BIL MarTREC Tier 1 UTC Project Request Form
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Submission Date: 03/06/2025
Lead Recipient/Grant Number: University of Arkansas / 69A3552348331
Principal Investigator Institution: Jackson State University
Center Name: Maritime Transportation Research and Education Center
USDOT Research Priority: Preserving the Existing Transportation System
Primary USDOT Strategic Goal (*select drop down*): Economic Strength and Global Competitiveness
Principal Investigator(s) with ORCID(s) and Contact Information: Sadik Khan, Ph.D., P.E., Associate Professor, https://orcid.org/0000-0002-0150-6105; Department of Civil & Environmental Engineering, Jackson State University, 1400 J. R. Lynch St., Jackson, MS, 39217, sadik.khan@jsums.edu, 601-979-6373
Project Partners: Mississippi Department of Transportation
Project Type (*select drop down*): Applied Research
Project Research Topic Type (*select drop down*): Maritime Sustainable and Resilient Infrastructure
Transportation Modes Involved (*check all that apply*): ☒Waterway ☒Road ☒Rail ☐Pipeline ☐Other
Research Project Funding: (USDOT + Matching funds = Total Cost): $55,000 (USDOT) + $27,500 (Matching funds) = $82,500 (Total Cost).
Project Start and End Dates (Format month/day/year to month/day/year): 06/01/2025 to 05/31/2026
Project Title: IoT Sensor Fusion for Low-Cost Cloud Based Monitoring for Resilient Levees and Embankments
Project Abstract (Brief Description): The performance and longevity of geo-infrastructure assets such as levees and highway embankments depend on geotechnical (embankment, foundations, slopes) components, both influenced by soil conditions, hydraulic loads, and disruptions due to weather. Continuous, data-driven monitoring is essential for reliable water resource management and disaster resilience. This research advances Geotechnical Asset Management (GAM) using advanced IoT-based IMU sensors installed onsite combined with periodic aerial LiDAR point-cloud data collection techniques. IoT-based IMU sensors will track multi-directional displacements, while accelerometers and vibration sensors will capture performance data under various conditions. An Earth Dam and highway embankment site in Jackson, MS, and a Levee section owned by USACE will serve as test locations. A 3D geospatial model combining drone-mounted LiDAR will track structural stability and environmental impacts. Periodic assessments will detect instability, settlement, and deformation, enabling proactive maintenance to prevent failures and minimize disruptions. Enhanced monitoring will ensure reliable, connected, and risk-mitigated infrastructure to support national economic competitiveness. Collected data will be transmitted to the AWS cloud for remote monitoring of the Embankment, Dam and Levee system. In addition, the analytical tools in the cloud platform will be used to analyze the data and identify threshold points based on the performance criteria to create an early detection of failure under extreme conditions. This project will develop a data-driven, scalable solution to enhance safety, efficiency, and resilience in water management infrastructure while strengthening investments, thus enabling US economic strength and global competitiveness.
USDOT Priorities: This research aligns with USDOT priorities by enhancing safety, economic strength, and infrastructure resilience against extreme events through real-time performance monitoring of embankment and levees. Using advanced Non-Destructive Evaluation (NDE) techniques and remote

sensing, this study provides a cutting-edge approach to preemptively identifying critical flaws and implementing timely interventions to prevent catastrophic failures. Periodic evaluations will detect instability, settlement, and deformation, ensuring early intervention to minimize failure risks and environmental disruptions. The project will enhance supply chain resilience, supporting USDOT's goal of strengthening national economic competitiveness by providing reliable, connected, and risk-mitigated infrastructure. Collected data will be transmitted to the cloud and integrated into a high-fidelity digital twin, improving system resilience against disruptions due to weather events. This initiative advances USDOT's transportation infrastructure resiliency priorities by reinforcing disaster preparedness and adaptive infrastructure management.

Outputs (results of the work performed): The proposed project will develop a comprehensive approach to real-time monitoring of dams, levees, and highway embankments, by implementing remote monitoring using low-cost IMU based IoT sensor package. NDE and remote sensing techniques will be integrated with a sensor package on the geotechnical assets capable of capturing real-time data, such as acceleration, vibrations, and movements, to develop a digital twin that mirrors the asset lifecycle. A framework for cloud-based data analytics will be developed, which is pivotal for the IoT-based geotechnical asset monitoring system. The proposed system will utilize open source sensors and microcontroller setup, facilitated by IMUs and ESP32s, will ensure the accurate measurement and initial processing of critical data points. The Raspberry Pi will be used as a central hub, receiving data from multiple nodes and enabling additional processing if required. Cloud integration and data analysis will be performed, including the application of machine learning algorithms. The performance evaluation framework incorporating advanced aerial LiDAR technologies collected periodically in combination with real-time IoT sensors-based data will enable the prediction of potential failures or anomalies in dams and levee systems.

Outcomes/Impacts: The primary outcome of the project will be integrating the IoT based IMU sensor fusion with microcontrollers for the Remote, Low-Cost Dam and Levee monitoring, which will complement the understanding of the LiDAR and Drone Imaging. A framework will be developed for the Early Movement Detection Techniques, which will help to make proactive maintenance for Geotechnical Asset Management. The developed approach will overcome challenges in field instrumentation using traditional sensors, which are quite expensive and collect limited data due to lack of incorporation of multiple sensors with a single data logger. On the other hand, the open source micro-controller based data logger allows a large number of sensors to be connected together. By achieving IMU based sensor fusion for low cost remote monitoring system of Dams and Levee Infrastructure, the early risk of failure can be identified. By generating comprehensive datasets from the test sites, the project will develop analytics to understand performance, reduce costs, and ensure the safety and longevity of Dam and Levee infrastructure, which will contribute to improving the nation's economic strength and global competitiveness.

Technology Transfer Activities: The understanding of the work will be shared through publications, presented at local and national conferences, and summarized in a final report submitted at the end of the project. The findings from this research will also be published in prominent journals such as Transportation Research Record, Transportation Geotechnics, and American Society of Civil Engineers (ASCE) Journal of Infrastructure Systems and Journal of Performance of Constructed Facilities. Presentations will be made at conferences and professional societies.

Final Research Report: Upon completion of the project, a URL link to the final report will be provided

Project Deliverables: ☒ PI agrees to submit all deliverables within 4 weeks after the project end date.

Data Management Plan (DMP): ☒ PI has reviewed and agrees to adhere to MarTREC DMP. Proposed project DMP must be attached to the submission email along with this form.

Center Director Approval Signature and Date: Heather Nachtmann 04.01.25