

Project Title: A Digital Twin for Visualizing, Evaluating and Maintaining Multimodal Transportation Infrastructure

Project Abstract (Brief Description): This research project will develop a digital twin that enables visualizing, evaluating and maintaining multimodal transportation infrastructure. The ultimate goal is to provide an opensource software tool and machine learning-based decision-making approaches that assist the relevant stakeholders in improving their information collection and tracking capabilities, and enhancing the resilience of multimodal transportation infrastructure and beyond. Specifically, we will focus on three research aspects: (1) developing an advanced NetLogo-based computer application (i.e., digital twin) with graphical user interface, which can record the states of locks, dams and ports, predict the water levels of interested sections of a navigable inland waterway based on historical data and spatio-temporal models, and track and simulate the movement and activities of vessels, based on the team's pilot simulation and visualization tool; (2) characterizing the uncertainty associated with infrastructure status in the digital twin and seeking to model and predict unscheduled maintenance with key factors, such as age and usage of locks and dams, climate and weather conditions, traffic volumes, and types of scheduled maintenance; and (3) enhancing the digital twin with decision support models for vessel routing/rerouting and infrastructure maintenance planning. For a full utilization of the nation's multimodal transportation infrastructures, the improvement of their transparency to stakeholders and users, and their resilience in response to contingencies, a digital twin with a collection of self-learning capabilities to be designed and tested will assist stakeholders in coordinating their operations and evaluating how short-term and long-term decisions will affect economic outcomes. The research findings to be achieved will be broadly disseminated to researchers and practitioners through research publications and presentations. The team will promote real-world applications of the digital twin by working with MarTREC partners and collaborators.

Describe Implementation of Research Outcomes - The expected outcomes/deliverables of this project include: (1) A digital twin prototype for visualizing and mimicking the operation of multimodal transportation infrastructure and for evaluating the impact of a human action or a natural event, (2) statistical and optimization models and machine learning tools related to data analytics and decision making for providing short- and long-term operation strategies, and (3) publishable case studies and documentations that illustrate the applications and economic impact of implementing the computerized system for data collection, analysis and visualization, and machine learning-based decision making.

Impacts/Benefits of Implementation - The project will train a female industrial engineering Ph.D. student recently recruited. The involvement of the student on the technical side includes: (1) software

development based on the team's prior work, and (2) investigation of various machine learning techniques and decisionmaking models. It is expected that this project will provide the theoretical foundation and preliminary results of the student's PhD. dissertation. Moreover, the student will be part of various outreach and technology transfer activities, such as giving oral and poster presentations at MarTREC annual research meetings and INFORMS conferences to pass our research findings on to practitioners and other researchers.

Web Links: martrec.uark.edu

Budget (Funding) Amounts & Source(s) (US DOT +Match(s) =Total Costs): MarTREC 150,000 and UA 75,000 = 225,000

Project Start and End Dates: 08/16/21-11/30/23 Complete

Principal Investigator(s) and Contact Information: Haitao Liao, Ph.D., liao@uark.edu 479-575-6196
Professor Industrial Engineering, Shengfan Zhang, Ph.D. and Heather Nachtmann, Ph.D.

Principal Investigator Institution (University): University of Arkansas