to Assess the Feasibility of Transit-Oriented Development (TOD) Projects
7. MPC-489: The Unresolved Relationship between Street Trees and Road Safety
8. MPC-490: Longevity of Air Pollution Mitigating Photo-Catalytic Coatings on Transportation Infrastructure
9. MPC-491: Self-Centering Buckling Restrained Braces for Curved Bridges
10. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
11. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
12. MPC-510: Business and Commute Optimization System: Development and Denver-Based Case Study
13. MPC-513: Optimal Deployment of Wireless Charging Facilities for an Electric Bus System
14. MPC-514: Impacts of Ridesourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior
15. MPC-515: Redefining the Child Pedestrian Safety Paradigm
16. MPC-517: Route Planning for Enhanced Transportation Network Utilization: A System Optimization Approach for Route Planning in Advanced Traveler Information Systems
17. MPC-518: Tribal Crash Reporting in ND: Practices, Perceptions, and Systematic Implementation
18. MPC-520: Financial Benefits of Proposed Access Management Treatments
19. MPC-526: Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement
20. MPC-527: Strategic Planning and Design for Electric Bus Systems

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-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
4. MPC-472: Developing an Optimization Model for Managing County Paved Roads
5. MPC-473: Bicycle and Pedestrian Design for Rural Communities
6. MPC-477: Characterizing the ductility of Portland cement stabilized soil

7. MPC-485: Development of a Model to Assess the Feasibility of Transit-Oriented Development (TOD) Projects
8. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
9. MPC-488: Effects of Infill Development and Regional Growth on At-Risk Populations' Exposure to Traffic Density
10. MPC-489: The Unresolved Relationship between Street Trees and Road Safety
11. MPC-490: Longevity of Air Pollution Mitigating Photo-Catalytic Coatings on Transportation Infrastructure
12. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
13. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
14. MPC-503: Characterization of Crushed Bases in Wyoming
15. MPC-509: Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment
16. MPC-510: Business and Commute Optimization System: Development and Denver-Based Case Study
17. MPC-513: Optimal Deployment of Wireless Charging Facilities for an Electric Bus System
18. MPC-514: Impacts of Ridesourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior
19. MPC-517: Route Planning for Enhanced Transportation Network Utilization: A System Optimization
20. Approach for Route Planning in Advanced Traveler Information Systems
21. MPC-524: Development of Next Generation Liquefaction (NGL) Database for Liquefaction-Induced Lateral Spread
22. MPC-527: Strategic Planning and Design for Electric Bus Systems

iii. Educational Accomplishments

The transportation and transportation-related courses offered during spring 2017, summer 2017 and Fall 2017 are listed in Table 6, 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 6: Transportation and Transportation-Related Courses Offered This Period

Major Subject Area	Course Title
Engineering & Design	1. CIVE 302 Evaluation of Civil Engineering Materials
	2. CIVE 355 Introduction to Geotechnical Engineering
	3. CIVE 466 Design and Behavior of Steel Structures
	4. CIVE 467 Design of Reinforced Concrete Structures
	5. CIVE 563 Structural Reliability, Theory, Application
	6. CIVE 566 Advanced Structural Analysis
	7. CIVE 567 Advanced Concrete Design
	8. CIVE 576 Engineering Applications of GPS and GIS
	9. CIVE 664 Mechanics of Fatigue and Fracture
	10. CEE 411 Bituminous Materials and Lab
	11. CEE 447 Foundation Engineering
	12. CEE 492 Highway Engineering
	13. CEE 759 Structural Dynamics

	14. CEE 791 Advanced Theory of Elasticity
	15. EM 741 Finite Element Analysis
	16. CEE 792 Statistical and Econometric Analysis
	17. CEE 5350 Foundation Analysis and Design
	18. CEE 106 Elementary Surveying and Lab
	19. CEE 456 Theory and Design of Reinforced Concrete
	20. CEE 363 Highway and Traffic Engineering
	21. CEE 492 Introduction to Traffic Safety
	22. CEE 755 Advanced Reinforced Concrete
	23. CEE 455 Steel Design
	24. CEE 749 Advanced Geotechnical Testing
	25. CEE 458 Design of Timber Structures
	26. CVEN 3602 Transportation Engineering
	27. CVEN 4602 Highway Engineering
	28. CVEN 5602 Advanced Street & Highway Design
	29. CVEN 5682 Pavement Design
	30. CE 3500 Highway Engineering
	31. CE 4510 Pavement Design
	32. CE 4610 Foundation Engineering
	33. CEE 5070 Steel Design
	34. CEE 6130 Structural Dynamics and Seismic Design
	35. CEE 6930 Design Loads
	36. CEE 6320 Deep Foundations
Planning & Environment	37. CVEN 5612 Traffic Impact Assessment
	38. CVEN 5460 Introduction to Sustainable Urban Infrastructure
	39. URPL 5040 Urban Sustainability
	40. URPL 5050 Urban Development
	41. URPL 6300 Planning Healthy Communities
	42. URPL 6350 Form and Formation of Cities
	43. URPL 6399 Introduction to Sustainable Urban Infrastructure
	44. URPL 6400 Community Development
	45. URPL 6550 Transportation Planning/Policy
	46. URPL 6645 Disaster/Climate Change Planning
	47. URPL 6370 Sprawl and Growth Management
	48. URPL 5000 Planning History and Theory
	49. URPL 5010 Planning Methods
	50. URPL 6650 Planning in the Developing World
	51. URPL 6650 Planning in the Developing World
	52. URPL 6600 Regional Planning
Public Transportation	53. URPL 6560 Transit Planning
Traffic & Operations	54. CVEN 5621 Highway Capacity Analysis
	55. CVEN 5622 Traffic Operations and Control
	56. CE 4530 Traffic Operation
	57. CE 5530 Traffic Operation

