**U.S. Department of Transportation**
**Research and Innovative Technology Administration**
**University Transportation Center Grant Agreement**

**Grant No. 69A3551747108 FASTACT**
**Mountain-Plains Consortium, North Dakota State University**
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**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: June 30, 2016 – September 30, 2022**

**Reporting Period End Date: March 31, 2018**
**Semi-Annual PPPR#2**

**Denver D. Tolliver**

**Director, Mountain-Plains Consortium**
**North Dakota State University**

**1. Accomplishments: What was done? What was learned?**
**a. What are the major goals of the program?**

The overall objectives are to: (1) conduct basic and applied research, the products of which are judged by peers or other experts in the field of transportation to advance the body of knowledge in transportation; (2) offer an education program in transportation that includes multidisciplinary course work and participation in research; (3) conduct workforce development activities and programs to expand the workforce of transportation professionals; 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 seven 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, Economic Competiveness, Organizational Excellence, and Security Preparedness and other supporting objectives while addressing critical issues of the region and stakeholder groups.

MPC projects selected include the following: MPC-533-571.

**b. What was accomplished under these goals?**
**i. Project Selection**

Thirty-nine research projects have been peer reviewed and selected for implementation between 2016-2018. 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 seven 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, Environmental Sustainability, Organizational Excellence, and Security Preparedness and other supporting objectives.

**ii. Programmatic Milestones**

In addition to the programmatic milestones described below, several milestones embedded within individual projects have been achieved. Most of the research projects call for literature reviews. The literature reviews for those projects with the earliest starts are substantially complete. Interim reports are not required after the literature review stage. So, no publications have been produced at this time. At this time, all projects are on schedule to be completed as planned during the program period.
The accomplishments to date are summarized in Table 1 by reference to milestones.

| Milestone Event | Description | Start Date | End Date |
|---|---|---|---|
| Development of Proposal Guidelines | Proposal guidelines were developed by the director, in consultation with other consortium members, to ensure a consistent solicitation and project selection process that facilitates peer review and links program activities to the Secretary's strategic goals. The research proposals guidelines are shown in Table 2. Similar but different guidelines were developed for education, workforce development, and technology transfer projects, to reflect the differences in tasks and outcomes associated with these projects. The proposal guidelines and related information have been posted on the Center's webpage. | 09/1/2016 | 12/30/2017 Done |

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|---|---|---|---|
| Call for Proposals | The solicitation of proposals occurred on each university campus, using proposal guidelines developed by the director. | 12/1/2016 | 12/15/2018<br>Ongoing |
| Execution of Grant Agreement | The grant was received from RITA and executed by NDSU's Sponsored Programs office. All of the necessary internal accounting and financial procedures were established, including subcontract agreements with consortium universities. | 12/01/2016 | 12/08/2016<br>Done<br>Ongoing with each new award |
| Center Directory | A directory of key center personnel was completed and published on the center's web page. | 01/15/2017 | 01/15/2017<br>Done |
| Center Webpage | The MPC webpage was updated and is fully functional for the current grant period | 01/15/2017 | 01/15/2017<br>Done |
| UTC/CUTC Meeting | The director and administrative staff attended the UTC/CUTC meeting at TRB and also the summer meeting to receive guidance from RITA regarding the forthcoming grant. | 01/07/2018<br>06/04/18 | 01/11/2018<br>06/7/18 |
| Peer Review of Proposals | All project proposals were subjected to external and internal peer review. | 02/15/2017 | 12/30/2018<br>Ongoing |
| Primary Focus | MPC's proposal targets the following FAST ACT research and technology deployment objectives under the goal of Improving Infrastructure Integrity: A) increase the reliability of life-cycle performance predictions used in infrastructure design, construction, and management; B) improve the ability of transportation agencies to deliver projects that meet expectations for timeliness, quality, and cost; C) reduce user delay attributable to infrastructure system performance, maintenance, rehabilitation, and construction; D) improve highway condition and performance through increased use of design, materials, construction, and maintenance innovations; and E) study vulnerabilities of the transportation system to seismic activities and extreme events and methods to reduce those vulnerabilities. | 11/30/2016 | 09/30/2022<br>Ongoing |
| Selection of Projects | Projects are being selected from the proposals received and awards were made to principal investigators, based on the peer reviews of proposals, stakeholder commitments, and the overall availability of funds. | 05/15/2017 | 12/30/2018<br>Ongoing with each award |
| Posting of Projects | The selected projects will be posted on the MPC webpage and added to the Research in Progress database. | 05/15/2015 | 12/30/2018<br>Ongoing with each project selected |
| Site Visit | A site visit to all MPC Universities will be conducted annually. | 11/30/2016 | 09/30/2022<br>Ongoing<br>Annually |

**Table 2: MPC Research Proposal Guidelines for Faculty**

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|---|---|
| **Title** | Provide a title that is descriptive of the project and includes key terms that will facilitate internet and library searches for the project. |

