Semi-Annual Progress Report for University Transportation Centers

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- **Program Director (PD) Name, Title, and Contact Information**
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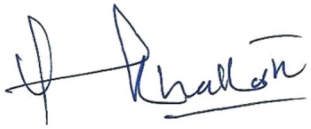

Aemal Khattak, MATC Director

1. ACCOMPLISHMENTS

What are the major goals of the program?

The major goals of the Mid-America Transportation Center (MATC), which were outlined in the MATC proposal, are indicated in the table below. Activities related to research, education, technology transfer, and USDOT requirements are well underway. Please refer to the table below for an update on the status of each activity.

Table 1: Status of MATC's Research, Educational, and Technology Transfer Activities and Reporting Requirements

Research Activities	**Status**	**Percent Completed for Years 1-6**
Call for Problem Statements	On Schedule	100%
Request for Proposals	On Schedule	100%
Final Proposal Ranking & Selection	On Schedule	100%
Data Management Plan (DMP) - Overarching Plan for MATC	On Schedule	100%
Collect DMPs from PIs for Individual Research Projects	On Schedule	82%
Collect ORCIDs from all MATC Researchers	On Schedule	71%
Submit Project Descriptions to TRB's RiP Database	On Schedule	100%
Submit Final Research Reports	On Schedule	75%
Collect & Store Final Data in UNL Data Repository	On Schedule	100%
Education and Outreach Activities		
Grad/Undergrad MATC Course Development & Implementation	In Process	25%
MATC Undergraduate Summer Internship Program	On Schedule	100%
MATC Scholars Program	On Schedule	100%
MATC/UTC Outstanding Student of the Year	On Schedule	100%
MATC Roads, Rails, and Race Cars After-School Program	On Schedule	100%
MATC/NCIA Sovereign Native Youth STEM Leadership Academy	On Schedule	100%
MATC Summer Institute	In Process	75%
MATC Research Experience for Undergraduates (REU) Program	On Schedule	100%
MATC Joint Activities with Student Chapters	On Schedule	100%
Technology Transfer Activities		
Technology Transfer Plan – Overarching Plan for MATC (Approved October 19, 2018)	On Schedule	100%
Collect Tech Transfer Plans from PIs for Individual Research Projects	On Schedule	59%
Technology Transfer Tech Briefs, Webinars & Presentations on Research Results	On Schedule	100%
Roadside Safety Short Course (UNL)	On Schedule	100%
Roadside Safety Workshop (UNL)	On Schedule	100%
Traffic Safety Classes (KU)	On Schedule	100%
Structural Condition Assessment Short Course (MS&T)	On Schedule	20%

LTAP Workshop	On Schedule	100%
USDOT OST-R Reporting Requirements:		
Federal Financial Reports	On Schedule	100%
Post Research Project Descriptions on MATC Website	On Schedule	100%
UTC Program Progress Performance Reports (Semi-annually)	On Schedule	100%
Annual Performance Indicators Reports	On Schedule	100%
Additional USDOT OST-R Requirements:		
Establish and Maintain Center Website	On Schedule	100%
Directory of Key Center Personnel	On Schedule	100%
Attendance at UTC Grantees' Meetings	On Schedule	100%

What was accomplished under these goals?

Research Activities

Although hindered by the COVID-19 Pandemic, all research activities have continued and the following research activities were accomplished during the reporting period of April 1, 2022 – September 30, 2022.

USDOT funding research projects through MATC are committed to having a sustained impact on the transportation system through technology transfer and workforce development efforts. Principal Investigators (PIs) have either submitted or are in the process of completing Data Management and Technology Transfer Plans for their individual research projects, which are in accordance with USDOT requirements and the Center's overarching plan. For example, under the direction of Dr. Li Zhao from the University of Nebraska-Lincoln (UNL), MATC researchers identified and developed several different signal control techniques between Driveway Assistance Device (DAD) signals for single or multiple driveways and mainline temporary traffic signals. Based on the preliminary research, it was found that the signal timing technique is one of the important contributing factors to the operational impacts of the DAD system and driver compliance rate along with other factors, such as traffic volume (e.g., mainline and driveway(s)), work zone length, and number of DADs).

As of this reporting period UNL, University of Nebraska-Omaha (UNO), and the University of Nebraska Medical Center (UNMC) currently have twenty (20) active USDOT-MATC funded projects, supported by thirty-two (32) PI's and Co-PI's. The University of Iowa (UI) currently has five (5) ongoing USDOT-MATC funded projects, supported by eight (8) PI's and Co-PI's. The University of Kansas (KU) and University of Kansas Medical Center (KUMC) currently have six (6) ongoing USDOT-MATC funded projects, supported by eleven (11) PI's and Co-PI's. The Missouri University of Science & Technology (MS&T) currently has eighteen (18) ongoing USDOT-MATC funded projects, supported by eleven (11) PI's and Co-PI's.

Throughout the reporting period, individual project PIs from Nebraska, Iowa, Kansas, and Missouri submitted quarterly reports detailing the progress, activities, and outcomes of their individual research projects. Some of the accomplishments reported by PIs are outlined below.

Specific Research Objectives, Significant Results, and Key Outcomes

In addition to ongoing extensive literature reviews, experiment development, data collection, and data analysis, MATC Researchers reported the following project objectives, results, and key outcomes for this reporting period.

At the University of Iowa, PIs Ann Campbell, George Constantinescu, Witold Krajewski, Salam Rahmatalla, and Albert Ratner worked hard to meet the deliverables of their ongoing research projects.

In a research project titled *Transportation Planning with Floods*, Dr. Campbell worked on a network design problem that maximized the improvement in accessibility and travel times between population centers and health care facilities subject to a given budget. They finished developing techniques for reducing the problem size to help make the problem tractable. For computational experiments, they utilized a dataset representing two road transportation networks of two cities, Coralville and Fort Dodge, in the state of Iowa. They used these two cities as samples of road networks of different sizes with different numbers of HCFs. They computationally explored the performance of their solution techniques on the CPU runtime in both cities to evaluate the effectiveness of proposed improvements, including network pruning techniques, variable elimination methods, creation of an initial feasible solution, and valid inequalities. They reported the most powerful methods among their proposed improvements in terms of impact on the number of eliminated decision variables.