	58. CEE 5220 Traffic Engineering
Transportation Safety	59. CVEN 5611 Traffic and Safety Data Analysis
	60. CVEN 5662 Transportation System Safety
Transportation Systems	61. URPL 6555 Transportation and Land Use
	62. CE 5585 Pavement management System
	63. CEE 6210 Transportation Systems Analysis

Altogether, 63 transportation and transportation-related courses have been offered this reporting period, for a total of 564 total transportation courses offered this grant period. In addition to the courses listed in Table 6, 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.

- ATSSA Flagger Certification
- ATSSA Traffic Control Technician
- ATTSA Traffic Control Supervisor
- Basics of a Good Road
- Heavy Equipment Operations
- Heavy Equipment Safety Operations
- Motor Grader Operator Field Training - On-site - Barnes County
- Motor Grader Operator Field Training - On-site - Ramsey County
- Motor Grader Operator Field Training - On-site - Towner & Walsh Counties
- OSHA - Workplace, Equipment and Jobsite Safety
- Registered Stormwater Inspector
- Roadway Drainage
- Transportation Safety Congress, Casper, Wyoming.
- Wyoming Materials certification in Aggregate, Asphalt, and Concrete. Laramie, Wyoming.

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.
456	Performance of Steel Girders Repaired with Advanced Composite Sheets in a Corrosive Environment	Jun 2017	MPC 17-325
488	Transportation and Land Use as Social Determinants of Health: Analysis of Exposure to Traffic in the Denver Metropolitan Region	Jun 2017	MPC 17-326
421	Development of Network-Based Measures and Computational Methods for Evaluating the Redundancy of Transportation Networks	Jul 2017	MPC 17-327
402	Seismic Performance of Self-Consolidating Concrete Bridge Columns	Sep 2017	MPC 17-329
485	A Framework for Assessing Feasibility of Transit-Oriented Development (TOD) Project Sites	Sep 2017	MPC 17-330
395	Implementation Guidance for Accelerated Bridge Construction in South Dakota	Sep 2017	MPC 17-331
381	Dynamic Assessment of Bridge Deck Performance Considering Realistic Bridge-Traffic Interaction	Sep 2017	MPC 17-333

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. Conferences and Workshops

- 2017 Transportation Research Board Conference. Washington D.C. January, 2017.
- American Society of Mechanical Engineers Convention, Newport Beach, CA
- American Water Resources Association: Colorado Section Annual Symposium, Golden, Colorado.
- Associated Schools of Construction 53rd Annual International Conference, April 5-7, 2017, Seattle, Washington.
- ASTM International June 2017 Committee Week, Toronto, ON.
- International Conference on Advances in Functional Materials, Los Angeles, CA
- International Cycling Safety Conference, Davis, CA, September 2017.
- Leadership in Sustainable Infrastructure, Canadian Society of Civil Engineers Annual Conference, 2017.
- Ninth International Structural Engineering and Construction Conference. Valencia, Spain. July 24-July 29, UK.
- Second International Symposium on Coupled Phenomena in Environmental Geotechnics (CPEG2), Leeds, Vancouver, Canada, May 31 – June 3, 2017
- South Dakota Water and Wastewater Association 2017 Annual Conference, Huron, SD.
- United States Society on Dams, Annual Meeting and Conference, April 2017, Anaheim. CA.
- University of Wyoming: National Tribal Conference, Tuscon, Arizona.
- University Relationship Professional Development Workshop: Building Stronger Curriculum with Kiewit (BSCK) workshop, Aurora, Colorado June 14-16, 2017.
- Walk21 Conference, Calgary, Alberta, Canada; September 2017.
- World Symposium of Transportation and Land Use Research; Brisbane, Australia; July 2017.

ii. Publications

- Banaei-Kashani, Ghaemi, Movaqar, Kazemitabar, Efficient Maximal Reverse Skyline Query Processing, Geoinformatica, Vol 21, Issue 3, pp. 549-572, July 2017.
- Bohn, L., Tazarv, M., and Wehbe, N., "Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders." South Dakota Department of Transportation, Report No. SD2014-20, Aug. 2017.
- Carnahan, Z., Mingo, M., Tazarv, M., and Wehbe, N. "Development of Alternative Superstructure Bridges for South Dakota Local Roads." South Dakota Department of Transportation, Report No. 2014-14, 143, Aug. 2017.
- Eadelat, W.A., Ksaibati, K., Wright, H.G.C., and Saha, P. (2017) “Relationship between the International Roughness Indices determined by Android-based Smartphone Application and

Inertial Profiler for Local Roads." ASCE Journal of Transportation Engineering: Part B, Pavements (revision submitted for publication).

