TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): __Iowa DOT_____

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *TPF-5(295)*	**Transportation Pooled Fund Program - Report Period:** Quarter 1 (January 1 – March 31, 2016) X Quarter 2 (April 1 – June 30) Quarter 3 (July 1 – September 30) Quarter 4 (October 1 – December 31)
Project Title: Midwest Smart Work Zone Deployment Initiative	

Name of Project Manager(s): Dan Sprengeler	**Phone Number:** 515-239-1823	**E-Mail** Dan.Sprengeler@dot.iowa.gov
Lead Agency Project ID: Keith Knapp	**Other Project ID (i.e., contract #):** Addendum 535	**Project Start Date:** July 1, 2014
Original Project End Date: June 30, 2020	**Current Project End Date:** June 30, 2019	**Number of Extensions:** None

Project schedule status:

X On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$700,000 (committed)	$248,462.85	0

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$97,952.76		0

Project Description:
The Midwest Smart Work Zone Deployment Initiative (MwSWZDI) was initiated in 1999 as a Federal Highway Administration (FHWA) Pooled Fund Study intended to coordinate and promote research among the participating states related to safety and mobility in highway work zones.

The program is an ongoing cooperative effort between State Departments of Transportation, universities, and industry. The studies completed have consisted of evaluations of various work zone related products, various innovative topics, and several synthesis studies. Completed reports and descriptions of ongoing projects can be obtained at the Iowa State University's Institute for Transportation (InTrans) website (www.intrans.iastate.edu/smartwz/) link to the Smart Work Zone Deployment Initiative. InTrans currently operates as the program manager of the pooled fund efforts and completes administrative tasks related to request for ideas and proposals, meetings, project files, quarterly reports, and recommending reimbursement.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Quarter Ending June 30, 2016 (Overall)
During this quarter we communicated with a number of principal investigators as needed. Resolved some progress issues as they occurred. Contracts for Years 2014 and 2015 continued and 2016 projects were started.

Problem statements were requested for Year 2017 and a meeting is being scheduled for the Board..

The following is a summary of accomplishments from April 1 to June 30, 2016 for the Year 2016, 2015, and 2014 individual research projects under fund account TPF-5(295).

2016 Program Projects

- Design Optimal and Effective Queue Detection and Notification: Design of a Low-Cost Work Zone Warning System, University of Wisconsin, Madhav Chitturi as PI.

  Project began June 15, 2016. Have been in communication with TAPCO about design of the low-cost system. TAPCO has developed a potential design already. Reaching out to potential TAC members and will solicit their input on the proposed design. Reached out to WisDOT to identify potential sites for testing and deploying the system.

  Project started on June 15, 2016 and is expected to finish on December 15, 2017. It is 10% complete.

- Understanding the Impact of Work Zone Activities on Traffic Flow Characteristics, University of Missouri-Columbia, Praveen Edara as PI.

  The project kickoff meeting was held on May 25th. Literature review is underway. Activity data is being extracted from several sources including weekly work zone schedules for the St. Louis region. Traffic flow data is being extracted from detectors and travel time data from RITIS/HERE.

  This project started on April 1, 2016 and is expected to finish on October 1, 2017. It is 10% complete.

- Best Practices for Managing Work Zone Data, University of Wisconsin-Madison, Steven Parker as PI.

  Started integrating the feedbacks from the last TAC meeting to the survey design. Started designing survey questions. Will be scheduling a meeting with the panel in late August/early September to review the survey questions before distribution.

  This project started on April 1, 2016 and is expected to finish on March 31, 2017. It is 15% complete.

- Development of a Data Collection Prototype and a Traffic Impact Assessment Tool for Moving Work Zone Operations, University of Missouri-Columbia, Praveen Edara as PI.

  The project kickoff meeting was held on May 25th. Literature review is under way. Data is being collected for moving work zones in St. Louis. Weekly work zone schedules were requested from the TMC in St. Louis.

  This project is 10% complete. The project started on March 15, 2016 and expected to be finished on July 31, 2017.

2015 Program Projects

- Evaluation of Alternative Work Zone Signing, University of Wisconsin – Madison, Madhav Chitturi as PI.

