Advanced Modeling and Predictive Analytics of Resource Optimization:
A Mixed Integer Programming Approach to Improve Oil Spill Response in Arctic Canada

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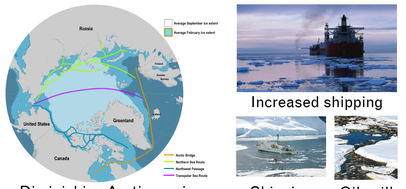
Introduction

Background



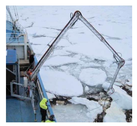
Diminishing Arctic sea ice opens shipping routes

Increased shipping

Shipping accident

Oil spill risk

Mechanical recovery



Dispersant application

In-situ burning

Research Question

Facility Location
- How many facilities to build?
- Where to build them in Arctic?

Resource Allocation
- How much resources to store in those facilities?

Purpose

- Serve sensitive areas with high priority
- Respond to Arctic oil spills within predetermined time window
- Mitigate negative consequences

Scientific Contribution

- Proposed a hierarchical multiobjective location allocation optimization model for maximum oil spill coverage
- Research gap on resource allocation centered on Arctic conditions is furnished
- An AI-based Mixed Integer Programming (MIP) can act as a Decision Support Tool, helping strategic decision-makers
- Compared to the current response facility setup and satisfactory results are found, demonstrated by network diagrams

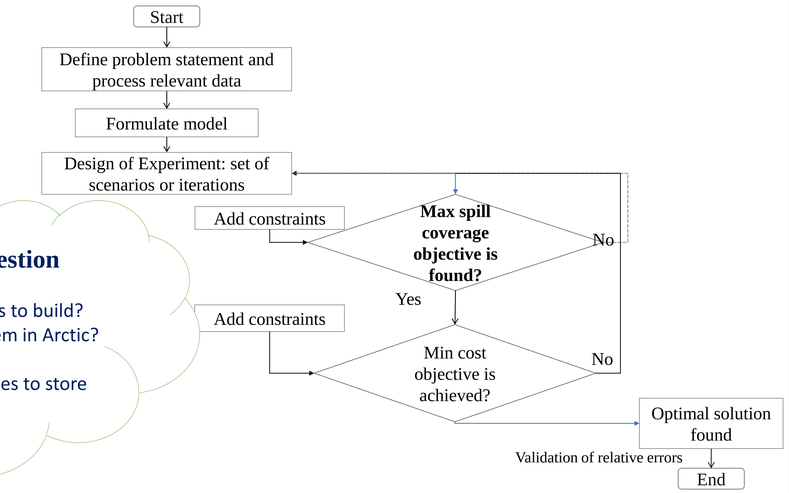
Acknowledgement

Funding received from Marine Observation, Prediction, and Response (MEOPAR) Network of Centres of Excellence, and the Nova Scotia Graduate Scholarship are highly appreciated

MEOPAR

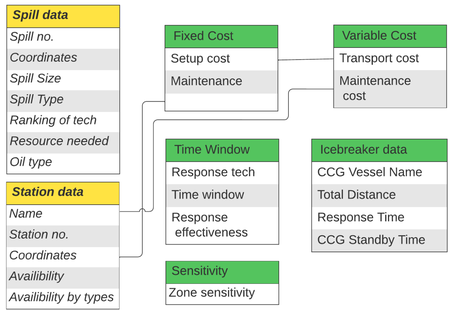
Method

Optimization Modeling Process Flow



This MIP model maximizes oil spill coverage (considering spill zone and environmental & cultural sensitivity, response time) and minimizes associated costs

Experimental Design and Data



Solution

- Branch & Cut algorithm
- Gurobi optimization solver is used to find solutions

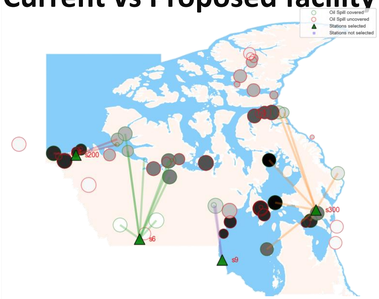
GUROBI OPTIMIZATION

python

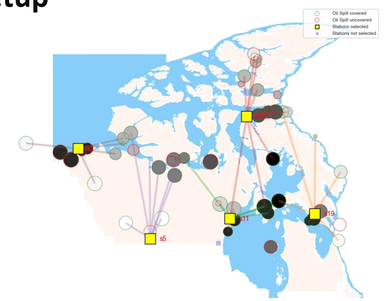
Data Source: [1,2,3] and literature

Result

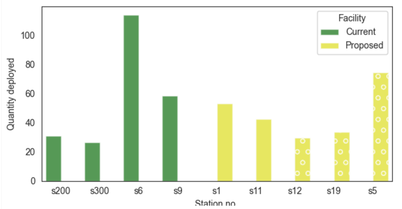
Current vs Proposed facility setup



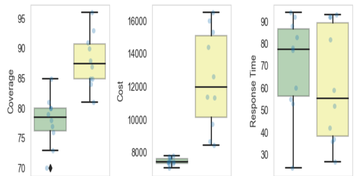
(a) Network Diagram by current setup in Canadian Arctic



(b) Proposed facility setup (Coverage enhanced from 49% to 78%, improved response time)



(c) Resource allocation to facilities



(d) Comparing Performance

Engagement

Through end-user engagement and involvement of industry experts, the societal relevance and usefulness of research objectives and results are ensured

Reference

[1] Das, T., Goerlandt, F., & Tabri, K. (2021). An optimized metamodel for predicting damage and oil outflow in tanker collision accidents. Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment, 236(2), 412–426. https://doi.org/10.1177/14750902211039659

[2] Das, T., & Goerlandt, F. (2022). Bayesian inference modeling to rank response technologies in arctic marine oil spills. Marine Pollution Bulletin, 185, 114203. https://doi.org/10.1016/j.marpolbul.2022.114203

[3] Das, T., Goerlandt, F., & Pelot, R. (2023). A Mixed Integer Programming Approach to Improve Oil Spill Resource Allocation in the Canadian Arctic. Journal of Risk & Reliability (Submitted).

Poster link

LinkedIn networking