- Ferenchak, N. and Marshall, W. Redefining the Child Pedestrian Safety Paradigm: Identifying High Fatality Concentrations in Urban Areas. Injury Prevention (doi: 10.1136/injuryprev-2016-042115).
- Katti, Dinesh and Katti, Kalpana, "The Role of Molecular Interactions on the Macroscale Properties of Swelling Clays: A Multiscale Modeling Approach", 16th International Clay Conference, Granada, Spain, 2017.
- Katti, Kalpana, Sharma, Anurag, and Katti, Dinesh, "Biomineralization inside nanoclay galleries: opportunities in regenerative medicine and cancer Therapy" 16th International Clay Conference, Granada, Spain, 2017.
- Katti,Dinesh, Katti, Kalpana, Thapa, Keshab and Faisal,H. M. Nasrullah, "Modeling the Nanoscale Kerogen Inclusions in Green River Oil Shale", 6th BIOT Conference, Paris, France, 2017.
- Kim, Y.J. and Alqurashi, A.* Thermomechanical relaxation of RC beams strengthened with CFRP, ACI Structural Journal, American Concrete Institute (ACI) (submission number-S-2017-088: accepted) Support acknowledged
- Kim, Y.J. and Bumadian, I. 2017. Chemicoelectrical response of concrete bonded with CFRP sheets in a corrosive environment, ACI Materials Journal, American Concrete Institute (ACI), 114(4), 549-558, Support acknowledged
- Liu, Z., and Song, Z. (2017) Robust planning of dynamic wireless charging infrastructure for battery electric buses. Transportation Research Part C: Emerging Technologies, vol. 83, 77-103.
- Liu, Z., Song, Z., and Yi, H.(2017) Optimal deployment of dynamic wireless charging facilities for an electric bus system. Transportation Research Record: Journal of the Transportation Research Board, vol. 2647, DOI: 10.3141/2647-12.
- Mannino, Fredrickson, Banaei-Kashani, Linck and Alqurashi, Development and Evaluation of a Similarity Measure for Medical Event Sequences, ACM Transactions on Management Information Systems (TMIS), Vol 8, Issue 2, 2017.
- Marshall, W. and Ferenchak, N. Assessing Equity and Urban/Rural Road Safety Disparities in the U.S. Journal of Urbanism (doi: 10.1080/17549175.2017.1310748).
- Marshall, W., Piatkowski, D., and Johnson, A. Scofflaw Bicyclists: Illegal but Rational. Journal of Transport and Land Use (doi: http://dx.doi.org/10.5198/jtlu.2016.871).
- Piatkowski, D., Marshall, W., and Johnson, A. Bicycle backlash: A qualitative examination of aggressive driver-bicyclist interactions. Transportation Research Record (doi: 10.3141/2662-03).
- Piatkowski, D., Marshall, W., and Johnson, A. Steering Clear of Confrontation: The Role of Drivers' Bicycling Experiences in Mixed-Traffic Encounters. Transportation Research – Part F, Vol. 46, Part A, 137-148, 2017 (doi: http://dx.doi.org/10.1016/j.trf.2017.01.009).
- Saha, P., Ksaibati, K., and Atadero, R. (2017) "Developing Pavement Distress Deterioration Models for Pavement Management System using Markovian Probabilistic Process." Advances in Civil Engineering (accepted for publication).
- Strong, K.C., Ozbek, M. E., Sharma, A., Akalp, D. (2017). "Decision Support Framework for Transit-Oriented Development Projects." Transportation Research Record (2671), 51-58.

iii. Conference Papers

- Abdallah, M., Tawfik, A., and Clevenger, C. (2017) “Time-Cost-Environment Trade-Off Analysis For Business Commuting Systems,” Leadership in Sustainable Infrastructure, Canadian Society of Civil Engineers Annual Conference, Vancouver, Canada, May 31 – June 3, 2017.
- Katti, Dinesh and Katti, Kalpana, "The Role of Molecular Interactions on the Macroscale Properties of Swelling Clays: A Multiscale Modeling Approach", 16th International Clay Conference, Granada, Spain, 2017.
- Katti, Kalpana, Sharma, Anurag, and Katti, Dinesh, "Biomineralization inside nanoclay galleries: opportunities in regenerative medicine and cancer Therapy" 16th International Clay Conference, Granada, Spain, 2017.
- Katti,Dinesh, Katti, Kalpana, Thapa, Keshab and Faisal,H. M. Nasrullah, "Modeling the Nanoscale Kerogen Inclusions in Green River Oil Shale", 6th BIOT Conference, Paris, France, 2017.
- Marshall, W., Piatkowski, D., and Johnson, A. Scofflaw Bicyclists: Illegal but Rational. World Symposium of Transportation and Land Use Research; Brisbane, Australia; July 2017.
- Okok M.A., Saha. P., and Ksaibati, K. “Developing Performance Models for Gravel Roads to Evaluate the Cost-Effectiveness of using Dust Chemical Treatments.” Transportation Research Board Meeting, Washington D.C., 2017.
- Ostrowsky, Jennifer L. "A New Approach for Evaluating the Ductility, Volumetric Stiffness and Permeability of Cutoff Wall Backfill Materials." Proceedings of the Deep Foundations Institute Annual Conference, New Orleans, LA. October 2017.
- Pan, H., Azimi, M., Gui, G., Yan, F., and Lin, Z. (2017). "Vibration-based support vector machine for structural health monitoring." 7th International Conference on Experimental Vibration Analysis for Civil Engineering Structures, San Diego, CA, USA.
- Pan, H., Ruisi Ge, Xingyu Wang, Jinhui Wang, Na Gong, and Lin, Z. (2017). "Embedded Wireless Passive Sensor Networks for Health Monitoring of Welded Joints in Onshore Metallic Pipelines", ASCE Pipeline 2017 at Phoenix, AZ, August 6-9.
- Tazarv, M., and Saiidi, M.S. (2017). “Analysis, Design, and Construction of SMA-Reinforced FRP-Confined Concrete Columns,” Proceedings of the Fourth Conference on Smart Monitoring, Assessment, and Rehabilitation of Civil Structures, SMAR 2017, ETH Zurich, Switzerland, Sept. 13-15.
- Terrill, T. and Ksaibati, K;” Investigating Challenges Affecting the 4Es of Transportation Safety on the Fort Peck Reservation”; Transportation Research Board Meeting, Washington D.C., 2017.