For the case study, they examined the results for the city of Coralville in more detail. They specified the vulnerable roads having the highest frequency in upgrading and reported their features. Next, by looking at each parameter's effect on the results and objective value, they tested different policies to provide decision-makers with managerial insights for building mitigation strategies.

The team demonstrated that the roads consistently selected for being upgraded are mostly the residential roads that guarantee accessibility within residential areas, even if they are far from HCFs. While a substantial number of papers in the literature define the available budget levels as the total number of upgradeable roads, results revealed the flaw in those methods by showing that upgrading more miles of roads does not always yield a larger number of roads.

In a project titled *Development of new design guidelines for protection against erosion at bridge abutments and embankments*, Dr. Constantinescu finished the matrix simulations of simulations conducted for flow in a straight channel containing a wing-wall abutment using a deformable free surface algorithm. The matrix of simulations contained cases with free surface or non-pressurized flow (FS) regime, submerged orifice (SO) regime and overtopping (OT) regime. For the pressurized cases, simulations were also conducted with the same incoming flow depths but without a bridge deck to be able to quantify the effect of pressurized flow conditions beneath the bridge deck on the critical discharge and critical Froude number corresponding to shear failure of the riprap stone. Most of this quarter was devoted to analyzing this data and investigating how the critical discharge/critical Froude number corresponding to entrainment of riprap stone of a certain size varied with increasing water elevation upstream of the abutments and with varying median diameter of the riprap stone.

In a project titled *Real-time Flood Forecasting for River Crossings*, Dr. Krajewski successfully transferred their HLM knowledge to the researchers at the University of Nebraska during the last months. During the last quarter, they successfully executed HLM with the snow module included in the Elkhorn River

Watershed (Nebraska). To test the model, researchers ran it using Stage IV rainfall and local temperature records for the event recorded during the early Spring of 2019. Dr. Krajewski has also been developing a strategy to perform data assimilation (DA) upstream of a gauged reach. The DA uses streamflow data to estimate the routing parameters v_0 and λ_1 (Mantilla, 2007). To test the algorithm, they created a hypothetical scenario where the routing parameters randomly change inside the Skunk River Watersheds (Iowa). Then, they obtained synthetic streamflow observations at the outlet running HLM for the hypothetical scenario. Finally, they used the Ensemble Kalman Inversion (EKI) approach to guess those parameters using only the synthetic streamflow.

In a project titled *Infrastructure Inspection During and After Unexpected Events – Phase V*, Dr. Rahmatalla's development of a small-scale bridge superstructure model inside a commercial software ANSYS is ongoing. These simulations are intended to aid in the design and construction of a simplified physical model. Overall dimensions will include a span of 24 inches and breadth of 12 inches. Current analyses are focused upon refinement of the mass and stiffness distributions, as well as the selection of boundary conditions. Presently, fixed-fixed boundaries are preferred as a surrogate for a single segment of a multi-span bridge. Preliminary analyses demonstrate hydrodynamic added mass ranging from 1,100% to 300% of the structural modal mass for like mode shapes when the bridge is fully inundated. These results demonstrate up to an eleven-fold increase in the effective modal mass for low order modes, resulting in a 72% reduction in the associated natural frequency. It should be noted that the results shown do not include additional mass that will eventually be distributed along the deck. As a result, the resonant frequencies are unrealistically high at present. Once additional structural mass is installed, resonant frequencies will fall and the values of the hydrodynamic added mass ratios will be somewhat reduced. Nonetheless, the fact remains – the fluid added mass can easily dominate that of the structure itself.

In a project titled *Reducing Flammability for Bakken Crude Oil for Train Transport*, Dr. Ratner continues to generate combustion data from the colloidal suspensions of nanofuels (single component surrogate fuels: n-dodecane, n-Hexadecane, Iso-cetene, Decalin, Toluene), made using carbon-based nanomaterial (Carbon dot), using the droplet combustion setup. Experiments are completed for n-Hexadecane based nanofuels. Data analysis is in progress for n-Hexadecane based nanofuels.

At the University of Kansas (KU) and University of Kansas Medical Center (KUMC), PIs Steven Schrock, Mario Medina, Christopher Depcik, Alexandra Kondyli, William Collins, and Shelley Bhattacharya worked hard to meet the deliverables of their ongoing research projects.

In a research project tilted *Low cost 3-D LIDAR Development for Transportation*, Dr. Christopher Depcik worked to finalize the physical design of the LIDAR prototype and began preparing the final report. Additionally, the team evaluated a depth estimation approach on real-world data and had issues integrating the RGB sensor into existing MATC system; therefore, the experiment was conducted solely on RGB-D sensor to demonstrate the feasibility of depth estimation in real-time application. Data is collected from Wichita State University campus from both indoor and outdoor environments. The main difficulties for integrating external information, such as RGB into single-point LiDAR system, are scene scale and frequency. First, the average time for single-point LiDAR to capture a full scene is not sufficient for RGB integration. Second, the scale of capturing scene in RGB is different from single-point LiDAR.

The integration requires RGB and depth to be not only on the same size, but on the same view perspective (which is defined using intrinsic parameters in the camera).

In a research project conducted by Dr. Bhattacharya at KUMC titled *Assessing and Improving the Cognitive and Visual Driving Fitness of CDL Drivers*, her team conducted the battery of cognitive and visual tests on the current Year 1-3 subjects requested annual driving record data for all subjects, without risk of penalty; collected baseline data on the task-evoked pupillary response (TEPR) reflex; provided subjects options for rehabilitation of cognitive, visual and TEPR tasks performed sub-optimally; and performed rehabilitative tasks as appropriate. The team has discovered that subjects were reluctant to return for their year 2 and 3 visits, therefore they had continued recruiting year 1 subjects until August 30, 2021. A total of thirty-two (32) subjects have been tested for their Year 1 assessment, ten (10) for Year 2, and five (5) for Year 3.

At the Missouri University of Science and Technology (MS&T), PIs Genda Chen, Steven Corns, Mohamed ElGawady, Xianbiao Hu, Suzanna Long, Chenglin Wu, and Guirong Yan worked hard to meet the deliverables of their ongoing research projects.

