

<b>Submission Date:</b> 12/2/24
<b>Lead Recipient/Grant Number:</b> University of Arkansas / 69A3552348331
<b>Principal Investigator Institution:</b> University of Arkansas
<b>Center Name:</b> Maritime Transportation Research and Education Center
<b>USDOT Research Priority:</b> Preserving the Existing Transportation System
<b>Primary USDOT Strategic Goal</b> ( <i>select drop down</i> ): Safety
<b>Principal Investigator(s) with ORCID(s) and Contact Information:</b> <i>Lead PI: Robert M. Curry, ORCID: <a href="https://orcid.org/0000-0001-5408-8333">https://orcid.org/0000-0001-5408-8333</a> ; Co-PI: Kelly Sullivan, ORCID: <a href="https://orcid.org/0000-0001-6862-3843">https://orcid.org/0000-0001-6862-3843</a></i>
<b>Project Partners:</b> <i>United States Northern Command (USNORTHCOM)</i>
<b>Project Type</b> ( <i>select drop down</i> ): Applied Research
<b>Project Research Topic Type</b> ( <i>select drop down</i> ): Maritime and Multimodal Supply Chain Management
<b>Transportation Modes Involved</b> ( <i>check all that apply</i> ): <input checked="" type="checkbox"/> Waterway <input type="checkbox"/> Road <input type="checkbox"/> Rail <input type="checkbox"/> Pipeline <input checked="" type="checkbox"/> Other
<b>Research Project Funding:</b> Federal funding amount: \$119,637; non-Federal funding amount: \$59,894; Total funding amount: \$179,531; Technology Transfer expenses from Federal Funding: \$12,000
<b>Project Start and End Dates:</b> 1/1/2025 to 7/1/2026
<b>Project Title:</b> Developing Optimization Methods for Maritime Escort Strategies for Littoral and Chokepoint Shipping Lanes
<b>Project Abstract:</b> Protecting maritime shipping lanes, particularly vulnerable littoral chokepoints, is critical to maintaining global economic stability. These narrow sea passages connecting major bodies of water are susceptible to disruption, as demonstrated by recent hostile activities in the Red Sea and Strait of Hormuz. This project aims to address the growing complexity of maritime threats by developing mathematical optimization models for allocating limited U.S. military assets to neutralize or alleviate the risk of potential threats. Our proposed research will develop mixed-integer programming (MIP) models to determine effective strategies involving a diverse set of protection assets, such as warship escorts, unmanned aerial vehicles, and missile defense systems. The project will specifically focus on minimizing risks to vessels while also optimizing the cost-benefit balance for defending these critical shipping corridors. By collaborating with U.S. Navy stakeholders at the U.S. Northern Command, the findings will support enhanced operational planning, contribute to securing domestic transportation infrastructure, and improve the resilience of the global supply chain. This work seeks to fill a gap in the literature by providing a comprehensive, quantitative approach to maritime defense in the context of modern threats.
<b>USDOT Priorities:</b> Our proposal aligns directly to the USDOT’s three key priorities: safety, infrastructure, and innovation. First, our work focuses on developing analytical methods to ensure the <i>safety</i> of shipping vessels domestically and internationally. This work then contributes to developing a most robust infrastructure that remains operable when faced with possible disruptions. Finally, our proposed methods will utilize the latest research in mathematical optimization along with working with stakeholders to include and understand some of the latest technologies available to the U.S. Navy (e.g., unmanned aerial vehicles). Finally, our work will also contribute <i>advanced</i> optimization models and

methodology that could be of broader interest for other applications related to securing transportation and logistics networks vital to the domestic and global economy.

**Outputs (results of the work performed):** We develop mixed-integer programming (MIP) models that allocate limited military assets to protect vessels along primary shipping routes. Our models will enable identifying strategies consisting of various protection assets (e.g., warship escort, UAVs, and sensors) for the purpose of defending against various threats (e.g., UAVs, USVs, and missiles)

Our work will also contribute new optimization models and methodology that could be of broader interest for other applications related to securing domestic transportation infrastructure and could spur further theoretical and methodological investigation within the optimization community.

Additionally, we do hope that our work on this project will provide a viable pipeline for a long-term research relationship with USNORTHCOM.

**Outcomes/Impacts:** Our proposed work can improve U.S. Navy operations related to planning the use of limited defensive resources to protect littoral and chokepoint sea lanes. The proposed work therefore stands to support economic stability and enhance the resilience of the global supply chain against an increasingly complex threat landscape.

**Technology Transfer Activities:** As a result of this work, we will transfer technical through academic journal submissions and through various conference presentations. As outline in our project description, we do plan to submit a manuscript to a peer-review journal describing our work on this project. We would target a journal whose audience might be the most interested in our work. Additionally, we will present intermediate and final progress on this work at academic conferences (e.g., the Institute for Industrial & Systems Engineering Annual Conference and the INFORMS Annual Meet) as well as military-focused research conferences (e.g., the MORS Annual Symposium). Between graduate student salary and travel expenses, this will make up at least 10% of the overall budget.

**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.

Center Director Approval Signature and Date:



12.23.24