iv. Presentations

- Abdallah, M., Tawfik, A., and Clevenger, C. (2017) “Time-Cost-Environment Trade-Off Analysis For Business Commuting Systems,” Leadership in Sustainable Infrastructure, Canadian Society of Civil Engineers Annual Conference, Vancouver, Canada, May 31 – June 3, 2017.
- Carnahan, Z., Tazarv, M., and Wehbe, N. " Glulam Timber Bridges for Local Roads." South Dakota Department of Transportation, May 24, 2017.
- Czyzyk, K.A., S. Hassani, J.D. Niemann, and J. Gironás, “Incorporating Channel Network Type in a Nonlinear Synthetic Unit Hydrograph Method,” American Water Resources Association, Colorado Section Annual Symposium, Golden, Colorado, May 2017.
- Ferenchak, N. and Marshall, W. Redefining Safe Streets Through a New Child Pedestrian Demand/Exposure Model. Walk21 Conference, Calgary, Alberta, Canada; September 2017.
- Ji, Y. and Kim, Y.J. 2017. Durability of advanced composite sheets in H2SO4, International Conference on Advances in Functional Materials (AFM 2017), Los Angeles, CA

- Jones, A.J., and Weber, J. "Task 5 Presentation to the SDDOT", SDDOT Project Technical Panel Meeting, April 11, Pierre, SD.
- Katti, Dinesh and Katti, Kalpana, "The Role of Molecular Interactions on the Macroscale Properties of Swelling Clays: A Multiscale Modeling Approach", 16th International Clay Conference, Granada, Spain, 2017.
- Katti, Kalpana, Sharma, Anurag, and Katti, Dinesh, "Biomineralization inside nanoclay galleries: opportunities in regenerative medicine and cancer Therapy" 16th International Clay Conference, Granada, Spain, 2017.
- Katti,Dinesh, Katti, Kalpana, Thapa, Keshab and Faisal,H. M. Nasrullah, "Modeling the Nanoscale Kerogen Inclusions in Green River Oil Shale", 6th BIOT Conference, Paris, France, 2017.
- Ksaibati, K.;" Developing a Safety Tool Kit for Tribes", The 20th Annual National Tribal Transportation Conference"; September 25-29, 2017; Tucson, Arizona.
- Marshall, W. and Ferenchak, N. The Relative (In)Effectiveness of Bicycle Sharrows on Safety Outcomes. International Cycling Safety Conference, Davis, CA, September 2017.
- Marshall, W. Emerging Computational Methods in Urban Design: Now What Do We Do? Association of Collegiate Schools of Planning Annual Conference; Denver, CO.
- Marshall, W. Why Are Bike-Friendly Cities Safer for All Road Users? International Cycling Safety Conference, Davis, CA, September 2017.
- Marshall, W., Piatkowski, D., and Johnson, A. Scofflaw Bicyclists: Illegal but Rational. World Symposium of Transportation and Land Use Research; Brisbane, Australia; July 2017.
- Okok M.A., Saha. P., and Ksaibati, K. "Developing Performance Models for Gravel Roads to Evaluate the Cost-Effectiveness of using Dust Chemical Treatments." Transportation Research Board Meeting, Washington D.C., 2017.
- Ostrowsky, Jennifer L. "A New Approach for Evaluating the Ductility, Volumetric Stiffness and Permeability of Cutoff Wall Backfill Materials. Poster presentation at United States Society on Dams Annual Meeting and Conference, April 2017.
- Pan, H., Azimi, M., Gui, G., Yan, F., and Lin, Z. (2017). "Vibration-based support vector machine for structural health monitoring." 7th International Conference on Experimental Vibration Analysis for Civil Engineering Structures, San Diego, CA, USA.
- Schmit, C., G. Hua, and G. Hooshyari. "Innovative Methods for E. Coli Reduction in Stormwater - Metal Shavings." South Dakota Water and Wastewater Association 2017 Annual Conference, Huron, SD, September 14, 2017.
- Tazarv, M., Bohn, L., and Wehbe, N., "Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders." South Dakota Department of Transportation, Aug. 30, 2017.
- Tazarv, M., Mingo, M., and Wehbe, N. " Precast Full-Depth Deck Panels Supported on Inverted Bulb-Tee Bridge Girders." South Dakota Department of Transportation, May 24, 2017.
- Tazarv, M., Mingo, M., Carnahan, Z., and Wehbe, N. " Development of an Alternative to the Double-Tee Bridge System." South Dakota Department of Transportation, Aug. 30, 2017.
- Terrill, T. and Ksaibati, K;" Investigating Challenges Affecting the 4Es of Transportation Safety on the Fort Peck Reservation"; Transportation Research Board Meeting, Washington D.C., 2017.
- Wehbe, N., and Boudaqa, A. "Estimation of Vehicular Collision Force for Bridge Columns Using Computational Methods." Ninth International Structural Engineering and Construction Conference, Valencia, Spain, July 25, 2017.

v. Other Items Produced During this Period

- Haq, M.T., M. Zlatkovic and K. Ksaibati. "Preliminary Safety Analysis for Freeway Truck Traffic in Wyoming." Paper submitted for the Transportation Research Board 2018.