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|---|---|
| **Universities** | If the project is a multi-university proposal, list each university involved. |
| **Principal Investigators** | If the project is a multi-university proposal, list a principal investigator from each university, with the university affiliations denoted in parentheses. |
| **Research Needs** | Provide a statement of the important issues and problems that give rise to the need for the project, including a brief literature review (if appropriate) that summarizes the state of knowledge in the subject area and identifies the knowledge gaps the project seeks to fill. It must be clear from the description that there are compelling needs for the study and it will address issues of national and regional importance. |
| **Research Objectives** | Provide a clear statement of the research objectives, including any hypotheses to be tested. At least some of the objectives must be measurable—i.e., at the conclusion of the project, it must be possible to ascertain whether the stated objectives have been achieved. |
| **Research Methods** | Provide a sufficient description so that reviewers can assess the appropriateness of the research approach and methods and the quality and reliability of data, including descriptions of any mathematical, statistical, operations research, and simulation techniques to be used, as well as surveys, lab tests, and field data. |
| **Expected Outcomes** | Provide a description of the expected outcomes in terms of potential findings and impacts, including advances in modeling, practices, and procedures; implications for future research; and how the results of the project can be used by practitioners. Describe any tangible products beyond the research report, including prototype software, equipment, guidebooks, or instructional manuals that may emanate from the project. |
| **Relevance to Strategic Goals** | Describe how the proposed project and its expected outcomes are related to one or more of the following goals: State of Good Repair, Safety, Economic Competiveness, Environmental Sustainability, and Livable Communities. |
| **Educational Benefits** | If applicable, describe how students will be involved in the project and any expected classroom or instructional uses of procedures, examples, or discoveries derived from the project. |
| **Work Plan** | Provide a description of the major tasks or steps in the project, along with an expected timeline. The tasks should be numbered and an expected completion date assigned to each one. Instead of calendar dates, the timeline should be expressed in months from the starting date. Typically, a work plan includes steps such as the completion (and testing) of questionnaires, lab tests, field tests or data collection efforts, input or focus group meetings, and critical steps such as the initial runs and calibrations of models. A draft report and other milestone events should be included, as well as a technology transfer plan that includes a research seminar via the Transportation Learning Network and/or plans to collaborate with an LTAP or TTAP center (if appropriate). If the research is basic in nature, other dissemination methods may be substituted for the TLN, LTAP, or TTAP distribution channels. |
| **Project Cost** | List the amount of MPC funds requested, the amount of the expected matching contributions, and the sources of the matching resources, including all agencies expected to contribute funds or in-kind resources to the project. MPC research projects require at least a dollar-for-dollar match. However, other federal funds (e.g., federal funds other than UTC funds) cannot be used as match, except for state planning and research funds and LTAP funds, which are eligible under exclusionary provisions of the authorizing legislation. The definition of "nonfederal funds" is based on the original source of funds. |

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| **Technology Transfer** | Provide a technology transfer plan for your project. Describe the process you will use for transferring your findings to other researchers, professionals and practitioners. The goal should be further development, commercialization and practical applications for the results of your research. Ultimately, technology transfer should sustain economic growth and improve efficiency, safety, and/or cost effectiveness through the development and commercialization of new technologies and practices. Technology transfer may occur through (but is not limited to) conferences, workshops, web pages, social media, and seminars. Please list how you intend to fulfill this requirement and remember to report your technology transfer activities in the PPPR for this project. |
| **Potential Peer Reviewers** | Provide the complete contact information of at least three persons who are qualified to review and critically assess the proposal, including the person's name, position title and organization, street address, city, state, zip code, and email address. Keep in mind that peer reviewers cannot have conflicts of interests, such as those that may arise if someone stands to personally or professionally benefit from the proposed project. Peer reviewers may include professionals at federal, state, metropolitan, or local agencies, as well as university and private-sector researchers. Given that at least three completed reviews are required for a proposal to move forward in the assessment process, the submission of more than three names may expedite the time frame for approval, in the event of one or more nonresponsive reviewers. |
| **TRB Keywords** | Provide a complete list of applicable TRB keywords |
| **References** | List the major references cited in the proposal and other seminal work in the field. |

Researcher guidance and template can be found here: https://www.mountain-plains.org/resources/researchers.php

**iii. Educational Accomplishments**

The transportation and transportation-related courses offered during Fall 2016 & Spring 2017 are listed in Table 3, 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 3: Transportation and Transportation-Related Courses Offered This Period**

| Major Subject Area | Course Title |
|---|---|
| **Engineering & Design** | 1. CIVE 507 Transportation Engineering |
| | 2. CIVE 508 Bridge Engineering |
| | 3. CEE 106 Elementary Surveying and Lab |
| | 4. CEE 411 Bituminous Materials and Lab |
| | 5. CEE 447/547 Foundation Engineering |
| | 6. CEE 456: Reinforced Concrete Theory and Design |
| | 7. CEE 458/558: Design of Timber Structures |
| | 8. CEE 492/592-S01: Highway Engineering |
| | 9. CEE 792-S01: Geosynthetics Design for Transportation Applications |
| | 10. EM 741: Finite Element Analysis |
| | 11. CEE 216-216L: Civil Engineering Materials and Lab |
| | 12. CEE 282: Civil Engineering Computer Aided Design |
| | 13. CEE 346-346L: Geotechnical Engineering and Lab |
| | 14. CEE 353: Structural Theory |
| | 15. CEE 363: Highway and Traffic Engineering |
| | 16. CEE 432: Hydraulic Engineering |
| | 17. CEE 452/552: Prestressed Concrete |
| | 18. CEE 455: Steel Design |
| | 19. CEE 692-S01: Pavement Stability |

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| | 20. CEE 732: Advanced Foundation Engineering |
| | 21. CEE 754: Advanced Design of Steel Structures |
| | 22. CEE 792-S01: Advanced Highway and Roadway Design |
| | 23. CVEN 3602 Transportation Engineering |
| | 24. CVEN 5682 Pavement Design |
| | 25. CVEN 4602 Highway Engineering |
| | 26. CVEN 5602 Advanced Street & Highway Design |
| | 27. URPL 3000 Planning the Built Environment |
| | 28. TRAN 4010 Introduction to Transportation Systems |
| | 29. TRAN 4330 Principles of Supply Chain: Management and Technologies |
| | 30. TRAN 4080 Transportation Law and Regulation: Domestic and International |
| | 31. CVEEN 2010 Statics |
| | 32. CVEEN 2140 Strength of Materials |
| | 33. CVEEN 3210 Structural Loads and Analysis |
| | 34. CVEEN 4221 Concrete Design I |
| | 35. CVEEN 5230/6230 Steel Design II |
| | 36. CVEEN 5240/6240 Masonry/Timber Design |
| | 37. CVEEN 5305 Intro to Foundations |
| | 38. CVEEN 7225 Prestressed Concrete |
| | 39. CVEEN 5570/6570 Pavement Design |
| | 40. CVEEN 3510 Civil Engineering Materials |
| | 41. CVEEN 3310 Geotechnical Engineering I |
| | 42. CVEEN 6340 Advanced Geotech Testing |
| | 43. CVEEN 2010 Statics |
| | 44. CVEEN 2140 Strength of Materials |
| | 45. CVEEN 3210 Structural Loads and Analysis |
| | 46. CVEEN 4222 Steel Design I |
| | 47. CVEEN 5220/6220 Concrete Design II |
| | 48. CVEEN 5210/6210 Structural Analysis II |
| | 49. CVEEN 7250 Structural Earthquake Engineering |
| | 50. CVEEN 6310 Foundation Engineering |
| | 51. CVEEN 3520 Transportation Engineering |
| | 52. CVEEN 5510/6510 Highway Design |
| | 53. CE 3500 Transportation Engineering |
| | 54. CE 4510 Pavement Design |
| | 55. CE 5510 Pavement Design |
| | 56. CE 4610 Foundation Engineering |
| | 57. CE 5610 Foundation Engineering |
| | 58. CE 3600 Soils Mechanics |
| | 59. CEE 3080 Design of Reinforced Concrete |
| | 60. CEE 5100 Infrastructure Renewal |
| | 61. CEE 5190 GIS Civil Engineers |
| | 62. CEE 6040 Structural Reliability |
| | 63. CEE 6930 Steel Design II |
| | 64. CEE 3160 Civil Engineering Materials |
| **Freight & Logistics** | 65. TRAN 4010 Introduction to Transportation Systems |
| | 66. TRAN 4330 Principles of Supply Chain: Management and Technologies |