In a research project titled *Deep Learning for Unmonitored Water Level Prediction and Risk Assessment*, information from upstream and downstream gauges previously collected by Dr. Steven Corns was included in the prediction algorithms along with rainfall data and historical rainfall and gauge height information. Algorithms now account for the major factors affecting gauge height. Predictions are being verified using actual gauged areas. Deep learning methods are providing useful results for predicting gauge height. Predictions that do not use any gauge height information in the training have also been created and will be validated. They are conducting research to create predictive tools to monitor areas reported as important for public safety by Missouri First Responders. This research will give first responders and emergency personnel the tools they need to protect the public from flood/flash flood events.

In a project titled *Transportation Safety Training in Rural Areas: An Exploration of Virtual Reality and Driving Simulation in Driver Response and Awareness*, virtual reality driving environments conducted by Dr. Suzanna Long comprising different road scenarios and hazards were evaluated for adaptability and usability. To conduct this research, a model of Route N in Crawford County was developed to include a few hazards peculiar to this route. The route and conditions were selected from inputs from Subject Matter Experts. The hazards include snow fall, flooding, animal crossing, and night driving.

Flood Scene: based on periodic occurrence and recommendations, two locations on the simulated road with periodic flooding were modeled. They include Route N at Blue Spring and Route N at White Creek.

Snow Fall Scene: a simulated heavy snow fall was created throughout Route N to evaluate drivers' behavior during such inclement weather conditions.

Animal Crossing: Vehicle-Animal collision is also a threat to safety in rural areas and during a short trip to Bourbon, researchers witnessed some deer crossing and are currently working on a creating a different virtual environment involving animal crossing for the experiment.

Night/Darkness: the last driving scenario of interest is driving through the dark to investigate the connectedness of visibility at night with road accidents in rural areas.

At the University of Nebraska-Lincoln (UNL), University of Nebraska-Omaha (UNO), and the University of Nebraska Medical Center (UNMC), PIs Aemal Khattak (MATC Director), Jongwan Eun, Ronald Faller, Ann Fruhling, Congrui Jin, Daniel Linzell, Sharon Metcalf, Mojdeh Asadollahi Pajouh, Tirthankar Roy, Chung Song, Joshua Steelman, Cody Stolle, Eric Thompson, Ernest Tufuor, Christine Wittich, Richard Wood, and Li Zhao worked hard to meet the deliverables of their ongoing research projects.

In a research project conducted by Dr. Eun titled *Assessing Performance of Geosynthetic Reinforced Pavement with a Large-Scale Track Wheel (LSTW) Test and Nondestructive Testing Tools*, the outer contractor installed a high voltage outlet and wiring cables to operate the motor of a large-scale track wheel (LSTW) testing apparatus at the PKI structural laboratory. There was an issue regarding the motor and electrical controller. Because of this issue, the actual testing was delayed. Additionally, the team will plan the instrumentation for the test. The team originally anticipated completing the fabrication of the apparatus by summer of 2021, but it is delayed because of other ongoing tests at the PKI structural lab. Also, due to the installation of a high voltage outlet to run the motor, the test has been delayed. Also, due to the global supply chain's problem, the material unit price and labor fee were increased a lot. This situation has affected the preparation of the test. Furthermore, due to the supply chain's problem, the ordered items were delayed. The team will keep establishing a detailed plan to implement sensors and monitor various variables.

In a research project conducted by Dr. Linzell titled *Protecting Critical Civil Infrastructure against Impact from Commercial Vehicles – Phase III, A Systems Based Approach Including Fire*, the following tasks were initiated/completed during the reporting period:

- Expanded investigations into fire/temperature effects on performance of bridge system supporting units subjected to impact and blast;
- Computed displacement response for RC bridge column subjected to combinations of fire, impact, and blast;
- Investigated column failure patterns and crack propagation for thermally damaged column subjected to impact and blast;
- Assessed column residual capacities; and
- Conducted parametric studies investigating effects of column's diameter, fire duration, and exposure conditions on isolated column response.

In this reporting period, a previously developed multi-step analysis approach was implemented to examine the response of structural elements to the multi-time scale problems resulting from the dynamic impact and blast loads and the quasi-static fire load. Consequently, developed models were used to examine the effects of vehicular impact and coupled with air blast followed by fire on the performance of RC bridge columns. Results obtained from structural analyses involving impact and blast were used as input to the subsequent three-dimensional heat transfer\fire analyses utilizing Interface-springback LS-DYNA's command. In the second analyses stage, strength reduction in the concrete and steel reinforcement due to fire was defined based on the maximum temperature they experienced according to Eurocode 2 and 3 reduction factors. Damage propagation, lateral displacement, final damage states, and residual capacities resulting from applying fire after impact and blast was compared to the case in which fire was applied initially and the case that involved only impact and blast for all column diameters and the following was observed:

- As expected, for a given impact speed and set standoff distance, longer fire duration contributed to more significant damage. Flexural-shear cracks and concrete spalling were observed in all cases; however, their severity increased with increasing fire duration and when the fire was applied to the

column's entire surface area. Irrespective of exposure condition, a 90-minute duration resulted in the largest lateral deflections. Moreover, for given exposure condition, more severe crack propagation and spalling was observed in the case of 750 mm diameter column.

- For the 750mm column, more significant shear cracking and core breach was observed when fire was applied after impact and blast compared to the case where fire was applied first.
- Based on the final damage states, lateral displacements, and residual axial load carrying capacities, fire prior to impact and blast created a more critical load sequence for the 1050 mm and 1350 mm columns that were studied. On the other hand, post impact and blast fire exposure was the critical loading condition for the 750 mm columns studied.