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/personnel/

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 products
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 principal investigators, faculty, and administrators participating in MPC projects:

Eight principal investigators, faculty, and administrators participating in MPC projects at **Colorado State University** are: Christopher Bareither, Paul Heyliger, Rebecca Atadero, Mehmet Ozbek, Suren Chen, Jeffrey D. Niemann, Kelly Strong, and Joseph Scalia. In addition, nine students are working on MPC research projects at **Colorado State University**: Doctorate Students –Guangyang Hou, Luke Chen, Yufen Zhou, Chao Jiang and Masters Students – Almotasem Maamon, Kelsey Czyzyk, Avi Sharma, Zana Taher and Trai Nguyen.

Fourteen principal investigators, faculty, and administrators participating in MPC projects at **North Dakota State University** are: Eunsu Lee, Ying Huang, Alan Dybing, Kimberly Vachal, Jill Hough, Andrew Kubas, Ying Mijia, Raj Bridgelall, Brenda Lantz, Pan Lu, Denver Tolliver, Zhibin Lin, Dinesh Katti, and Kalpana Katti. In addition, twenty-one students are working on MPC projects at **North Dakota State University**: Bhavana Bakare, Leonard Chia, Christopher Dehaan, Neeraj Dhingra, Kenechukwa Ezekwem, Fesseha Gebremikael, Mingwei Guo, Seyed Ali Haji Esmaeili, Md Daulat Hossain, Chijioke Ifepe, Fecri Karanki, Poyraz Kayabas, Amin Keramati, Narendra Malalgoda, Dilip Mistry, Yong Shin Park, Ali Rahim Taleqani, Yuan Xu, Fangzheng Yuan, Zijan Zheng, and Asif Arshid

Thirteen principal investigators, faculty, and administrators participating in MPC projects at **South Dakota State University** are: Allen L. Jones, Guanghui Hua, Christopher Schmit, Kyungnan Min, Nadim Wehbe, Mostafa Tazarv, Junwon Seo, Jonathan Wood, Rouzbeh Ghabchi, Michael Pawlovich, Vikash Gayah, Ilgin Guler and Francis Ting. In addition, seventeen students are working in MPC research projects at **South Dakota State University**: Masters Students – Sandip Rimal, Ghaem Hooshyari, Peng Dai, Gregory Hansen, Lucas Bohn, Michael Mingo, Zachary Carnahan, Eduardo Torres, William Augustus Schaffer, Puskar Kumar Duhal, Thomas Cook, Shaohu Zhang, Chamika Prashan Dharmarathna, Buddhika Prasad, and Undergraduate Students - Jason Weber, Brian Kidd and Sara Schoening.

Nine principal investigators, faculty, and administrators participating in MPC projects at the **University of Colorado Denver** are: Wesley Marshall, Carolyn McAndrews, Bruce Janson, Jimmy Kim, Austin

Troy, Moatassem Abdallah, Matthew Cross, Caroline Clevenger, Mehmet Ozbek, Dan Piatkowski, Krista Nordback and Farnoush Banaei-Kashani. In addition, fourtneen students are working on MPC research projects at the **University of Colorado Denver**: Doctorate Students - Nick Ferenchak, Ibrahim Bumadian, Yaneev Golombek, Shahryar Monghasemi, Alejandro Henao, Abdullah Alajmi, Aaron Johnson, D. Akalp, Rob Fitzgerald; Masters Students – Evan Rosenlieb, Ahmed Ibrahim, Nick Coppola, Rosenlieb E, and Yifeo Chai.

One principal investigators, faculty, and administrators participating in MPC projects at the **University of Denver is**: Patrick Sherry. In addition, 2 students are working on MPC research projects at the **University of Denver**: Masters Students - Jessica Mantia and Clare Jinzhao Zhao.

Fifteen principal investigators, faculty, and administrators participating in MPC projects at the **University of Utah** are: Richard J. Porter, Milan Zlatkovic, Kevin Franke, Pedro Romero, Ran Wei, Steven Bartlett, Cathy Liu, David Sanbonmatsu, David Strayer, Joel Cooper, Pedro Romero, Amanda Bordelon, Chris P. Pantelides, Juan Medina, and Brendan Duffy. In addition, thirty one students are working on MPC research projects at the **University of Utah**: Anurag Upadhyay, Anusha Musunuru, Arwen Behrends, Bhaskar Kunwar, Catalina Arboleda, Chris Merket, Daniel Sudbury, Dillon Li, Donald Godfrey, Jafar Allahham, James Holt, Jeff Taylor, Jeffrey Orrego, Jem Locquaio, Joseph Herkimer, Kathryn Hein, Kiavash Fayyaz, Kyle Strayer, Yang Li, Lingkun Li, M. Scott Shea, Martin Dinsmore, Massoud Hosseinali, McEntee Vanessa, Min Ook Kim, Ruoyang Wu, Sean Strayer, Daniel Sudbury, Taylor Adams, Zhenghui Yu and Zhuo Chen.