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| | 67. TRAN 4080 Transportation Law and Regulation: Domestic and International |
| | 68. TRAN 4800 Analysis of Freight & Passenger Transportation Business Segments |
| | 69. TRAN 4430 Applied Micro Economics & Pricing |
| | 70. TRAN 4440 Marketing & Sales Management Strategies |
| | 71. TRAN 4450 Legal Studies: Contracts & Regulation |
| | 72. TRAN 4460 Financial & Managerial Accounting |
| | 73. TRAN 4470 Financial Analysis & Capital Structures |
| | 74. TRAN 4480 Capital Decision-making & Capital Markets |
| | 75. TRAN 4490 Global Trade & Economics |
| **Planning & Environment** | 76. CIVE 303 Infrastructure and transportation system |
| | 77. CVEN 5460 Introduction to Sustainable Urban Infrastructure |
| | 78. URPL 6399 Introduction to Sustainable Urban Infrastructure |
| | 79. URPL 6410 Social Justice in Planning |
| | 80. URPL 6600 Regional Planning |
| | 81. URPL 5050 Urban Development |
| | 82. URPL 6350 Form and Formation of Cities |
| | 83. URPL 6355 Urban Redevelopment Strategies |
| | 84. URPL 6365 Parks and Public Spaces |
| | 85. URPL 6400 Community Development |
| | 86. TRAN 4710 Transportation Finance |
| | 87. TRAN 4020 Transportation Economics |
| | 88. TRAN 4060 Transportation Marketing and Sales Tools |
| | 89. TRAN 4330 Principles of Supply Chain: Management and Technologies |
| | 90. TRAN 4320 Transportation Management, Leadership, and Values |
| | 91. TRAN 4400 Excellence in Leadership for Transportation |
| | 92. TRAN 4410 Executive Management Practices in Organizations |
| | 93. TRAN 4420 Leading with Integrity |
| | 94. CVEEN 1000 Intro to Environmental Engineering |
| | 95. CVEEN 3610 Environmental Engineering I |
| | 96. CVEEN 5500 Sustainable Materials |
| | 97. CVEEN 6560 Transportation Planning |
| | 98. CVEEN 6600 Solid Hazard Waste Engineering |
| **Public Transportation** | 99. URPL 6560 Transit Planning |
| | 100. TRAN 4080 Transportation Law and Regulation: Domestic and International |
| | 101. TRAN 4860 Senior Management-Executives & Issues Seminar |
| | 102. TRAN 4870 Individual Leadership Development Project |
| | 103. TRAN 4880 Business Development & Productivity Impr ovement Planning Project |
| | 104. TRAN 4890 International Transportation Travel Seminar |
| **Traffic & Operations** | 105. CVEN 5621 Traffic Impact Assessment |
| | 106. CVEN 3520 Transportation Engineering |
| | 107. CE 5700 Traffic Simulation |
| | 108. CE 5575 ITS |
| | 109. CEE 5220 Traffic Engineering |

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|---|---|
| | 110. CEE 3210 Intro to Transportation Engineering |
| **Transportation Safety** | 111. CVEN 5611 Traffic and Safety Data Analysis |
| | 112. CE 5560 Traffic Safety |
| | 113. CEE 6250 Transport Data/ Safety |
| **Transportation Systems** | 114. URPL 6555 Transportation and Land Use |
| | 115. CIVE 303 Infrastructure and Transportation System |
| | 116. TRAN 4830 Advanced Transportation & Supply Chain |
| | 117. TRAN 4010 Introduction to Transportation Systems |
| | 118. TRAN 4050 Intermodal Transportation Systems |

Altogether, 118 transportation and transportation-related courses have been offered this reporting period, for a total of 194 total transportation courses offered this grant period. In addition to the courses listed in Table 3, 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 are presented below.

- Autonomous, Connected Vehicles & Smart Highways - Tech & Policy Imp
- Regional Local Roads Conference
- Winter Maintenance & Cold Weather Survival - Bowman
- John Maxwell's 17 Indisputable Laws of Teamwork
- Winter Maintenance & Cold Weather Survival - McLean County
- Winter Maintenance & Cold Weather Survival - Bowman
- Construction Site SWPPP Compliance, Tools, Tricks & Tips
- Chain Saw Operation & Safety
- Truck Weight Education Training - On-site – Casselton
- Truck Weight Education Training - On-site – Beulah
- Bridge 101 - on site - Ellendale - Dickey County
- Improving Gravel Roads - Understanding Design Criteria
- Bridge 101 - on site - Bottineau County
- Trenching Safety & Confined Spaces
- Backing Safety & Blind Spot Awareness
- Professional Communication in Today's Electronic Workplace
- Enhanced Culvert Inspections Best Practices - MNDOT Guidebook
- Legal Aspects of Traffic Control on Highway Work Zones (Tort Liability)
- Truck Weight Education - on site - Jamestown
- High Strength Bolt Installation for Field Personnel
- Welding 101
- Corrugated Steel Pipe
- Uncovering Leadership Blind Spots
- Navigating the Landscape of Conflict
- Truck Weight mailing to Ag Industry (30)
- Truck Weight mailing to Ag Industry (30)
- ND Asphalt Conf Sponsorship letters mailed (90)
- UGPTI Annual Awards Banquet
- Regional Local Roads Conference Rapid City
- Hosted NDLTAP Training with Bruce Drewes in Valley City & West Fargo

- Enhanced Culvert Inspections Best Practices - MNDOT Guidebook
- Legal Aspects of Traffic Control on Highway Work Zones (Tort Liability)

Conferences, workshops, and publications are summarized under "products."