In a research project conducted by Dr. Fruhling titled *Real-Time Emergency Communication System for HAZMAT Incidents (REaCH)*, the team conducted a number of experiments:

- For lab experiments with multiple devices and sensors to the REACH system, the system test went well and data transmission was correct. This successful lab experiment is the foundation for a future field test. ECG data was correctly captured and displayed.
- Continued discussions with Makusafe.com, a business from Iowa with whom they are working on completing an NDA and discussing technology innovation collaboration.
- Developed a survey to collect feedback from professional truck drivers on their potential use of wearable technology to monitor their environment and health. The survey has been validated by experts from law enforcement and the trucking industry across the United States. The survey was implemented through Facebook Ads and email lists at trucking companies.
- Prototyped a computational approach to analyze data obtained from the Polar H10 device. The data contains both heart rate information and RR intervals (i.e., the time between two successive R-waves in the QRS complex of the electrocardiogram). RR intervals can be used to compute heart rate variability (HRV), a measure that is associated with overall cardiovascular health. In order to prototype their code, the team is working with a publicly available dataset of RR intervals obtained from PhysioNet (https://physionet.org/content/?topic=rr+interval). The dataset contains RR intervals obtained over a 24-h period for 54 healthy subjects and 29 patients with congestive heart failure. The dataset will allow them to determine how well HRV can discriminate between healthy individuals and patients with heart failure. Furthermore, the data will also be useful to benchmark the dashboard and for demonstration purposes. They prototyped a simple Machine Learning model based on Decision Trees to discriminate between healthy subjects and patients with heart failure. The model incorporates several published measures of heart rate variability as well as heart rate, and had a cross-validated accuracy of ~80%.
- Began research comparing health behavior monitoring attitudes between first responders and professional drivers since both groups of individuals could potentially be involved in a HAZMAT transportation incident.

Education and Outreach Activities

MATC has implemented several educational outreach programs in support of USDOT's Strategic Plan and the center's mission to increase the number of students from underrepresented groups in STEM education and transportation-related careers. Descriptions of each educational program and the activities that took place during April 1, 2022 through September 30, 2022 are detailed below.

MATC After-School Program - Road, Rails, and Race Cars (RRRC)

MATC's after-school program combines the talents of 4-12th grade teachers, engineering graduate and undergraduate college and university student mentors, and professional and industry partners to educate the diverse leaders of tomorrow about STEM principles. Each participating school offers the club for an hour every week. Mentors present on an engineering or transportation-related topic and lead students in an interactive activity that encompasses the concepts of the lesson. Examples of activities include constructing bridges and conducting strength tests, creating towers that can withstand simulated earthquakes, and building racecars powered by potential energy stored in a rubber band.

The reporting period of 4/1/2022 – 9/30/2022 coincides with the continuing COVID-19 pandemic community restrictions. The pandemic has caused school closures and restrictions on access to school sites at most of our nine (9) locations in four (4) cities across Nebraska. However, a limited number of sites implemented RRRC on an intermittent basis, combining in-person and online lessons with materials supplied by MATC staff. The programming details are as follows.

Spring 2022 Programming
The spring semester portion of RRRC was implemented at three (3) sites in Lincoln, NE: Mickle Middle School, Park Middle School, Saratoga Elementary School; and one (1) site in Macy, NE: Omaha Nation Public School. Weekly implementation was carried out on-site, with MATC's Education and Outreach Coordinator leading clubs. Clubs were scheduled to begin in each school's third quarter, but due to the outbreak of the Omicron variant in early 2022, clubs were postponed until fourth quarter.

For the Spring 2022 semester, RRRC at Park Middle School was offered on Wednesdays from 3:15 p.m. to 4:15 p.m. A total of six (6) implementation dates were completed during the reporting period between March 31, 2022 and May 18th, 2022, with the total attendance being sixty-three (63) by twelve (12) students. The curriculum included activities related to earthquake engineering, art, and engineering.

For the Spring 2022 semester, RRRC at Mickle Middle School was offered on Thursday from 3:15 p.m. to 4:15 p.m. A total of six implementation dates were completed during the reporting period between March 31, 2022 and May 19th, 2022, with the total attendance being 6 by 1 student. The curriculum included activities related to earthquake engineering, art, and engineering.

For the Spring 2022 semester, RRRC at Omaha Nation Public School was offered on Tuesdays from 3:45 p.m. to 5:15 p.m. A total of four (4) implementation dates were completed during the reporting period between March 31, 2022 and May 17, 2022. The curriculum included activities under the topics of civil engineering and buoyancy.

For the Spring 2021 programming, RRRC employed: one (1) Education and Outreach Coordinator, and three (3) on-site teachers. Additional RRRC tasks completed included revising existing lessons and activities, developing an online curriculum of lessons and activities, and coordinating with teachers and CLC staff.

Fall 2022 RRRC Programming
During the reporting period, no in-person RRRC occurred at any participating sites. Clubs will resume in the 2nd Quarter of the Fall 2022 semester at three (3) sites in Lincoln, with the possibility of

implementation outside of Lincoln, NE. Updates on club activity will be included in the upcoming quarterly report.

MATC Sovereign Native Youth Leadership Academy (SNYLA)

The MATC Sovereign Native Youth STEM Leadership Academy is a six-day summer program held on the University of Nebraska-Lincoln campus. The mission is two-fold: 1) to provide an extended learning opportunity in science, technology, engineering, and math (STEM) subjects, and 2) explore a wide-range of postsecondary education and career options after high school.

The Summer 2022 Summer Academy marked the return to an in-person event post coronavirus. High School students were hosted on the campus of University of Nebraska-Lincoln from Sunday, June 26th to Friday, July 1st and chose which activities to participate in. This year's program theme reflects commitment to the Seventh Generation Principle. This is a forward-looking principle held by many Indigenous peoples that decisions today should benefit seven generations into the future. The activities throughout the week strengthen values that students can take forward into their own lives and communities.

Thirty-three (33) students, grades 9-12 attended, from urban, rural, and reservation schools; one (1) teacher from the Umo^{n}ho^{n} Nation Public School, and two (2) teachers from Santee Community School were Academy Teachers, seven (7) undergraduate students were Student Mentors; MATC Staff participation included MATC Director, Education and Outreach Coordinator, Graphic Designer, Event Coordinator, IT Specialist, and Editor. Non-MATC participation included the NCIA Executive Director, and numerous UNL and non-UNL collaborators.

MATC Scholars Program

The MATC Scholars Program is a multi-day conference that brings students from underrepresented groups together with diverse faculty. MATC's Scholars Program fills an existing gap for minority students by encouraging them to attend graduate school and teaching them necessary skills to succeed in obtaining graduate degrees in their chosen STEM-related fields. Students from historically black colleges and universities, tribal colleges, and other minority-serving institutions across the country are given the valuable opportunity to network and attend seminars led by experienced faculty members and educational administrators at the University of Nebraska-Lincoln campus.