Eight principal investigators, faculty, and administrators participating in MPC projects at the **University of Wyoming** are: Khaled Ksaibati, Bart Evans, Mohamed Ahmed, Rhonda Young, Dennis Trusty, Kam Ng, Promothes Saha, and Milan Zlatkovic. In addition, thirteen students are working on MPC research projects at the **University of Wyoming**: Masters Students – Dawit Mebrahtom, Md Julfiker Hossain, Melake Brhanemeskel, Muhammad Tahmidul Haq, Nikolai Greer, Rameshwor Chalise, Sadia Sharmin, Sandeep Thapa, Sherif Gaweesh, Thomas Peel, Trenna Terrell, Engineer, Waleed Mohammed Abd Allah Al Eadelat and Undergraduate Student - Nicole Peterson.

Eight principal investigators, faculty, and administrators participating in MPC projects at **Utah State University** are: Anthony Chen, Xiangdong Xu, Sarawut Jansuwan, Jim Bay, John Rice, Paul Barr, Marv Halling and Ziqi Song. In addition, eleven students are working on MPC research projects at **Utah State University**: Doctorate Students – Zhaocai Liu, Yi He, Seungkyu Ryu, and Sohrab Mamdoohi; Masters Students - Nirdosh Gaire, Jen Ostrowski, Phillip Powelson, Ethan Pickett, Justin Pace and Holly Llyod and Undergraduate Student- Jen Ostrowski.

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.

- AAA Foundation for Traffic Safety
- Ajou University, Korea
- California State Fresno
- Campbell County Road and Bridge Department
- Campbell's Scientific
- City of Watertown, SD
- Colorado Department of Transportation
- Construction and Rehabilitation
- Converse County Road and Bridge Department
- Crook County Road and Bridge Department
- Denver Regional Transportation District
- Digital Glove Foundation
- East Dakota Water Development District

- Fehr & Peers
- FHWA, Wyoming Division.
- Geneva Rock
- Inberg Miller Engineers, Casper WY
- James River Water Development District
- Key Laboratory of Road and Traffic Engineering, Tongji University, Shanghai, China.
- Lincoln County Road and Bridge Department
- Missouri Department of Transportation
- National Institute of Development Administration (NIDA), Bangkok, Thailand.
- New Jersey City University
- Nibble City (Utah), Campbell Scientific, Bridge Diagnostic Inc. (BDI)
- North Carolina Pedestrian and Bicycle Information Center
- Pacific Earthquake Engineering Research Center
- Penn State University
- Roaring Fork Transportation Authority
- Sisseton Wahpeton Oyate Reservation
- South Dakota Department of Environment and Natural Resources
- South Dakota Department of Transportation
- Standing Rock Sioux Tribe Indian Reservation
- StarSeismic LLC
- Structural Technologies Inc.
- Teton County Road and Bridge Department
- University of California Los Angeles
- University of Colorado Boulder
- University of Nebraska-Lincoln
- Utah Department of Transportation
- Utah Transit Authority
- Virginia Tech
- Wisconsin Department of Transportation
- Wyoming Technology Transfer Center
- 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

North Dakota State University: Students supported by UTC funds here at North Dakota State University have gone onto very successful positions with fortune 500 companies, academia, federal, state, and local transportation agencies. Students continue to excel while building transportation skills that will enhance the transportation workforce now into the future. With the support of UTC funds, NDSU researchers have been able to focus on tribal needs throughout the state, infrastructure assessment, asset management, bridge strength analysis, and technology transfer. These efforts will continue to develop the skills and knowledge of the transportation workforce to face the challenges of the 21st century. NDSU researchers continue to move into sensor networks, smart city applications, and addressing the needs and challenges of public transportation in rural and metropolitan areas. Research findings are being disseminated through webinars, transportation learning network, newsletters, social media, and email blasts.

Wyoming: The MPC projects provided excellent learning opportunities to students at the graduate level as well as the undergraduate levels. The UW research projects helped in implementing PMS on county paved roads. In addition, the tribal safety studies helped several tribes in the region implement a safety improvement program.

Colorado State University: The projects at CSU have supported the education of many graduate students. Some projects have developed new techniques for designers (MPC -481, MPC-461), or for

laboratory study (MPC-509 and MPC-486).

South Dakota State University: The projects provided research and learning experience for sixteen graduate and two undergraduate students. Additionally, the cost savings and test time efficiency improvement of the recommended DCP test methods are the main benefits of the research conducted. The DCP method would either substantially decrease or eliminate all of these inefficiencies and simplify the verification process. The cost-effective rehabilitation methods proposed in the present study for the longitudinal joint of double-tee bridges can save millions of dollars for SD local governments and bridge owners, since the rehabilitation cost is only 30% of a bridge superstructure replacement. The lifetime of the bridge girder-to-girder joints can be extended for another 75 years by incorporating the proposed rehabilitation methods. Through this research three new bridge systems were proposed and tested through full-scale experiments. The systems were a fully precast bridge, a glulam timber girder bridge, and a glulam timber slab bridge. It was found that all three bridge systems are viable alternatives to the currently used double-tee bridges. Each system is suitable for a certain range of span. The cost of the new bridge systems is comparable to or lower than the cost of double-tee bridges. Local governments will now have more options when planning to construct a new bridge or to replace an old one on local roads in SD. Potential reuse of MIEX brine for ice control at SDDOT which could lead to the implementation of beneficial reuse of this waste stream at SDDOT. Development of standard SCC mix design and new recommendations for prestressed SCC mix design.

