Systematic Mapping of Modeling and Simulation for Operational Analysis of Future Naval Mine Countermeasure Systems

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Survey:
Future Naval Mine Warfare and Underwater Warfare

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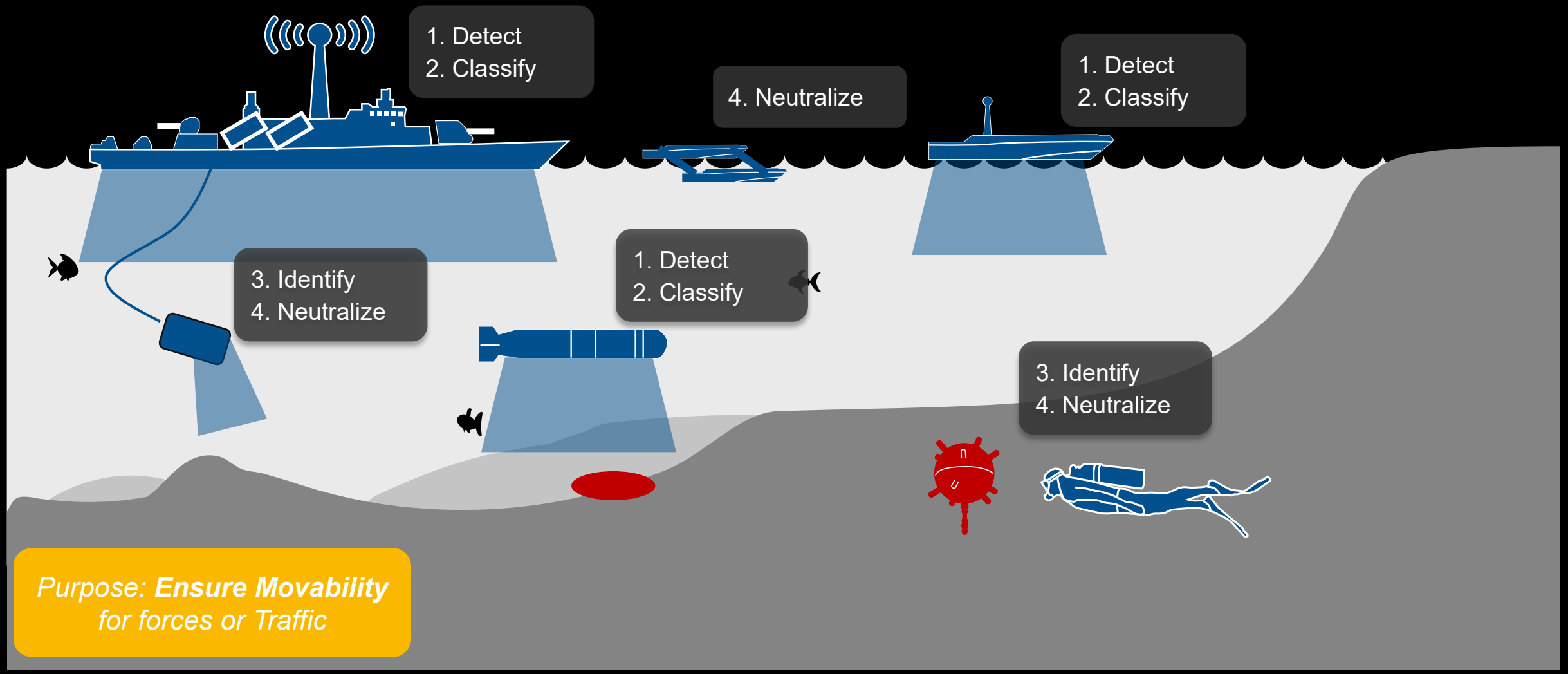
Background

Formalize a decision support for concept development and evaluation of future naval mine countermeasures systems (NMCM)

- *Decision Support* – Quantitative support, emphasis on exploration rather than optimal solution
- *For concept evaluation* – how to compare SoS designs containing both new and legacy systems. Operating in different environments
- *Naval mine countermeasure systems* – includes both surface, and underwater systems; MCMV, AUV, ROV, USV cooperating..
- *Future* – what if analysis regarding both design concept and scenario