The Spring 2022 Scholars Program for Tribal College and University (TCU) students was scheduled to be held on the campus of the University of Nebraska-Lincoln during March 23-25, 2022. Given concerns for the recent outbreak of Covid-19 variants and resulting travel restrictions, it was decided to postpone the program until October 5-7, 2022. Logistics, preparation, and recruiting were carried out during the reported period. Details on the program will be included in the upcoming quarterly report.

MATC Intern Program

The MATC Intern Program partners with private companies, local government, and academia to provide undergraduate students with paid summer internship opportunities in the transportation and engineering fields. During this 12-week program, students gain hands-on experience in their area of interest under the mentorship of a professional. Students work 40 hours per week while experiencing the day-to-day tasks and responsibilities of their desired career. The program culminates in a written paper and presentation detailing the student's internship experience.

The 2022 program took place from May 23 – August 12, 2022. Six (6) UNL undergraduate students were hired to complete internships with five (5) sponsoring organizations; Benesch, Nebraska Department of Transportation, JEO-Omaha, the City of Lincoln, and Felsburg, Holt & Ullevig.

A 2022 kick-off meeting and orientation was held on Friday, May 20, 2022. Individual internships were conducted as prescribed by the sponsor.

The 2022 program culminated in a closing ceremony held on August 12, 2022. Each of the interns gave a PowerPoint presentation to supervisors and fellow interns about what they accomplished and learned over the summer. To view past interns' reports, visit http://matc.unl.edu/internship/internship_success.php.

MATC Summer Institute

MATC is actively working to expand the MATC Summer Institute, which unites transportation professionals and K-12 educators to develop classroom materials based on transportation research at the member institutions. Teachers work closely with both MATC faculty and graduate students to develop grade-level-appropriate transportation-oriented lesson plans. These lesson plans meet all state curriculum standards, and are available on the MATC website for any interested teacher to utilize. MATC is committed to working with middle- and high-school math, science, and industrial technology teachers from schools that have significant populations of underrepresented groups.

MATC Research Experience for Undergraduates (REU)

MATC was not able to support an REU student during this reporting period. We are reviewing undergraduate options and hope to support a summer 2023 MATC REU student.

How have the results been disseminated?

MATC staff continue to maintain individual project records on the Transportation Research Board's Research in Progress (RiP) database and on MATC's online database at http://matc.unl.edu/research/research_search.php. Links to the individual RiP and TRID records are provided on their corresponding project page in the MATC research database.

MATC projects are committed to having a sustained impact on the transportation system through technology transfer and workforce development efforts. MATC PIs are developing technology transfer plans for their individual projects to ensure transferability of their research to other regions. For example, recent technology transfer plans include projects focusing on infrastructure inspections during and after unexpected events, and protecting critical civil infrastructure against impact from commercial vehicles.

MATC Research Webinars

No USDOT funded research webinars were hosted by MATC during this reporting period. Previously hosted webinars are uploaded to the MATC YouTube channel (https://www.youtube.com/user/MidAmericaTrans/videos) with full research briefs and presenter bios available on the MATC website (http://matc.unl.edu/webinarseries.php).

2. PARTICIPANTS & COLLABORATING ORGANIZATIONS

What organizations have been involved as partners?

During the reporting period, MATC worked with forty (40) organizations to develop and implement research, education, and technology transfer activities. Each organization and its location are listed in Table 2 along with information describing the specific area or capacity in which the respective organization is committed to supporting the center.

Table 2: MATC Partners and Type of Collaboration

MATC Program Affiliation	Organization Name	City	State	Financial	In-Kind Support	Contribution Facilities	Collaborative Research	Personnel Exchanges
All Programs	University of Nebraska-Lincoln	Lincoln	NE	X	X	X	X	X
All Programs	Nebraska Transportation Center	Lincoln	NE		X	X	X	X
Roads, Rails, and Race Cars Program (RRRC)	Culler Middle School	Lincoln	NE		X	X		
RRRC	Mickle Middle School	Lincoln	NE		X	X		
RRRC	Park Middle School	Lincoln	NE		X	X		
RRRC	Umó^{N}ho^{N} Nation Public School	Macy	NE	X	X	X	X	
RRRC; Academy	Lincoln Public Schools	Lincoln	NE	X			X	
RRRC; Academy	Winnebago Public School	Winnebago	NE	X	X	X	X	
RRRC; Academy	Santee Community School	Santee	NE	X	X	X	X	
RRRC; Academy	Nebraska Indian Community College	Macy	NE	X			X	
Academy	University of Nebraska Medical Center	Omaha	NE	X		X		
Academy	Little Priest Tribal College	Winnebago	NE				X	
Academy	Claire M. Hubbard Foundation	Omaha	NE	X				
Academy	National Institutes of Health (Worlds of Connections)	Lincoln	NE	X				
Academy; Scholars	Nebraska Commission on Indian Affairs	Lincoln	NE				X	

Intern Program	City of Lincoln LTU Traffic Engr	Lincoln	NE		X	X		
Intern Program	City of Omaha Public Works	Omaha	NE		X	X		
Intern Program	Nebraska Department of Transportation	Lincoln	NE	X	X	X		
Intern Program	Felsburg Holt & Ullevig	Omaha	NE		X	X		
Intern Program	JEO Consulting Group	Omaha	NE	X		X		
Intern Program	Alfred Benesch & Co.	Omaha	NE	X		X		
Research	KUMC Research Institute	Kansas City	KS	X				
Research	Durham Buses	Kansas City	KS	X				X
Research	Wichita State University	Wichita	KS				X	
Research	Alaska DOT & Public Facilities	Juneau	AK					
Research	Iowa DOT	Des Moines	IA	X				
Research	Kansas DOT	Kansas City	KS	X				
Research	Missouri DOT	Jefferson City	MO	X	X		X	
Research	Virginia DOT	Richmond	VA			X		
Research	Utah DOT	Salt Lake City	UT			X		
Research	U.S. Geological Survey	Rolla	MO		X	X	X	
Research	National Weather Service	Springfield	MO		X	X	X	
Research	Iowa Flood Center	Iowa City	IA		X	X	X	
Research	University of Iowa Computer Science Department	Iowa City	IA			X	X	
Research	University of Iowa Hydroinformatics Lab	Iowa City	IA			X	X	
Research	United States Army Corps of Engineers	Kansas City	MO		X	X	X	
Research	United States Army Corps of Engineers	Washington	DC				X	
Research	Santa Catarina State University	Florianópolis	Brazil		X			
Research	Marshall University	Marshalltown	WV		X			
Research	FARO Technologies, Inc.	Lake Mary	FL		X			

3. OUTPUTS

In the center's overarching Technology Transfer Plan, MATC identified three performance measures and three corresponding goals related to the outputs, or products, resulting from research and development activities. Table 3 contains a description of each performance measure, the associated goal, and the center total for the reporting period.