University of Colorado Denver: For the Civil Engineering discipline, the MPC associated research and education efforts have been instrumental in helping grow our transportation program and establish a solid reputation. We have once again broadened our reach and brought in researchers from not only Urban Planning but also Geography, GIS, Computer Science, and Construction Engineering. Our efforts are helping build a transportation workforce with both technical skill and expertise as well as the ability to understand the larger context of their work. Our affiliation with the MPC and the UTC program is the improving national reputation of CU Denver's research and education work within the field of transportation. This program period continues our successes with regard to publications, presentations, and popular press articles related to these efforts. The research activities address three important national issues - infrastructure deterioration, safety, and sustainability. Our educational program is also helping building better students in areas of national need.

University of Denver: No input.

University of Utah: The projects in our program have contributed to significant savings in maintenance budgets thanks to better information for decision making. In addition, better preparation in selection of maintenance strategies and better understanding of infrastructure materials has been achieved. Another impact is longer lasting pavements and better use of resources. In another area, a physical NOx photocatalytic analysis system was developed which can be used for all sorts of materials that fit within to measure the NO and NO2 photocatalytic efficiency. This analysis box can be used by other disciplines. The SEM was used as a tool for measuring chemistry and microstructure topography. This technology is introduced into classes. Since air pollution effects everyone, this technology will help to analyze solutions to removing NOx in the air. In a structures-related project, new seismic retrofit techniques are introduced that could benefit existing bridges against seismic damage. The seismic repair techniques are fast to implement for both pre- and post-earthquake repair and retrofit. The installation of the technology classifies as an emergency seismic repair since it can be completed in less than three days. In another project, age dependent properties of FRC as used in pavement design and pavement modeling have been developed. The investigators have built a wedge-splitting test apparatus for fracture testing and a Ring Shrinkage concrete test apparatus; the equipment and manual for the ring test apparatus is available for others to use at Utah DOT's facility. For another project, regarding the incorporation of maintenance costs into highway design decisions, even though the main tasks are still underway, ideas developed in early

tasks have already been incorporated into the University of Utah's graduate-level "Highway and Traffic Engineering" course. In another project, data collected as part of a project regarding novel lane-by-lane analysis of crashes at intersections, contributed to additional findings and defining future research directions. A different project has resulted in better selection of materials for pavements, understanding of priorities and better tools for selection of materials. The impact of the project has resulted in better knowledge of testing and materials selection, new methods for evaluate materials at low temperatures and better, longer lasting roads. Several DOT's which utilize wall piers in their bridges could use new seismic retrofit and repair methods being developed. Instead of demolishing existing concrete wall piers the retrofit techniques could be used to seismically upgrade these bridges. In a traffic related project, the investigators are assisting the Utah Transit Authority to identify the optimal deployment strategies for electric bus systems to achieve specified planning goals. Finally, in a materials related project, a device capable of measuring water or moisture content in cementitious materials has been developed. This constitutes a connection between civil engineering and electrical engineering disciplines and introduces a new device in the market.

Utah State University: We are currently supporting several students through undergraduate and graduate studies. This is significant not only for them personally but also for the workforce development. I think one of the major impacts this program has had is we are currently searching for a third transportation faculty member. We have never had three faculty members in transportation at USU. This program has been a major influence on me being able to convince the Dean that transportation is a growing area and worth the investment. This will have major implications as we move forward to the future of research, workforce development and technology transfer.

b. Expected Impacts

North Dakota State University: NDSU transportation and logistics students will continue to infiltrate the transportation workforce bringing excellent data analysis and assessment skills to the organizations. Students continue to present and participate in industry workshops and conferences, and seek top level transportation positions around the world. NDSU researchers continue to disseminate the results of ongoing projects and research to transportation professionals around the state. Expected outcomes will continue to be shared through technology transfer opportunities, webinars, and social media.

Wyoming: The MPC funding will continue supporting graduate students who will join the transportation workforce after graduation. The research studies conducted will facilitate selecting maintenance and rehabilitation strategies on local paved roads, reduce crashes on tribal roads, enhance the effectiveness of air quality programs such as the CMAQ program, and reduce truck related crashes in rural areas.

Colorado State University: As the findings of our projects are disseminated and make their way into transportation practice we anticipate several impacts. For example, the new model developed in MPC 481 overcomes limitations of existing models and should facilitate better hydrologic design of transportation infrastructure. MPC-485 studies the topic of Transit Oriented Development, which is a very timely topic and thus the project has the potential to help better inform many decision makers and local government agencies considering new TOD projects. MPC-508 should help promote the use of polymer soil amendments in appropriate circumstances.