  Literature Review completed.
  Survey protocol approved by IRBs at both UW-Madison and University of Missouri.
  Purchased tablet-PCs for survey.
  Presented the signs being considered in the survey to the TAC.
  Revised the methodology to a 3-stage survey based on ANSI standard.
  Administered stage 1 of the survey at a DMV in Milwaukee.

  Based on ANSI standards, we changed the survey methodology to a 3-stage process. We presented this proposed change to the TAC. We completed stage 1 of the survey and are compiling the results. We are currently programming the tablets to administer the stage 2 of survey. Following this a stage 3 survey will be conducted. At the end of this 3-stage survey, the driving simulator evaluation will be conducted by University of Missouri.

  This project is 35% complete. It is expected to end by August 31, 2016, but a request has been received to extend this project to March 31, 2017. It is under review.

- Developing a Data Driven Traffic Impact Assessment Tool for Work Zones, University of Missouri-Columbia, Praveen Edara as PI.

  Work zone travel time prediction models were developed using work zone data for I-70, I-270, and MO 141 in St. Louis. A prototype tool integrating the prediction model, travel time and work zone data, and work zone location information is under development. The final report documenting the data collection, reduction, and prototype development is being compiled.

  The project is approximately 60% complete. It is expected to end by December 31, 2016.

- Orange Work Zone Pavement Marking Midwest Field Test, University of Wisconsin – Madison, Madhav Chitturi as PI.

  Literature review is completed. We have collected information on standards and specifications of different agencies and also material specifications from different vendors. Met with Wisconsin DOT again to identify

potential sites for field evaluation of orange pavement markings. We have identified a site on I-94 (between Madison and Milwaukee) in Wisconsin. It is expected to be put down in August 2016. We had also been in touch with Pennsylvania DOT for a potential test site. We communicated with WisDOT and FHWA and developed a test plan for the field evaluation. We developed a Request to Experiment and it was submitted to FHWA by WisDOT.

We are currently purchasing and integrating the equipment to collect field data.

The project is still about 20% complete. It is expected to end by September 30, 2016, but a request has been made to extend it to March 31, 2017. It is under review.

- Setting Work Zone Speed Limits, Iowa State University, Anuj Sharma as PI.

  Multiple sources: project reports, 511 messages, workzone crash marker in crash data base were processed to find best estimate of time period when a workzone was active and generate the type of closure.

  Based on these time periods preliminary crash models have been generated for count and severity.

  The same data set is being used to update the speed models.

  Final report is being drafted in parallel with the data modeling activities.

  Data inconsistencies were found about the start and stop dates obtained from multiple sources: project reports, 511 messages, workzone crash marker in crash data base. Even after obtaining a join between the above dates it is very difficult to ascertain the geo-location on lane closure activities. We are currently moving with periods which are consistent across multiple data bases as our study cases. An extension was requested (see below).

  This project started March 15, 2015 and is approximately 94% complete. It was been extended to October 31, 2016 during this quarter. Its original end date was May 31, 2016.

2014 Program Projects

- Safety Assessment Tool for Construction Work Zone Phasing Plans, University of Missouri, Henry Brown as PI.

  Task 6. Development of Assessment Tool
  The development of the user-friendly spreadsheet tool was completed. The spreadsheet collects input data on crashes and work zone characteristics from the user and provides crash frequency and cost by severity as output. The spreadsheet also includes a tutorial to help the user become familiar with how to use the tool. A draft version of the spreadsheet was sent to the TAC for review on January 27, 2016. The TAC provided some suggestions for the tool, and the tool was revised based on the comments from the TAC. The revised spreadsheet tool was then sent for review by the SWZDI Board of Directors. No comments on the tool were received from the SWZDI Board of Directors. The tool has been posted to the SWZDI website.

  Task 7. Draft Report Preparation and Review
  A draft of the final report was prepared and submitted to the TAC on January 27, 2016 for review. Feedback was received from the TAC, and the report was revised based on the TAC feedback.

Task 8. Final Report Preparation
After the report was revised based on the TAC feedback, it was sent to the SWZDI Board of Directors for review on April 8, 2016. No comments on the report were received from the SWZDI Board of Directors. The final report has been processed for publication by SWZDI and is now available on the SWZDI website.

The project is 100 percent complete and the report posted. It had an original end date of December 31, 2015. And extensions to June 30, 2016 were granted.