Table 3: Performance Measures, Goals, and Totals for MATC Outputs

	Performance Measure	Description	Goal	Center Total for April 1, 2022 – September 30, 2022
Output 1	Products and Processes	Quantity of new or improved processes, practices, technologies, software, training aids, or other tangible products.	Thirty (30) new products and processes by the end of the grant period.	Zero (0) MATC is on schedule to develop new and improved processes, practices, technologies, and other products by the end of the grant cycle.
Output 2	Technical Communications	Number of technical communications (journal papers, conference papers, final reports, etc.).	Fifteen (15) technical communications each year of the grant period.	Twenty-four (24) During the reporting period, sixteen (16) peer reviewed journal papers and; eight (8) conference papers/presentations were submitted/published/given.
Output 3	Outreach Activities	Number of outreach activities (webinars, social media, workshops, newsletters, and presentations, etc.).	Fifteen (15) outreach activities for each year of the grant period.	Eleven (11) During the reporting period, eleven (11) websites and social media platforms were utilized.

Publications, conference papers, and presentations

Journal Publications

1. Alabbad, Y., J. Mount, A. M. Campbell, and I. Demir, "Assessment of transportation system disruption and accessibility to critical amenities during flooding: Iowa case study," *Science of The Total Environment*, (2021): 148476.
2. Alomari, Q. and D. Linzell, "Bridge Pier Column Multi-Hazard Response – Fire, Impact and Blast. In Bridge Safety, Maintenance, Management, Life-Cycle, Resilience and Sustainability: Proceedings of the Eleventh International Conference on Bridge Maintenance, Safety and Management," *CRC Press*, (June 2022): 2276, IABMAS (conference), Barcelona, Spain, (July 11-15, 2022).
3. Alomari, Q. and D. Linzell, "Computational Investigation of the Combined Effects of Vehicular Impact, Air Blast, and Fire on Isolated, Reinforced Concrete, Round Bridge Columns," Submitted to *Transportation Research Board (TRB) 102nd Annual Meeting*, (Under Review).
4. Alomari, Q. and D. Linzell, "Numerical Modeling of Post Fire Impact and Blast Performance of Single Reinforced Concrete Bridge Pier Columns," Submitted to *Journal of Fire Safety*, (Under Review).
5. Tran, Dang, Nate Ahlgren, Chris Depcik, and Hongsheng He, "Adaptive Active Fusion of Visual and Single-Point LiDAR Sensors," *IEEE Transactions on Instrumentation and Measurement*, (2022), (under review).
6. Kanwar, Bhanu and Steven Corns, "Deep Learning-based Disaster Management Planning and Risk Analysis of Flash Flood-Prone Regions," *Proceedings of the 2021 ASEM International Annual Conference*, (2021).
7. Kanwar, B., J. Hale, S. Corns, and S. Long, "Deep Neural Network Classifier for Flash Flood Susceptibility," Submitted to *International Journal of Flood Risk Management*, (2022).
8. Koya, S., N. Velasquez, R. Mantilla, M. Rojas, Dan Kirk, W. Krajewski, and R. Tirthankar, "A prototype flood forecasting system for Nebraska Watersheds," To be submitted (2022).
9. Pensoneault, A., W. Krajewski, N. Velasquez, X. Zhu, and R. Mantilla, "Ensemble Kalman Inversión with Limited Observations for Parameter Estimation and Upstream Streamflow Prediction," *Advances in water resources*.
10. Quintero, F., and N. Velasquez, "Implementation of TETIS hydrologic model into the Hillslope-Link Model framework," *Water* 14, no. 17, (2022).
11. Sharafkhani, Fahimeh, Steven Corns, and Suzanna Long, "Predicting Water Level at Unmonitored River Locations Via Deep Learning," *Proceedings of the 2022 ASEM International Annual Conference*, (2022).
12. Velásquez, N., R. Mantilla, W. Krajewski, M. Fonley, and F. Quintero, "Improving Hillslope Link Model Performance from Non-Linear Representation of Natural and Artificially Drained Subsurface Flows," *Hydrology* 8, no. 7, (2022).
13. Velásquez, N., F. Quintero, S. R. Koya, T. Roy, and R. Mantilla, "Application of HLM-Snow to assess the flood of spring 2019 in Western Iowa," *Journal of Hydrology, Regional Studies,* (submitted 2022).
14. Velásquez, Nicolás, Ricardo Mantilla, Witold Krajewski, Felipe Quintero, and André D.L. Zanchetta, "Identification and Regionalization of Streamflow Routing Parameters for the HLM Hydrological Model in Iowa," *JAMES* 14, no. 7, (2022).
15. Wu, H., J. Zeng, and G. Constantinescu, "A multiparameter design formula for riprap size selection at wing-wall abutments," *Journal Hydraulic Research* 59, no. 4, (2021): 651-661, DOI: 10.1080/00221686.2020.1818310.
16. Wu, H., J. Zeng, and G. Constantinescu, "A design formula for sizing rock riprap at spill-through abutments in compound channels," *Journal Hydraulic Engineering* 147, no. 10, (2021) https://doi.org/10.1061/(ASCE)HY.1943-7900.0001919

Conference Papers

1. Bhattacharya, S., H. Devos, C. Lemke, C. Branstetter, R. Jenkins, J. Rooker, M. Kranick, N. Patel, R. Gibson, and A. Akinwuntan, "Road Safety and Simulation," (June 2022).
2. Bennett, J. M. Saladin, D. Sizoo, S. Stewart, G. Wood, T. DeAgostino, and C. Depcik, "Design of an Efficient, Low-Cost, Stationary Lidar System for Roadway Condition Monitoring" *ASME 2021 International Mechanical Engineering Congress & Exposition Conference*, (1-5 November 2021), Virtual: IMECE 2021-69308.
3. Patel, N., J. Rooker, and S. B. Bhattacharya, 2022 Student Research Forum, "Association of Demographic Variables, Clinical Off-Road Driving Related Tests, and Simulator Driving Performance," *KUSOM*, (April 2022).
4. Rooker, J., M. Kranick, N. Patel, R. Jenkins, C. Branstetter, and S. B. Bhattacharya, KAFP annual meeting, "Demographic Characteristics of CDL Drivers in the Kansas-Missouri Bistate Region," *Kansas Academy of Family Physicians*, Kansas City, KS, United States, (June 2022).