Example: Minehunting



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Purpose of Mapping Study

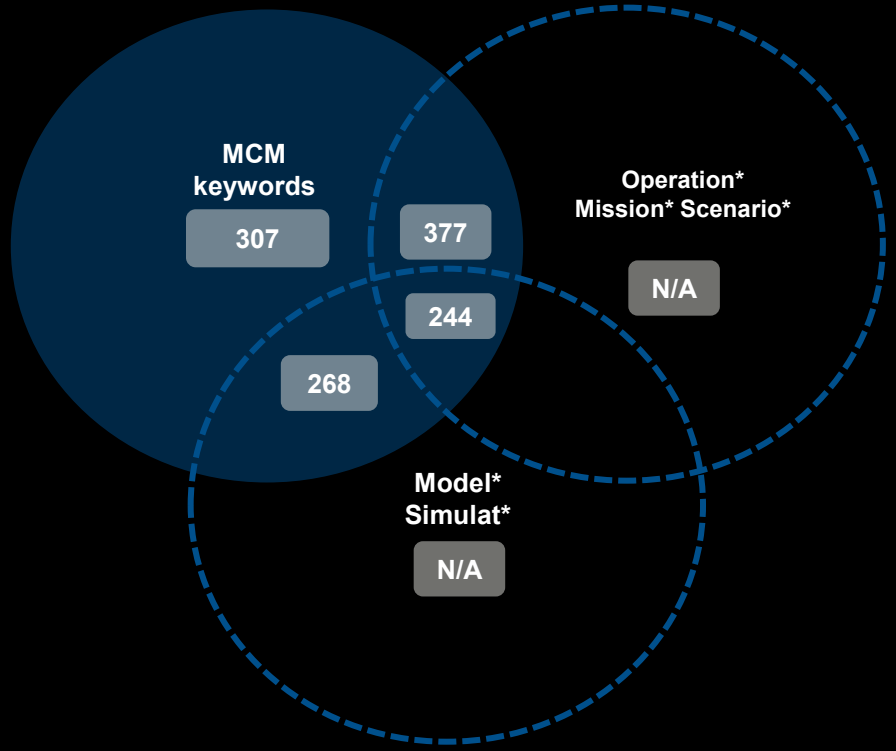
RQ1: *What is the current state of the naval mine countermeasures field with respect to operational analysis through modeling and simulation?*

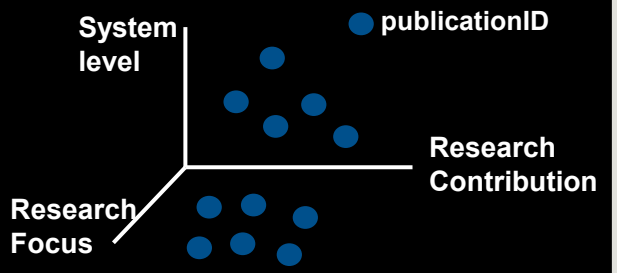
RQ2: *What modeling and simulation methods are most commonly used to support operational analysis of future naval mine countermeasure systems in terms of measures of effectiveness, risk analysis, and cost analysis?*

RQ3: *What are the key challenges in applying modeling and simulation for operational analysis of naval mine countermeasure systems during conceptual design?*

Mapping Methodology

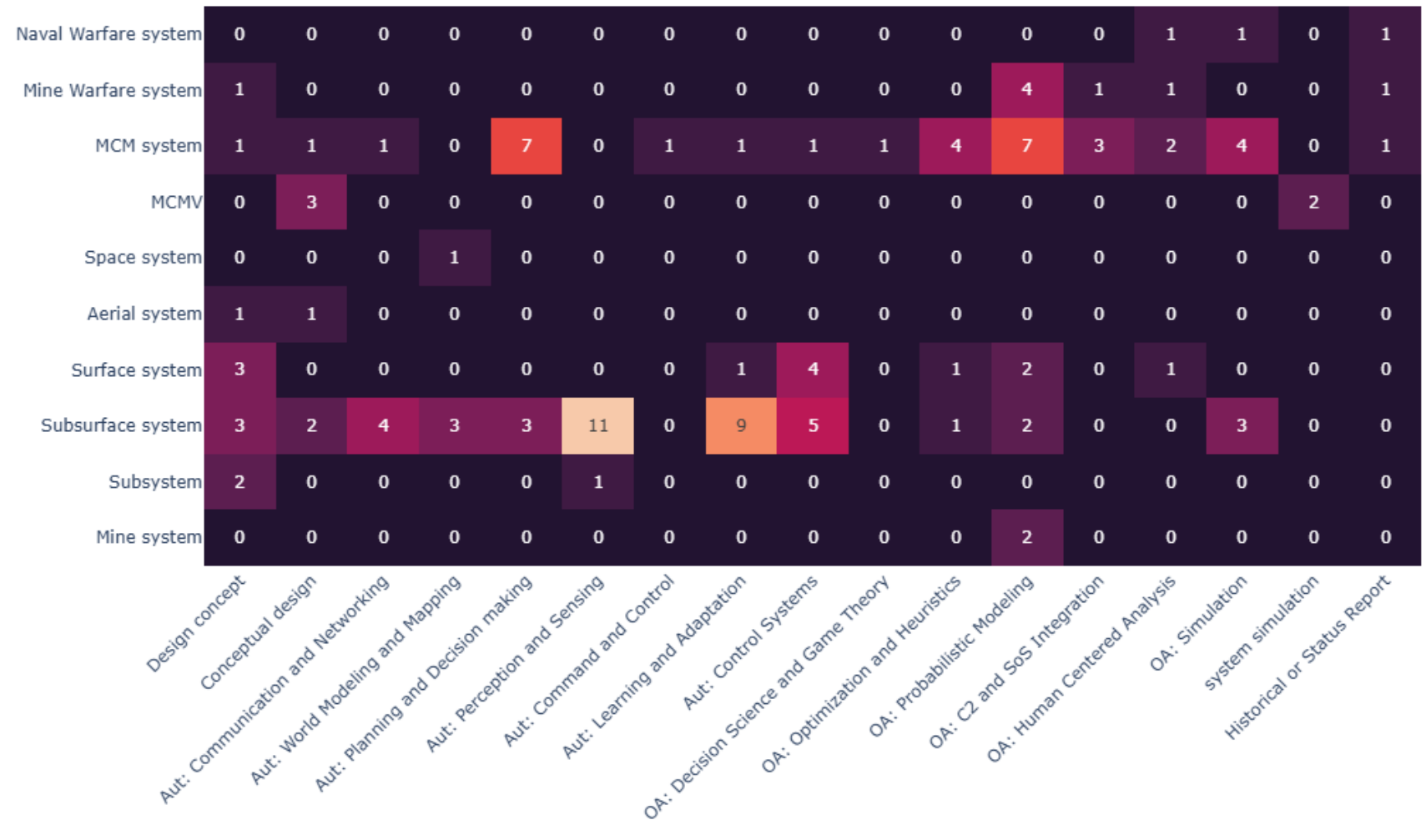
1196
1. Database Search
Remove Duplicates
244
2. Inclusion Criteria
117
3. Title and Abstract Review
117
4. Conclusion and Disposition Review
117
5. Full Paper Review
117
6. Answer Research Questions