- Length of Need for Free-Standing, F-Shape, Portable 12.5' Concrete Protection Barrier, University of Nebraska, Ron Faller as PI

Previously, MwRSF completed simulation of impacts on the upstream and downstream ends of the 200 ft long barrier system to determine the length of need. It was determined that three barriers would be recommended for both the beginning and the end of length-of-need for the TCB system, until the results could be further discussed with the TAC.

The next step of the simulation analysis was to conduct impacts at the selected beginning and end of length-of-need lengths for a reduced system length in order to verify that the length-of-need definitions work for shorter lengths and to examine the minimum potential length of the TCB system. Simulation models were evaluated using a seven barrier long TCB system. The results of these models found that the 2270P vehicle was successfully redirected for the seven barrier installation at both the beginning and end of the LON. In both cases, the reduced barrier system increased barrier deflections by approximately 16" over the full-length, 16 barrier system. Additionally, the impact at the end of the LON indicated a potential for the last barrier in the system to rotate rapidly towards the vehicle as it was redirected and impact the vehicle door. Thus, while the vehicle was redirected and the increases in deflections were manageable, the impact of the barrier with the driver side door was a concern.

These findings were discussed in detail at the July 21st TAC meeting in order to determine what the TAC concerns were and what was desired to be investigated through full-scale testing. The TAC indicated that the rotation and impact of the end barrier with the vehicle was a concern and wished to analyze the system with eight barriers, 3 for the beginning of LON, one in the middle, and 4 on the end of the LON. These models were simulated. Again both models successfully redirected the impacting vehicle. The addition of the fourth barrier on the end of LON mitigated the impact of the barriers on the vehicle door. Barrier deflections for impact at the beginning and end of LON for the 8 barrier installation were found to be 94.8 in. and 90 in., respectively. These results were given to the TAC in a meeting on 10-15-15. They concurred that testing should proceed on the 8 barrier installation.

Details for the full-scale crash testing of the 8 barrier installation were developed and sent to the MwRSF Outdoor Testing Facility. Barriers for both full-scale crash tests were fabricated and received. Currently, full-scale testing of the 8 barrier installation will commence as soon as possible within the current MwRSF test queue.
standard TL-3 impact conditions.

In this quarter, MwRSF conducted the full-scale crash testing and evaluation of the reduced system lengths indicated by the simulation analysis. Two full-scale crash tests were conducted.
1. NELON-1 = Test designation no. 3-35 at beginning of LON
2. NELON-2 = Test designation no. 3-37 at end of LON

In test no. NELON-1, the 2270P pickup truck vehicle impacted the eight barrier long PCB system 4.3 ft upstream of the joint between barrier nos. 3 and 4 to evaluate an impact at the beginning of length-of-need. During the impact, the vehicle was safely redirected. The deflection of the barrier system was significantly

higher than previous tests with a 16 barrier long PCB system in terms of both lateral motion and longitudinal motion. A peak dynamic lateral barrier deflection of 128.3 in. was measured in test NELON-1. In addition, it was noted that the increased deflection of the barriers upstream of the impacting vehicle allowed a knee to form at the joint between barrier nos. 5 and 6 that impacted the rear passenger door on the driver's side of the vehicle. While this impact did not create an occupant risk, it was one of the behaviors noted in the simulation analysis that caused concern with reduced length PCB systems.

In test no. NELON-2, the 2270P pickup truck vehicle impacted the eight barrier long PCB system 4.3 ft upstream of the joint between barrier nos. 4 and 5 to evaluate an impact at the end of length-of-need. During the impact, the vehicle was redirected, but increased roll of the vehicle was observed that caused the vehicle to roll over 80 degrees onto the driver side after exiting the system. This vehicle instability exceeded the 75 degree limitation on vehicle roll in MASH, the test result was deemed not acceptable according to MASH TL-3. Examination of the test results are continuing, but two factors are believed to have contributed to the excess roll. First, the reduced length of the PCB system allowed increased deflection of the barrier segments upstream of the vehicle which delayed the tail slap of the back end of the vehicle with the PCB system when compared to previous testing of longer systems. This delay in the impact of the rear of the truck with the PCB system as it was redirected may have provided less lateral support for the truck as it was yawing and rolling, thus allowing for increased roll of the vehicle. A second factor that may have contributed to increased vehicle roll was the formation of a knee between barrier nos. 6 and 7. Similar to test no. NELON-1, a knee formed between barrier nos. 6 and 7 in test no. NELON-2 that extended forward and impacted the rear of the front fender as well as the driver door and the rear passenger door on the driver's side of the vehicle. The lateral loading of side of the vehicle by the knee in the barrier system may have increased vehicle roll and instability.