Presentations

1. Bennett, J., M. Saladin, D. Sizoo, S. Stewart, G. Wood, T. DeAgostino, and C. Depcik "Design of an Efficient, Low-Cost, Stationary Lidar System for Roadway Condition Monitoring," *ASME 2021 International Mechanical Engineering Congress & Exposition Conference*, (1-5 November 2021), Virtual: IMECE 2021-69308.
2. Velasquez, N., W. Krajewski, and G. Radoslaw "A web interface to perform comprehensive hydrological model performance assessment," *AGU Fall Meeting*, (2022).
3. Velasquez, N., and W. Krajewski, "Validating simulated peak-flows statistical behavior in Iowa," *AGU Fall Meeting* (2022).
4. Wu, H., J. Zeng, and G. Constantinescu, "Use of CFD to understand conditions for riprap entrainment at bridge abutments in straight and curved channels," *39th IAHR Congress*, Granada, Spain, (2022).

Website(s) or other Internet site(s):

MATC maintains five online sites that distribute information utilizing the internet. Links to each site as well as report period information can be found below.

MATC Website

By clicking the following link, http://matc.unl.edu, you will be directed to MATC's website. Below is highlighted information from Google Analytics about the website's traffic from April 1, 2022 – September 30, 2022. By understanding and capitalizing on this knowledge, we are able to make our homepage engaging, relevant, and resourceful to our viewers. Since our last progress report, the total number of site visits decreased by 15,572.

Visits: 8,546	Page views: 19,273	Pages per visit: 2.13	Average visit duration: 00:00:28

SlideShare

Below is a snapshot of MATC's SlideShare activity and the link to view the page: https://www.slideshare.net/matcRegion7UTC/presentations/. MATC's SlideShare uploads have increased by 7 since the last reporting period.

Total Views: 2,797	New Uploads: 7	Downloads: 0	Favorites: 0

Facebook

Metrics for the MATC Facebook page can be viewed below, and the page can be accessed by clicking on the following link. MATC's reach increased by 2,033 since the last reporting period. https://www.facebook.com/pages/Mid-America-Transportation-Center-MATC/141238439284182.

Total Page Likes: 436	Reach: 2,803	Total Countries (of Followers): 10

Twitter

MATC's Twitter handle is @MATCNews. The page can be viewed by clicking the following link: https://twitter.com/MATCNews. The highlighted numbers for MATC's Twitter activity can be seen below. The number of tweets MATC produced increased by 5, and the number of profile visits increased by 171 since the last reporting period.

New Followers: 4	Tweet Impressions: 1,929	Profile Visits: 708	Tweets: 8

YouTube

MATC's YouTube feed can be viewed by clicking the following link: http://www.youtube.com/user/midamericatrans?feature=results_main. MATC uploaded 2 fewer videos and minutes watched decreased by 6,786 compared to the last reporting period.

New Videos: 2	Views: 1,035	Minutes Watched: 3,762	New Subscribers: 2

Additional Partner Websites

Several MATC Principal Investigators created websites to share information about their research projects. The links to these websites are provided in Table 4 along with the corresponding MATC project.

Table 4: Websites for Individual MATC Research Projects Created by Principal Investigators

Project Title	Principal Investigator	Website Link
Transportation Planning with Floods	Ann Campbell Ibrahim Demir	http://iihr-vl01.iihr.uiowa.edu/dev/routing/
Assessing and improving the cognitive and visual driving fitness of CDL drivers	Shelley Bhattacharya	http://www.kumc.edu/landon-center-on aging/research/truck-safety-study.html.
Real-time Flood Forecasting for River Crossings	Witold Krajewski	http://siihr50.iihr.uiowa.edu/smap/demo/
Low Cost 3-D LIDAR Development for Transportation	Chris Depcik	https://depcik.ku.edu/lidar https://github.com/depcik/lidar
Real-Time Emergency Communication System for HAZMAT Incidents (REaCH)	Ann Fruhling	https://afruhling.github.io/Reach.html

4. OUTCOMES

MATC identified three performance measures and three corresponding goals related to program outcomes in the center's Technology Transfer Plan. Table 5 contains a description of each performance measure, the associated goal, and the center total for the reporting period.

Table 5: Performance Measures, Goals, and Totals for MATC Outcomes

	Performance Measure	Description	Goal	Center Total for April 1, 2022 – September 30, 2022
Outcome 1	Commercialized Products	Quantity of invention disclosures, patent disclosures, patents issued, cooperative research and/or user agreements, and new business entities created.	Ten (10) products that are commercialized or in the commercialization process by end of grant period.	Zero (0) MATC is on schedule to develop commercialized products by the end of the grant period. This process is reflected in each PI's individual tech transfer plan.
Outcome 2	Output Adoption	Number of changes made to the transportation system (including regulations, legislation, standard plans, technical guides, or policy) resulting from MATC research.	Ten (10) that have been adopted or in the process of adoption by the end of grant period.	Zero (0) MATC is on schedule to implement changes to the transportation system by the end of the grant period.
Outcome 3	Product Utilization	Number of MATC products utilized (including citations, references, views, report downloads, and report requests).	Forty (40) by the end of the grant period.	Sixty-six (66) Including sixty-one (61) unique downloads of MATC research reports and five (5) unique clicks on the links to final data.