**c. How have the results been disseminated?**
The results will be 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. Because effective starting dates of most projects were after September 2016, no tangible results have been produced so far. Therefore, we have nothing to report.

**d. What do you plan to do during the next reporting period to accomplish the goals/objectives?**
Projects will continue to be selected and research will continue to done and implemented.

**2. Products: What has the program produced?**

**a. Publications, conference papers, presentations**

**i. Key Conferences and Workshops**

- Tailings & Mine Waste 2017, Banff, Alberta, Canada.
- ASTM International Committee Week, January 2017, New Orleans, Louisiana, USA.
- American Geophysical Union Hydrology Days, Colorado State University, Fort Collins, Colorado
- Road sensor network for smart city applications, 2018 SPIE conference of smart structures & NDE, March 2018.
- In-pavement fiber Bragg grating sensor for vehicle speed and wheelbase estimation, 2018 SPIE conference of smart structures & NDE, March 2018.
- Pavement bottom-up crack detection using in-pavement point sensors, 2018 SPIE conference of smart structures & NDE, March 2018.
- Experimental Detect Cracking in Concrete Pavement by using Strain Sensors, ND EPSCoR 2018 State Conference, April 17, 2018.
- Engineering Mechanics Institute Conference, San Diego, CA
- BIOT 2017 Conference, Paris, France
- 16th International Clay Conference, Granada, Spain, 2017
- Materials Research Society Annual Conference, Boston, MA, 2017
- MS&T 2017, Pittsburg, 2017
- Vienna Center for Engineering in Medicine: Invited Inaugural Presentation
- Plasticity, Puerto Rico, 2018
- TMS 2018, Phoenix, AZ, 2018
- American Concrete Institute Fall Convention, Oct. 2017
- American Concrete Institute Fall Convention, Mar. 2018
- Transportation Research Board; Washington, D.C.; Jan. 2018.
- Association of Collegiate Schools of Planning Annual Conference; Denver, CO; October 2017.
- Active Living Research Conference, Banff, Canada; February 2018.
- Construction Research Congress, ASCE, New Orleans, April 2018
- Congress for the New Urbanism Annual Meeting; Seattle; May 2017.
- International Cycling Safety Conference, Davis, CA, September 2017.
- Walk21 Conference, Calgary, Alberta, Canada; September 2017.
- World Symposium of Transportation and Land Use Research; Brisbane, Australia; July 2017.
- Transportation Research Board Annual Meeting, Washington, DC.
- American Concrete Institute: Fall meeting, Anaheim, CA
- American Concrete Institute: Spring meeting, Salt Lake City
- 97th Annual Meeting of the Transportation Research Board, Washington DC.

- Transportation Research Board Annual Meeting, 2018
- Utah State University: 2018 Conference on Electric Roads and Vehicles (CERV), Park City, UT, 26-27 February 2018

**ii. Key Publications**

- M. Al-Tarawneh, Y. Huang, P. Lu, and D. Tolliver, "Vehicle Classification System Using In-pavement Fiber Bragg Grating Sensors", IEEE Sensors Journal, Vol. 18, No. 7, pp. 2807-2815, (2018) [Impact factor: 1.9] (Published, Yes on acknowledgement of federal support).
- Katti, Dinesh, Thapa, Keshab and Katti, Kalpana, The Role of Fluid Polarity in the Swelling of Na-Montmorillonite Clay: A Molecular Dynamics and Fourier Transform Infrared Spectroscopy Study, Journal of Rock Mechanics and Geotechnical Engineering, under-review, 2018.
- 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.
- Katti, D., Sharma, A., Katti, K. (2017). Chapter 10 - Predictive Methodologies for Design of Bone Tissue Engineering Scaffolds A2 - Bose, Susmita. In A. Bandyopadhyay (Ed.), Materials for Bone Disorders (pp. 453-492). Academic Press. (Current Status: Published). http://www.sciencedirect.com/science/article/pii/B9780128027929000100
- 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)
- Kim, Y.J. and Alqurashi, A. 2018. Thermomechanical relaxation of RC beams strengthened with CFRP, ACI Structural Journal, American Concrete Institute (ACI) , 115(1), 259-268 (support acknowledged)
- Kim, Y.J. and Ibraheem, A. Functional periodicity for debonding-control of CFRP-concrete interface, ACI Structural Journal, American Concrete Institute (ACI) (submission number-S-2017-426: accepted) (support acknowledged)
- Marshall, W. Understanding International Road Safety Disparities: Why is Australia so much safer than the United States? Accident Analysis & Prevention, Vol. 111: 251-265, 2018 (doi: 10.1016/j.aap.2017.11.031).
- Apronti, D.T., Saha,P., Moomen,M., and Ksaibati, K. Truck Safety Evaluation on Wyoming Mountain Passes. Accident Analysis and Prevention.2017, 1-8.
- Moomen, M., Mashhadi, M.M.R., and Ksaibati, K. An Investigation of Influential Factors of Truck Crashes: A Logistic Regression Approach. Journal of Traffic and Transportation Engineering. 2018. (In Press).
- Saha, P., & Ksaibati, K. (2017). Developing an Optimization Model to Manage Unpaved Roads. Journal of Advanced Transportation, 2017.
- Aleadelat, W., & Ksaibati, K. (2017). Estimation of Gravel Roads Ride Quality through Android-based Smartphone. Transportation Research Record Journal of the Transportation Research Board, 2017.
- Aleadelat, W., & Ksaibati, K. (2017). A comprehensive approach for quantifying environmental costs associated with unpaved roads dust. Journal of Environmental Economics and Policy, 2017.
- Thomas, Robert J., Marc Maguire, Andrew D. Sorensen, and Ivan Quezada. Calcium sulfoaluminate cement: Benefits and applications. Concrete International 40 (4), 2018.