South Dakota State University: The implementation of the SDDOT Base and Subbase Moisture Density Curves may decrease the time required to obtain target density and optimum moisture. This should result in both cost savings to perform the test as well as construction costs by reducing over-compaction. Development of a low-maintenance, low-cost mixed-media filtration system for stormwater treatment. This filtration system can be used to reduce the impact of highway runoff on surface waters and improve the environmental sustainability of transportation. Aqueous waste streams can be produced from many

commercial, industrial, and municipal processes or activities. The results of this research could help transform waste streams that are now environmentally and financially expensive to discard into valuable materials for transportation-related applications. Additionally, the results of this research could be used by the SDDOT and other agencies to improve the performance of ice and dust control on roadways, reduce the costs of roadway maintenance, and reduce the costs of purchasing new materials (such as rock salt). Development of standard SCC mix design that achieves desired structural performance for use in prestressed girders. Development of new a testing standard for mechanical bar splices and generation of comprehensive database for mechanical bar splices. The development of a crash prediction model and CMFs will allow the estimation of accurate predictions of crash outcomes for various design options related to access management in South Dakota. The software will improve decision making and provide benefit estimates that can be used for marketing and communicating the benefits to the public. This will result in time and financial savings to local governments and SDDOT. It will also improve understanding of the impacts of access management on traffic operations, the environment, and the local economy. This is expected to aid SDDOT in improving its current practice of selection of tack coat type and application rate. The results from this study will be used to develop recommendations and development of quality control measures for tack coats for enhanced performance. Such measures will benefit SDDOT by reducing pavement maintenance costs by minimizing tack coat-related failures of pavements. Development of visual load rating method for double-tee bridges and of an alternative approach to predicting bridge scour in cohesive soils. The results of this proposed research will be directly applicable to engineering practice, first by giving the design engineer detailed guidelines to identify bridge sites where the Scour-Rate-In-Cohesive-Soils (SRICOS) method may be useful and, second, by providing step-by-step instructions on how to generate flood hydrographs for scour prediction using the SRICOS method.

University of Colorado Denver: Expanding our portfolio of work has continued to help grow the UTC program at CU Denver. More importantly, the work we are doing is helping develop the next generation of transportation professionals and doing so in a way that will benefit society in many different fashions. These projects will be of particular benefit to those looking to provide and promote a safer and more resilient transportation system.

University of Denver: No input.

University of Utah: One study provides an understanding of some of the critical factors shaping attitudes toward completely autonomous, self-driving vehicles. The findings will be relevant to the field of transportation safety and the automotive industry because these attitudes will determine the willingness to adopt autonomous vehicles, and the support for the legal and physical infrastructure needed to put these vehicles on the road. The research also furthers our understanding of judgment and decision making, and, thus, contributes to psychology, marketing, economics, and other fields where these processes are of fundamental interest. Another study will contribute to a better understanding of the surface treatments used on the roads. The expected outcomes of another project are related to environmental sustainability and livable community strategic goals in the sense that the technology studied has the potential to reduce the environmental impact of emissions generated by transportation activities, and improve the air quality in urban areas. In a project related to seismic retrofit of bridges, it is expected that DOT's will adopt these techniques. Alaska, California and Utah are currently considering these seismic retrofit techniques. In a related study, new seismic retrofit and repair techniques for existing concrete wall piers using FRP composite materials are being developed. Comparisons of seismic performance of existing piers built to old codes and new piers built to current codes will be carried out.
In a pavement related study, it is not well understood what saw-cut joint spacing is needed or the net deflection or de-bonding effects can be expected when utilizing fiber-reinforcement in the top overlay material. Measurements will provide knowledge on how the FRC properties change at these early ages in which cracking is typically started. In a transportation related project, the goal is to identify how

transportation system- and project-level design decisions impact long-term maintenance costs and operations, and recommend possible changes to standard drawings and practice that minimize maintenance costs and optimize maintenance operations while fully considering other operational and safety impacts and trade-offs. This will result in improved maintenance operations and subsequent cost-savings from making more fully-informed design decisions. This project will also produce a tool to ask maintenance and cost questions, even after project completion. This is expected to significantly increase the value of the research as a general tool implementable elsewhere. In a project related to safety effects of left-turn phases, data collected includes new levels of detail not available from previous studies in the literature. This study is expected to produce insights on the effects of different left-turn phasing, and countermeasures directly applicable to Utah and elsewhere for specific left-turning schemes. In particular, the approach-level data collection is the key element to isolate the effects of left-turn phasing. This approach requires extensive data collection and manual data reduction. The project will produce models to estimate crash frequency, severity, and crash modification factors to quantify expected changes in performance when left-turn phases are updated.
In a pavement related project, millions of dollars in savings as a result of the improvements in materials selection resulting in the elimination of early pavement failures and reduction in maintenance requirements are expected to be developed. In a geotechnical related project, a community database of lateral spread case histories for use by DOTs and researchers is being developed. The database will be used to develop new empirical and numerical models. Another study is expected to contribute to the field of transportation safety by furthering our understanding of the impact of distraction on driving. More generally, the study will contribute to psychological science by increasing our knowledge of the dynamics of human performance. In another project, the procedures for collecting electric bus and transit data, performing feasibility analysis and evaluating the cost-and-benefits will lead to new material and possibly group projects to teach the students practical skills on transportation planning. In a project related to hotspot and sampling analysis for effective maintenance management and performance monitoring, based on the sampling results, the project will help UDOT in accurately estimating the statewide overall level of maintenance and assist with budget allocation.

Utah State University: I think we have a blend on projects. The benefit of this is we can impact the field on multiple fronts. The main focus has been on Transportation, Structures and Geotechnical. However we also have been significantly involved with electrical engineering with our efforts on the electric vehicle work. We had the Secretary of Transportation on campus during this reporting period and were able to take him and show him, along with seven legislators, the transportation facilities that we have. This is significant and something that we have never done before. We are trying to use this program to expand our contact with these key players in the region.

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