MarTREC
Maritime Transportation Research & Education Center

MarTREC Tier 1 UTC Project Request Form
MarTREC Project 7017

Submission Date: 03.14.25
Lead Recipient/Grant Number: University of Arkansas / 69A3552348331
Principal Investigator Institution:
Center Name: Maritime Transportation Research and Education Center
USDOT Research Priority: Preserving the Existing Transportation System
Primary USDOT Strategic Goal (*select drop down*): System Resilience
Principal Investigator(s) with ORCID(s) and Contact Information: *Michelle L. Bernhardt-Barry, ORCID: 0000-0002-0947-5307, mlbernha@uark.edu, (479) 575-6027*
Project Partners: *US Army Corps of Engineers Little Rock District, Seth Martin*
Project Type (*select drop down*): Advanced Research
Project Research Topic Type (*select drop down*): Resilient Maritime Infrastructure
Transportation Modes Involved (*check all that apply*): ☒Waterway ☒Road ☒Rail ☐Pipeline ☐Other
Research Project Funding: *Federal: $200,410; non-Federal: $100,254; Total funding: $300,664*
Project Start and End Dates: 07/01/2025 - 06/30/2027
Project Title: Automatic Boundary Detection and Change Analysis Using Static and Dynamic Imagery
Project Abstract (Brief Description): This project aims to develop an automated segmentation and boundary detection system capable of identifying geometric features and changes in river boundaries using advanced image processing techniques on satellite imagery, digital photographs, and videos. Current aerial remote sensing and data collection techniques use LiDAR, photogrammetry, or other methods that require significant time and computational power to assess and identify key features of interest. Therefore, rapid or real-time monitoring of dynamic conditions such as flooding is difficult or impossible. By combining a fast segmentation algorithm with novel edge detection and AI-based classification methods to analyze boundary changes, the proposed system will allow for temporal monitoring of river conditions and adjacent infrastructure, and aid in the detection of any deviations from established boundary norms. While this system has numerous potential use cases, the main focus of this research will be the creation and training of a system that can identify and quantify a number of key features used for asset management, flood monitoring, and disaster response associated with levees and adjacent transportation infrastructure.
USDOT Priorities: This proposal introduces a novel approach leveraging advanced image processing techniques and AI classification to automatically detect and segment geometrical features. Existing segmentation methods are not able to detect complex features in dynamic environments like rivers and levees, especially under changing conditions such as flooding and vegetation growth. The processing also requires significant computational time, making real-time detection virtually impossible. The proposed system will use a novel approach being currently explored by the PIs to expand on existing segmentation algorithms such as FastSAM, so that higher accuracy and precision can be gained while still allowing for rapid, real-time detection. Unlike existing flood detection methods that focus solely on water level estimation, our system and proposed approach identifies spatial changes in river boundaries relative to adjacent infrastructure, offering a unique perspective on potential overflow events. The implementation of this approach offers an efficient and scalable solution to enhance flood impact predictions and early warning capabilities, especially in areas lacking other monitoring systems or where

the landscape may be rapidly changing and past hydrological analysis may be obsolete. This contributes to the maritime and multimodal body of knowledge by enhancing early flood detection and providing valuable data for hydrological modeling, thus supporting proactive disaster management and safeguarding transportation infrastructure in and around maritime environments.

Outputs (results of the work performed): The project will generate datasets including identified changes in river boundaries related to the accuracy of the system, timestamps to assess the speed of processing and ability to operate the system for real-time detection, and the sensitivity of the system to various features. We aim to collaborate with agencies such as the U.S. Geological Survey (USGS) and the U.S. Army Corps of Engineers (USACE) for access to historical flood data and river monitoring expertise. PI Barry has ongoing collaborations with the USACE Little Rock District as well as the Engineering Research and Development Center (ERDC). Partnerships with satellite data providers like ESA and NASA will be sought out to obtain better access to high-quality imagery for analysis. A large amount of satellite imagery is already available for free to the public through various websites and platforms; however, establishing formal partnerships and data-sharing agreements with ESA or NASA would help facilitate the implementation of this system in the future phases of this work.

Outcomes/Impacts: This project contributes by providing an automated, scalable solution for identifying levee geometry, monitoring river boundaries, and detecting flood risks. By leveraging satellite and aerial imagery and advanced image processing techniques, it enhances the ability to identify and predict the impact of flood events and provide early warnings for road closures and evacuation planning. Expected outcomes include: improved flood risk assessment, timely alerts for potential overflow events or closure of adjacent infrastructure, and valuable data for hydrological model integration, ultimately contributing to the safety and resilience of river valley communities. Maritime stakeholders, such as river transport operators and flood management agencies, will benefit from timely alerts, enabling better preparation and emergency management response. We plan to collaborate with the USACE to validate the system and evaluate its implementation into existing flood monitoring frameworks. Once developed and validated, the program can be developed into an app or executable, and commercialization opportunities can be explored. While the focus of this research is on maritime transportation-related flood monitoring and mitigation, the same techniques can be easily adapted for numerous other applications.

Technology Transfer Activities: The final dataset and project deliverables will be made publicly available as per federal guidelines. We will work with the USACE to validate and test the program and then we will explore IP and commercialization opportunities for this or other applications of the technology. The PI and research associate will travel to the USACE Engineering Research and Development Center to meet with representatives at the Geotechnical and Structures Laboratory and discuss the further development of the program and potential technology transfer activities. The project team will also meet with representatives from the Arkansas Waterways Commission, as well as others in the state to discuss the program and its potential implementation or further development. At least 5% of the project budget (in the form of travel and salaries) will be directed to technology transfer activities and potential implementation of the program within the stakeholder agencies or other interested parties.

Final Research Report: Upon completion of the project, provide a URL link to 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.