**iii. Key Conference Papers**

- Y. Huang, R. Bridgelall, and P. Lu, “Road sensor network for smart city applications”, 2018 SPIE conference of smart structures & NDE, Denver, CO, March 2018.
- M. Al-Tarawneh and Y. Huang, “In-pavement fiber Bragg grating sensor for vehicle speed and wheelbase estimation”, 2018 SPIE conference of smart structures & NDE, Denver, CO, March 2018.
- M. Alshandah, Y. Huang, P. Lu, and D. Tolliver, “Pavement bottom-up crack detection using in-pavement point sensors”, 2018 SPIE conference of smart structures & NDE, Denver, CO, March 2018.
- 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. The Road Safety Lessons of Australia. Transportation Research Board; Washington, D.C.; Jan. 2018.
- Delbosc, A., Reynolds, J., Marshall, W., and Wall, A. American Complete Streets and Australian SmartRoads: What Can We Learn From Each Other? Transportation Research Board; Washington, D.C.; Jan. 2018.
- Monghasemi, S.; Abdallah, M.; Tawfik, A.; and Clevenger. C. “Analysis of GHG Emissions Reduction Policies on Commuters and Organizations,” Construction Research Congress, American Society of Civil Engineers, New Orleans, Louisiana, April, 2018.
- Monghasemi, S.; Abdallah, M.; Tawfik, A.; and Clevenger. C. "Analyzing Implementation of Greenhous Gas Emissions Reduction Tools and Systems on Businesses and Employees" International Conference of Transportation Development, ASCE, June, 2018.
- Marshall, W., Piatkowski, D., and Johnson, A. Scofflaw Bicyclists: Illegal but Rational. World Symposium of Transportation and Land Use Research; Brisbane, Australia; July 2017.

**iv. Key Presentations**

- Y. Huang, R. Bridgelall, and P. Lu, “Road sensor network for smart city applications”, 2018 SPIE conference of smart structures & NDE, Denver, CO, March 2018.
- M. Al-Tarawneh and Y. Huang, “In-pavement fiber Bragg grating sensor for vehicle speed and wheelbase estimation”, 2018 SPIE conference of smart structures & NDE, Denver, CO, March 2018.
- M. Alshandah, Y. Huang, P. Lu, and D. Tolliver, “Pavement bottom-up crack detection using in-pavement point sensors”, 2018 SPIE conference of smart structures & NDE, Denver, CO, March 2018.
- M. Alshandah and Y. Huang, Experimental Detect Cracking in Concrete Pavement by using Strain Sensors, ND EPSCoR 2018 State Conference, Grant Forks, April 17, 2018.
- 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.
- Thapa, Keshab, Oil Shale and Swelling Clays, NDSU College of Graduate and Interdisciplinary Studies, 3-minute presentation and poster competition, Won: Showcase People's Choice Award
- Kim, Y.J. 2018. Big data for highway bridges in the United States, ACI Spring Convention, Salt Lake City, UT, Mar. 27, 2018

- Marshall, W. The Road Safety Lessons of Australia. Transportation Research Board; Washington, D.C.; Jan. 2018.
- Delbosc, A., Reynolds, J., Marshall, W., and Wall, A. American Complete Streets and Australian SmartRoads: What Can We Learn From Each Other? Transportation Research Board; Washington, D.C.; Jan. 2018.
- Ferenchak, N. and Marshall, W. Does a Lack of Casualties Mean That You Are Safe? Using Parental Perceptions and Mode Choice to Explore Child Pedestrian and Bicyclist Safety to School. Lifesavers National Conference on Highway Safety Priorities, San Antonio, Texas; April 2018.
- Ferenchak, N. and Marshall, W. Does a Lack of Casualties Mean That You Are Safe? Using Parental Perceptions and Mode Choice to Explore Child Pedestrian and Bicyclist Safety. Active Living Research Conference, Banff, Canada; February 2018.
- "Analysis of GHG Emissions Reduction Policies on Commuters and Organizations," Construction Research Congress, American Society of Civil Engineers, New Orleans, Louisiana, April, 2018.
- Marshall, W., Piatkowski, D., and Johnson, A. Scofflaw Bicyclists: Illegal but Rational. World Symposium of Transportation and Land Use Research; Brisbane, Australia; July 2017.
- "Leadership in Transportation Industry" - Bay Area Transportation Commission, San Francisco, CA. January 19, 2018.
- "Leadership Styles and Managerial Competencies" - Mineta Transportation Institute, San Jose, CA. February 16, 2018.
- "Leadership: Power & Passion" - Alameda County Transportation Commission, Oakland CA. march 16, 2018
- "Safety Culture in the Maritime Freight Industry" CMA-CGM Conference, Marseille, FR. Feb 7 2018.
- Tanner J.E., Wood S. "ASR - Using an Autoclave to Accelerate Exposure" ACI TG201. March 26, 2017.
- An Investigation of Influential Factors of Truck Crashes on Two-Lane Downgrades: A Logistic Regression Approach, 97th Annual Meeting of the Transportation Research Board, Washington DC, January 7-11,2018.
- Aleadelat, W., & Ksaibati, K. (2017). Estimation of Gravel Roads Ride Quality through Android-based Smartphone. Transportation Research Record Journal of the Transportation Research Board, 2017.
- Halling, M., and T. Gardner. "Design, Construction, and Maintenance of Electrified Roadways." 2018 Conference on Electric Roads and Vehicles (CERV), Park City, UT, 26-27 February 2018

**v. Other Items Produced During this Period**

- Nothing to report at this time.

**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/admin-personnel.php

**d. Technologies or Techniques**
Nothing to report at this time.

**e. Inventions, patent applications, and/or licenses?**
Nothing to report at this time.

**f. Other**
Nothing to report at this time.

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

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

Ten principal investigators, faculty, and administrators participating in MPC projects at **Colorado State University** are: Rebecca Atadero, Mehemet Ozbek, Suren Chen, Yanlin Guo, John W. van de Lindt, Gaofeng Jia, Jeffrey Niemann, Douglas Woolridge, Joseph Scalia, and Chris Bareither. In addition, six students are working on MPC research projects at **Colorado State University**: Doctorate students Min Li, Guangyang Hou, and Kaisen Yao, and Masters Students Brandon Perry Douglas Woolridge and Zana Taher.