5. IMPACTS

MATC identified three performance measures and three corresponding goals related to program impacts in the center's Technology Transfer Plan. Table 6 contains a description of each performance measure, the associated goal, and the center total for the reporting period.

Table 6: Performance Measures, Goals, and Totals for MATC Impacts

	Performance Measure	Description	Goal	Center Total for April 1, 2022 – September 30, 2022
Impact 1	Public Stakeholder Participation	Number of public organizations serving as sponsors of research and T2 programs.	Five (5) public sector external partners providing support to MATC activities	Thirty-nine (39) MATC partnered with thirty-nine (39) public organizations on research, education, and technology

			for each year of the grant period.	transfer activities. See Table 2 for the complete list.
Impact 2	Private Stakeholder Participation	Number of private organizations serving as sponsors of various research and T2 programs.	Five (5) private sector external partners providing support to MATC activities for each year of the grant period.	One (1) MATC partnered with one (1) private organization on research, education, and technology transfer activities. See Table 2 for the complete list.
Impact 3	Transportation Professional Participation	Number of transportation professionals who participate in MATC T2 activities.	One hundred (100) transportation professionals for each year of grant period.	Fifty (50) MATC partnered with fifty (50) transportation professionals in MATC activities during the reporting period.

What is the impact on the effectiveness of the transportation system?

Ongoing MATC research projects will have a wide variety of impacts on the effectiveness of the transportation system. In a project led at the University of Iowa, Dr. Albert Ratner believes that his research will result in making transportation of highly inflammable crude oil by rail safer. This is expected to increase the effectiveness of the transportation system by preventing fires resulting from crude oil train derailments, which in the past have caused several fatalities and serious damage to property and infrastructure.

At the Missouri University of Science and Technology, Dr. Suzanna Long's anticipated research contributions will be an understanding of the comparative effectiveness of VR driving training as compared to traditional simulative training methods; particularly their ability to cost effectively improve the driving behaviors and safety of operatives in rural roadway conditions. To conduct this study, a prototype VR driver training simulator will be developed serving as the second proposal deliverable. This prototype will incorporate elements and scenarios affecting rural road travel safety but will be tunable to the conditions incumbent of other environments.

In a project led by Dr. Christopher Depcik at the University of Kansas, sufficiently fast LIDAR systems would allow vehicles to measure proximity to road hazards without the complications of image processing. His developed device could be easily setup to monitor traffic and improve congestion by providing live feedback to the traffic lights and minimizing unnecessary wait times. In addition, an inexpensive system could be widely distributed within the transportation system fostering a greater ability to monitor threats to safety.

At the University of Nebraska-Lincoln, Dr. Daniel Linzell's overall purpose of his research study is to improve the resiliency and robustness of bridge pier columns in the event of intentional or accidental vehicle collision coupled with an explosive event and fire.

Additionally, Dr. Tirthankar Roy believes the outcomes of this research will let transportation systems take precautions well before flood hazards are realized. Flood forecasting will be improved by replacing the old and outdated regression equations with advanced machine learning schemes.

What is the impact on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company?

Ongoing MATC research projects have a variety of impacts on the adoption of new practices and could lead to the initiation of a start-up company. Through studying the ATMA technology operation domain and the deployment guideline in a project led by Dr. Xianbiao Hu at the Missouri University of Science and Technology, he expects his research to help state DOTs and industry vendors pave the foundation for autonomous vehicle development and promotion. The proposed technology is jointly funded by a pool fund of 12 state DOTs and has the potential of being widely adopted nation-wide and internationally.

At the University of Kansas Medical Center, Dr. Shelley Bhattacharya expects her data will show what specific clinical tests can make CDL drivers safer behind-the-wheel, which should help the DOT give guidance to clinicians of what tests to administer for their DOT physicals.

Through research conducted at the University of Nebraska-Lincoln, Dr. Mojdeh Asadollahi Pajouh's final PCB design with improved crash performance, once tested, will be installed on roadsides and work zones throughout the country and the world, resolving safety concerns of roadways accidents.

What is the impact on the body of scientific knowledge?

MATC's current and ongoing transportation research will have a variety of safety-related impacts on the current body of scientific knowledge. Dr. Steven Corns at the Missouri University of Science and Technology has developed research that will create a hybrid method for using deep learning algorithms, leveraging the strengths of different deep learning algorithms to generate information vital to predicting water levels near road networks with an acceptable level of accuracy.

Experimental data collected at the University of Nebraska-Lincoln conducted by Dr. Joshua Steelman will be generated for large-scale dynamic impact behavior of soft soils. Information available in literature for roadside safety hardware focuses on strong soils, and soft soil experimental data has only been produced at small scales, requiring unvalidated extrapolation for large-scale application in engineering research and practice. Additionally, this research will provide insight into performance of foundations supporting breakaway features. Breakaway hardware is typically mounted to rigid or very stiff foundations in strong soil, leaving performance of foundations in weak soil as a gap in knowledge.

What is the impact on transportation workforce development?

MATC's research and education activities play a vital role in inspiring and preparing students to become future professionals of the transportation workforce. The MATC Scholars Program, STEM Academy, Intern Program, and After-School Program are designed to increase access and retain students from underrepresented groups in STEM and transportation-related degree granting programs and careers. MATC research projects provide graduate students with the opportunity to gain hands-on research experience in the field of transportation. The interdisciplinary projects completed during program activities bolstered students' conceptual and practical skills in STEM subjects. Students were encouraged to reconfigure their expectations of STEM subjects and perceived barriers and extend their interest beyond classroom experiences.

MATC research being conducted by Dr. Ernest Tufuor and Dr. Li Zhao at the University of Nebraska-Lincoln will enrich the capacity of transportation workforce to better understand and analyze reliability performance measures. Consequently, this will help to effectively report on the MAP21 and FAST ACT mobility performance monitoring indicators.

6. CHANGES/PROBLEMS

The COVID-19 pandemic and business responses play a factor in ongoing and future efforts. The research teams have not been shut down and are working effectively however, much of the personnel have transitioned to working remotely, as has much of the country during this time of social distancing. These are unprecedented times. Testing activities have been slowed by the pandemic, and may require delays in testing and data collection. As such, it is difficult to predict how long it will last and how it will affect research projects moving forward.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to report.