Preliminary review of the review of these two tests suggests that defining a minimum of 3 barriers for the beginning of length-of-need for an 8 barrier long system was acceptable, but that 4 barriers for the end of length-of-need was insufficient. Thus, an eight barrier system length is not acceptable. However, the use of a 9 barrier system with 3 barriers for the beginning of length-of-need, 1 barrier in the length-of-need, and 5 barriers for the end of length-of-need would be sufficient. We can extrapolate that this system would be successful because test no. NELON-1 worked with and 8 barrier long system with 3 barriers for the beginning of length-of-need and 5 barriers downstream of impact. Thus, it would stand to reason that a 9 barrier long system should perform equally well if the end of length-of-need is defined as 5 barriers at minimum.

Following the full-scale crash tests, the researchers have conducted simulations of both crash tests to calibrate the models to the dynamic deflection observed in the tests. These calibrated models are completed and models to estimate barrier deflections for intermediate lengths under MASH TL-3 impact conditions are currently being simulated and compiled. In addition, the final report for the research has been partially completed with details from the full-scale testing. Details of the simulation efforts will be added in the upcoming quarter.

The remaining work for the project will consist of additional simulation analysis and reporting. Simulations investigating the 85% impact severity on both the standard length and reduced length systems will be performed.

The summary report of the research including the analysis, full-scale crash testing, and conclusions and recommendations is currently underway and will continue in the upcoming quarter.

This project is 75 percent complete and had an initial end date of December 31, 2015. An extension to December 31, 2016 has been granted.

- Development of a TL-3 Transition between Temporary Concrete Barrier and Guardrail, University of Nebraska, Ron Faller as PI

  Previously, MwRSF conducted all three of the full-scale crash tests for evaluation of the MASH TL-3 guardrail to PCB transition system. The test matrix is listed below.

  1. MGSPCB-1 - Test no. 3-21 - Impact of the 2270P vehicle on the centerline of the fifth guardrail post upstream from the end-shoe attachment at a speed of 62 mph and an angle of 25 degrees.
  2. MGSPCB-2 - Test no. 3-21R - Reverse direction impact of the 2270P vehicle 12 ft – 6 in. upstream from the end-shoe attachment at a speed of 62 mph and an angle of 25 degrees.
  3. MGSPCB-3 - Test no. 3-20 - Impact of the 1100C vehicle on the critical impact point of the guardrail to PCB transition at a speed of 62 mph and an angle of 25 degrees. MASH procedures and engineering analysis will be used to determine the critical impact point.

  All three of the full-scale crash tests successfully met the MASH TL-3 criteria. Thus, the system evaluation was completely successful. Currently, MwRSF is in the process of compiling the test report and recommendations for the implementation of the design. MwRSF was unable to complete the summary report prior to the original project end date of 12/31/15. Thus, a no-cost project extension was requested and granted.

  A TAC meeting was held on 10-15-15 to update the project status and review the full-scale crash test results.

  During this quarter, MwRSF has continued to compile the research report evaluating the three successful crash tests. The initial draft of the report was reviewed and edited by the PI this quarter and secondary edits are in progress. Guidance for implementation of the new system were also developed and added to the report. Submission of a TRB paper for the 2017 meeting is also planned.

  In the upcoming quarter, MwRSF will continue efforts to complete the research report summarizing the testing and evaluation of the guardrail to PCB transition. Additionally, the project team will prepare a technical brief as well as a summary presentation of the research results for the TAC.

  This project is 85 percent complete and had an original end date of December 31, 2015. An extension to December 31, 2016 has been granted.

Anticipated work next quarter:

Work will continue on contracted projects. Problem statements will be chosen and a meeting held to select those to include in the 2017 RFP. The Program Year 2017 RFP will be distributed and proposals gathered.

Significant Results:

Program Year 2016 project were contracted.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Currently there are no problems to report with the administrative contract. Any issues that have come up with the individual projects that may impact schedule or budget are resolved on a case by case basis.

Potential Implementation:

One project was finished and posted this quarter.