Six principal investigators, faculty, and administrators participating in MPC projects at **North Dakota State University** are: Ying Huang, Pan Lu, Raj Bridgelall, Dinesh Katti, Kalpana Katti, and Denver Tolliver. In addition, eleven students are working on MPC projects at **North Dakota State University**: Doctorate students Bhavana Bhardwaj, Leonard Chia, Amin Keramati, Neeraj Dhingra, H M Nasrullah Faisal, Keshab Thapa, M. Alshandah, and Al-Tarawneh, Masters students Hu, and Yang and Undergraduate Student Blazanin.

One principal investigator, faculty, and administrator is participating in MPC projects at **South Dakota State University,** Junwon Seo**.** In addition, one student is working in MPC research projects at **South Dakota State University**: Matthew Zobel.

Seven principal investigators, faculty, and administrators participating in MPC projects at the **University of Colorado Denver** are: Moatassem Abdallah, Caroline Clevenger, Yail Jimmy Kim, Meng Li, Carolyn McAndrews, Wesley Marshall, and Bruce Janson. In addition, ten students are working on MPC research projects at the **University of Colorado Denver**: Doctorate students Shahryar Monghasemi, Nick Ferenchak, and Manze Guo, Masters students Ahmed Ibrahim, Mallory Redmon, Shalini Mahanthege, and Molly North, and Undergraduate students Alayna Truong, Ricardo Gonzalez, and Brady Heath.

One principal investigators, faculty, and administrators participating in MPC projects at the **University of Denver is**: Patrick Sherry. In addition, one student is working on MPC research projects at the **University of Denver**: Masters Student- Madeline Bremer.

Three principal investigators, faculty, and administrators participating in MPC projects at the **University of Utah** are: Xiaoyue Cathy Liu, Chris P. Pantelides, and Pedro Romero. In addition, six students are working on MPC research projects at the **University of Utah**: Doctorate students Zhuo Chen, Nima Haghighi, Roghayeh Zoleikani, Dipendra Thapa, and Faramarz Safazadeh, and Masters student Shuanli Bao.

Two principal investigators, faculty, and administrators participating in MPC projects at the **University of Wyoming** are: Khaled Ksaibati, and Jennifer Tanner. In addition, seventeen students are working on MPC research projects at the **University of Wyoming**: Doctorate students Md. Tarik Hossain, Milhan Moomen, and Waleed Aleadelat, and Masters students Fayez AlMutawa, Mustaffa Raja.

Seven principal investigators, faculty, and administrators participating in MPC projects at **Utah State University** are: Ziqi Song, Patrick Singleton, Marc Maguire, Andrew Sorensen, Robert J. Thomas, John Rice, and Marv Halling. In addition, seven students are working on MPC research projects at **Utah State University**: Doctorate students Zhaocai Liu and Pilaiwan Vaikasi, Masters students Nicholas Markosian and lastly Undergraduate students David Christensen, Peter Gilbert, Adam Pack, and Joshua Ward..

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

- Bay Area Transportation Commission, San Francisco, CA, In-Kind Consultation, Consultation on Workforce Development Activities.
- City of Fort Collins, Fort Collins, CO, Provide data and access to local bridges
- CMA-CGM Maritime, Inc., Washington, DC, In-Kind Consultation, Survey Completion.
- Colorado Dam Safety, Pueblo, Colorado, Technical Support
- Colorado Water Conservation Board, Denver, Colorado, Financial Support
- CTS Cement, Anaheim, CA
- Forterra Precast, provides concrete and forms for building the specimens.
- Forterra Precast, Salt Lake City, UT

- Keolis Commuter Services, Boston, MA, In-Kind Consultation, Survey Completion.
- Mineta Transportation Institute, San Jose, CA, In-Kind Consultation, Consultation on Workforce Development Activities.
- Monticello, MN, technical supports for sensor installation, sensor data collection.
- Mountainland Association of Governments, Orem, Utah, Technical Advisory Committee
- Olympus Precast, Bluffdale, UT
- Port of Oakland, Oakland, CA, In-Kind Consultation, Survey Completion.
- RSG, Inc., Salt Lake City, Utah, Collaborative Research
- RSG, Inc., Salt Lake City, Utah, Collaborative Research
- University of Sydney, Sydney, Australia, In-Kind Use of Facilities
- Utah Department of Transportation, Salt Lake City, UT, Financial Support
- Wasatch Front Regional Council, Salt Lake City, Utah, Technical Advisory Committee
- Wyoming Department of Transportation, Cheyenne, WY, Financial Support.
- Wyoming Technology Transfer Center, Laramie, WY, Collaborate in the Research.

**c. Have other collaborators or contacts been involved?**
Nothing to report at this time.

**4. Impact**

**a. What is the impact on the development of the principal discipline(s)?**

**Colorado State University**
MPC-533 — Use of Life Cycle Cost Analysis to Enhance Inspection Planning for Transportation Infrastructure DOTs and agencies responsible for bridge management and inspection are not always quick to adopt new inspection technologies. It can be difficult to determine if the higher costs of NDE methods are cost-effective in the long term. This project is expected to provide agencies with lifecycle cost information that they can use to enhance their inspection decision making. MPC-534 — Traffic Performance Assessment of Disrupted Roadway Networks Following Earthquakes. It will help understanding the traffic flow performance considering interactions with earthquake and also infrastructure interdependency. MPC-535 — Development of Unmanned Aerial Vehicle (UAV) Bridge Inspection Procedures. This research is expected to provide the bridge management sectors (e.g. state DOTs) with a highly efficient, cost-effective, quantitative and safe proof-of-concept for bridge inspection. MPC-536 — Development of Age and State Dependent Stochastic Model for Improved Bridge Deterioration Prediction. The deterioration model to be developed in this research will advance the state-of-the-art modeling on deterioration of bridges by incorporating the variability in the deterioration processes (e.g., corrosion) and the impact of various environmental and loading conditions (e.g., using of deicing salt, traffic volume etc.). The results will help predict bridge conditions in the future more accurately. Decision makers can use this information to guide better inspection, maintenance, repair, and rehabilitation planning. MPC-537 — Quantifying Mountain Basin Runoff Mechanisms for Better Hydrologic Design of Bridges and Culverts. Sustainable construction and maintenance of surface transportation systems requires accurate hydrologic design. A critical element of hydrologic design is the estimation of flood discharges that bridges and culverts must convey and their abutments must withstand. Traditional flood hydrology methods utilize low infiltration rates to model flood runoff solely by an infiltration-excess mechanism. Saturation-excess runoff can occur when a relatively shallow soil is underlain by a layer with much lower permeability (usually bedrock). This study will ultimately determine the importance of saturation-excess runoff for large storms in the Front Range and propose a model for incorporating this mechanism in hydrologic design.

**University of Colorado Denver**
These projects are all underway and just beginning to see results, which we will soon see the impact of on the discipline. In the meantime, we can highlight the impacts that these projects are having on the students that are working on them in terms of providing an opportunity for research and the various research-related skill development.

**University of Utah**
MPC-542 — Exploratory Modeling and Analysis for Automated Vehicles in Utah
AVs will impact mobility in a variety of ways. AVs will deliver mobility to historically low mobility demographics

such as the elderly, disabled, and children. AVs will also reduce the burden of long travel times by enabling passengers to focus on tasks other than driving. Both of these effects suggest that AVs will amplify growth in VMT that is already projected to increase due to population growth in Utah. The main impact of the project is to help public agencies DOTs and MPOs – who are in a reactive mode of the AV technology in figuring out how best to respond. MPC-543 — Big Transportation Data Analytics. The research will reveal the value of analytics in predicting traffic volume and reliability changes based on the historic traffic count record, as dependent on several other variables (incident, work zone, adverse weather, etc.) Based on statistical measures of fit, a best analytical approach, or set of approaches, can be incorporated into a DOT's traffic operation program to predict future traffic volumes and reliability for state and federal-aid routes, and for new planned highway segments. This information could be used to automatically feed the annual Highway Performance Monitoring System (HPMS) reporting UDOT is required to prepare, as well as to provide planning-level traffic forecasts, as an alternative to travel modeling approaches. MPC-544 — Lifecycle Assessment Using Snowplow Trucks' Automatic Vehicle Location (AVL) Data. With USDOT's emphasis on improving the conditions of the aging infrastructure, this project establishes a data-driven framework to document and follow the impact of a $6 million dollar per year infusion of funds into the Class 8 truck replacement cycle. The analysis leveraging high-resolution AVL data will assist UDOT to ensure that they are on target and demonstrating full value of the program through transparent evaluation and measurement of the impacts of the funding. The results of project will also assist UDOT to modify the program as needed and ensure the ability to respond to stakeholders (senior leadership, legislature, public) about the value and impact the funding is having in achieving the objectives and providing value to the transportation system and traveling public. MPC-545 — Self-Centering Bridge Bent for Accelerated Bridge Construction in Seismic Regions. Develop a new seismically resilient bridge system.

**Utah State University**
The principal discipline is Civil Engineering. Although our work with companies and cities has expanded it beyond just these areas. Workforce development and design continue to be primarily focus areas with increases in public transportation planning and safety.

**b. What is the impact on other disciplines?**

**Colorado State University**
MPC-534 — Traffic Performance Assessment of Disrupted Roadway Networks Following Earthquakes
Help on community resilience study, hazard mitigation. It may also foster collaborations on emergency response and public health following earthquakes. MPC-537 — Quantifying Mountain Basin Runoff Mechanisms for Better Hydrologic Design of Bridges and Culverts. Similar hydrologic analysis methods are used to evaluate dam safety and size spillways. Thus, the improved understanding of runoff generation and the new modeling methods are also expected to benefit dam safety. Colorado Dam Safety is actively engaged in this project and providing technical support.

**University of Colorado Denver**
These projects will have multi-disciplinary impacts such as with the bridge construction industry and the autonomous car community.

**University of Utah**
MPC-545 — Self-Centering Bridge Bent for Accelerated Bridge Construction in Seismic Regions. This study improved understanding of self-centering and energy dissipation in structures.

**c. What is the impact on the development of transportation workforce development?**

**Colorado State University**
MPC-533 — Use of Life Cycle Cost Analysis to Enhance Inspection Planning for Transportation Infrastructure. This project will help train at least one graduate student in transportation related research. MPC-534 — Traffic Performance Assessment of Disrupted Roadway Networks Following Earthquakes. Improve the techniques of graduate students on understanding the hazard impact and simulation techniques. MPC-537 — Quantifying Mountain Basin Runoff Mechanisms for Better Hydrologic Design of Bridges and Culverts. This project is supporting an M.S. student in the Department of Civil and Environmental Engineering. Through research, this project provides valuable training in hydrologic aspects of transportation. This student is expected to become part of

the transportation workforce. MPC-538 — Representative Testing of Expansive Soil Treatment Technologies for Transportation Earthworks. Provided opportunity for research in transportation related discipline, and development of innovating testing methods & apparatus.

**University of Colorado Denver**
The seven MPC projects have been instrumental in providing opportunities for several graduate students. They are all gaining experience in research methods, paper writing, and presenting as well as developing new skills.

**University of Denver**
The major impact at this point is that we have taken the results of our research and begun to work with a small group of leaders in the a regional planning organization. Taking the findings of our research and expanding them to managers and planners is a key development in terms o the impact of our research program.

**University of Utah**
MPC-542 — Exploratory Modeling and Analysis for Automated Vehicles in Utah
The PI is currently offering a graduate level course "Transportation Network Modeling" every Fall semester. The simulation-based framework developed in this research will lead to new material included in the course to teach the students practical skills on simulation and analytic techniques for modeling AV's impact on transportation network. MPC-543 — Big Transportation Data Analytics. The undergraduate course CVEEN 3520 Introduction to Transportation Engineering and graduate course CVEEN 7545 Transportation Network Modeling, are the ideal platform to introduce the concept of machine learning techniques for traffic prediction. The modeling procedure developed in this research will lead to new material included in the course to teach the students practical and interdisciplinary skills on computational techniques for transportation analysis. MPC-544 — Lifecycle Assessment Using Snowplow Trucks' Automatic Vehicle Location (AVL) Data. The graduate course CVEEN 7545 Transportation Network Modeling is the ideal platform to introduce the analytics of truck AVL data, and the DEA modeling approach. The truck lifecycle analysis and operational efficiency modeling developed in this research will lead to new material included in the course to teach the students practical skills on infrastructure asset management.

**Utah State University**
We have worked very hard to involve and support as many students as possible with these funds. It has been great opportunity to not only involve students directly but also motivate other potential students. It has been a good thing for the public as well.

**d. What is the impact on physical, institutional, and information resources at the university or other partner institutions?**

**Colorado State University**
MPC-538 — Representative Testing of Expansive Soil Treatment Technologies for Transportation Earthworks. Development of a new large-scale apparatus for representative testing of expansive soil mitigation techniques.

**Utah State University**
We use the TimeLab, SMASH lab and the Electric Vehicle Center as the three primary university resources.

**e. What is the impact on technology transfer?**

**University of Colorado Denver**
The results of these MPC projects have already been published in well-regarded peer review journals and highlighted at numerous conferences.

**University of Denver**
The program has contributed to the importance of the measurement of of safety culture and have been giving presentations to persons in Boston at MBTA and other freight transportation industries such as CGM-CMA a global freight and shipping company in Washington DC for this year.

**Utah State University**
Technology transfer has been in terms of publications, although smaller at this stage, and conference participation. We have not had much activity in terms of commercialization. We hope that the research will result in new design practices.

**f. What is the impact on society beyond science and technology?**

**Colorado State University**
MPC-534 — Traffic Performance Assessment of Disrupted Roadway Networks Following Earthquakes
Help improve the society to understand the importance of hazard resistance and how to understand the associated risks.

**University of Colorado Denver**
These MPC projects continue to lay the foundation for improving the built environment and extending the longevity of the existing infrastructure. The intent is to help make our roads safer and more efficient, and the results should help do so.

**University of Denver**
The program has contributed to the importance of women in the transportation industry and the importance of fatigue in the transportation industry. . Also identification of effective fatigue countermeasures in the intermodal transportation industry. We have also been working in the area of safety culture and have been giving presentations to persons in Boston and San Francisco for this year.
Overall, we hope to be able to cite instances of the use of key interventions for the improvement of safety culture in transit operations.

**University of Utah**
MPC-542 — Exploratory Modeling and Analysis for Automated Vehicles in Utah
The research will inform the Long Range Transportation plans of UDOT, WFRC, and MAG. It is clear that AVs will integrate into the vehicle fleet over the time frame of the analysis, to 2040. Not accounting for AVs will certainly underestimate future VMT. This research will result in greater certainty surrounding the impacts of AVs on VMT, and may be used to understand future capacity needs, as well as point to operational needs during the transition period when AVs begin getting absorbed into the overall vehicle fleet, but represent small fractions thereof. MPC-544 — Lifecycle Assessment Using Snowplow Trucks' Automatic Vehicle Location (AVL) Data. Class 8 snowplow trucks are the primary tool for clearing snow and delivering the winter maintenance program at the UDOT. The state legislature has allocated an additional $6 million per year to help bring the average age of the fleet from 11+ years old, down to the 4.5 year old target. It is important to document and follow the impact of this $6 million dollar per year infusion of funds into the Class 8 truck replacement cycle. UDOT needs to ensure they are on target and demonstrates full value of the program through transparent evaluation and measurement of the impacts of the funding. MPC-545 — Self-Centering Bridge Bent for Accelerated Bridge Construction in Seismic Regions. New techniques will be developed for seismic resilience.

**Utah State University**
We have had good interaction with the public and some lawmakers on the Electric Vehicle and bridge instrumentation. These opportunities are good for people outside the direct program to gain a better understanding of the value of the program.

**5. Changes/Problems**

**Colorado State University**
MPC-538 Work was delayed as the contract, and fund transfer(Representative Testing of Expansive Soil Treatment Technologies for Transportation Earthworks) was completed. This project will allow testing by a novel, representative, method, and will greatly enhance the potential value of the study. MPC-538 is now moving forward, as will testing for this project.

**University of Colorado Denver**

One project reallocated budget line item for statistical consulting to a student because our math department's statistical consulting services shut down. We hired a math grad student instead and it's all working out great.

**University of Wyoming**
Previous work, Wood (2017) has indicated that the accelerated mortar bar test has provided better results. We are considering exploring this option. Additional Information Regarding Products and Impacts

**5a. Additional Information Regarding Products and Impacts**
Nothing to report at this time.

**PROGRAM OUTPUTS:**
Nothing to report at this time.

**PROGRAM OUTCOMES:**
**Colorado State University**
MPC-534 — Traffic Performance Assessment of Disrupted Roadway Networks Following Earthquakes
This study will help future traffic planning to better respond to earthquake hazards, as well as some other hazards. For the first time, the proposed model can model various disruptions happening on bridges and roads due to various hazards, such as earthquakes. The traffic performance of the disrupted roads and bridges will be further predicted, which has not been conducted before. MPC-537 — Quantifying Mountain Basin Runoff Mechanisms for Better Hydrologic Design of Bridges and CulvertsThe project is likely to produce a better understanding of runoff production mechanisms that are active along the Front Range. In addition, it is likely to produce new modeling methods that capture the relevant mechanisms. The research will be documented in a peer-reviewed paper, and the modeling methods will be made publically available for use by hydrologic engineers working in the fields of transportation and dam safety.

**University of Utah**
MPC-542 — Exploratory Modeling and Analysis for Automated Vehicles in Utah
The outcomes of the project include the following:
1. AV's impact on travel demand from currently mobility-challenged markets – youth and the elderly;
2. AV's impact on travel demand due to the reduced disutility of travel time; and
3. The potential impact on capacity from AV technologies enabling vehicle platooning.
MPC-543 — Big Transportation Data Analytics. Determination of the most effective analytical methods (statistical modeling, machine learning) for predicting traffic volumes and travel reliability on major freeway and arterials within the Salt Lake City metropolitan area.Development of methods for incorporating analytics into UDOT Asset Management and Planning functions (e.g. for HPMS reporting, for estimation of future traffic volumes and reliability). Findings that will inform UDOT into methods for incorporating Big Data analytics into their business enterprises, including supporting the development of a Business Plan/Roadmap for evolving the department to leverage Big Data in the future. MPC-544 — Lifecycle Assessment

**Utah State University**
We have had students supported and will provide lifetime careers in the field of transportation engineering. The impact this will have over the years is difficult to quantify at this point. We are on the leading edge in the electric vehicle area which is really exciting and we are looking for additional opportunities to participate in this area.

**PROGRAM IMPACTS:**
Nothing to report at this time.

**6. SPECIAL REPORTING REQUIREMENTS:** None