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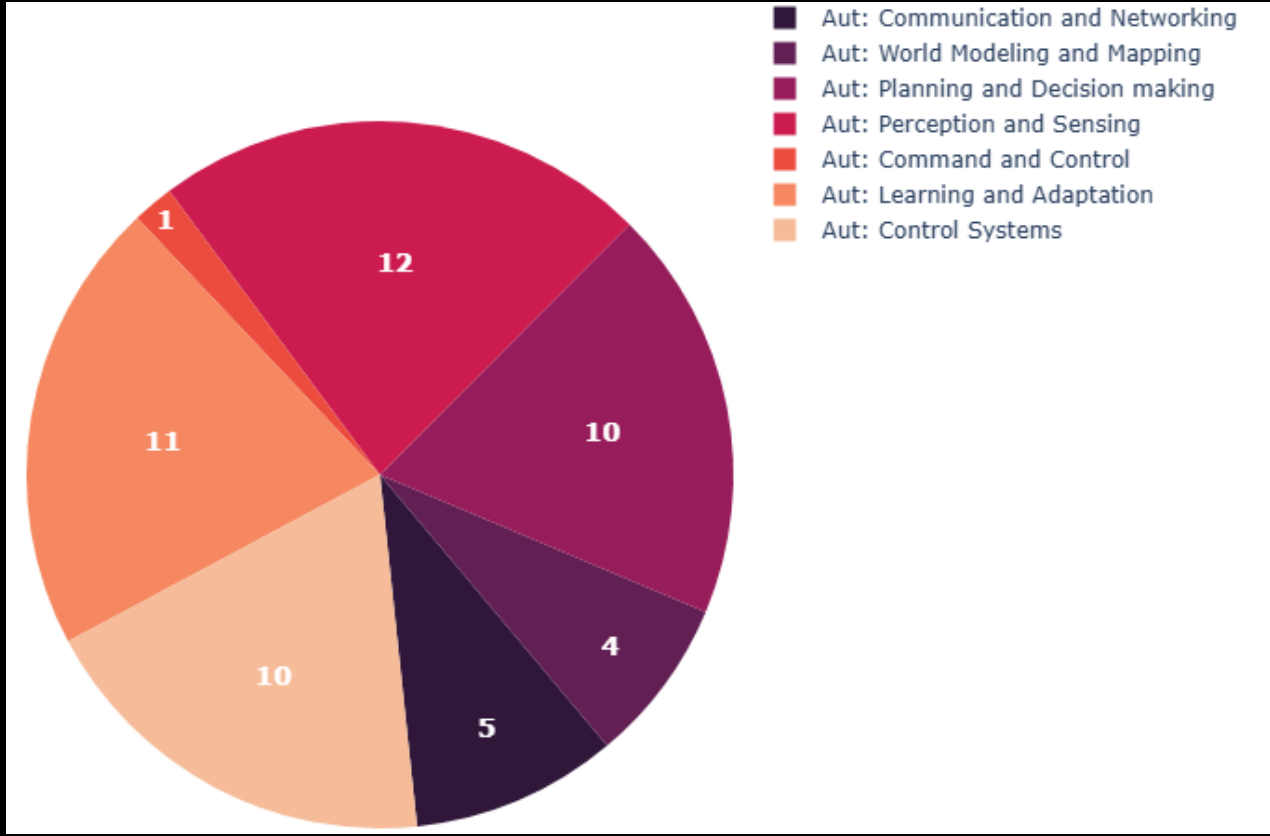
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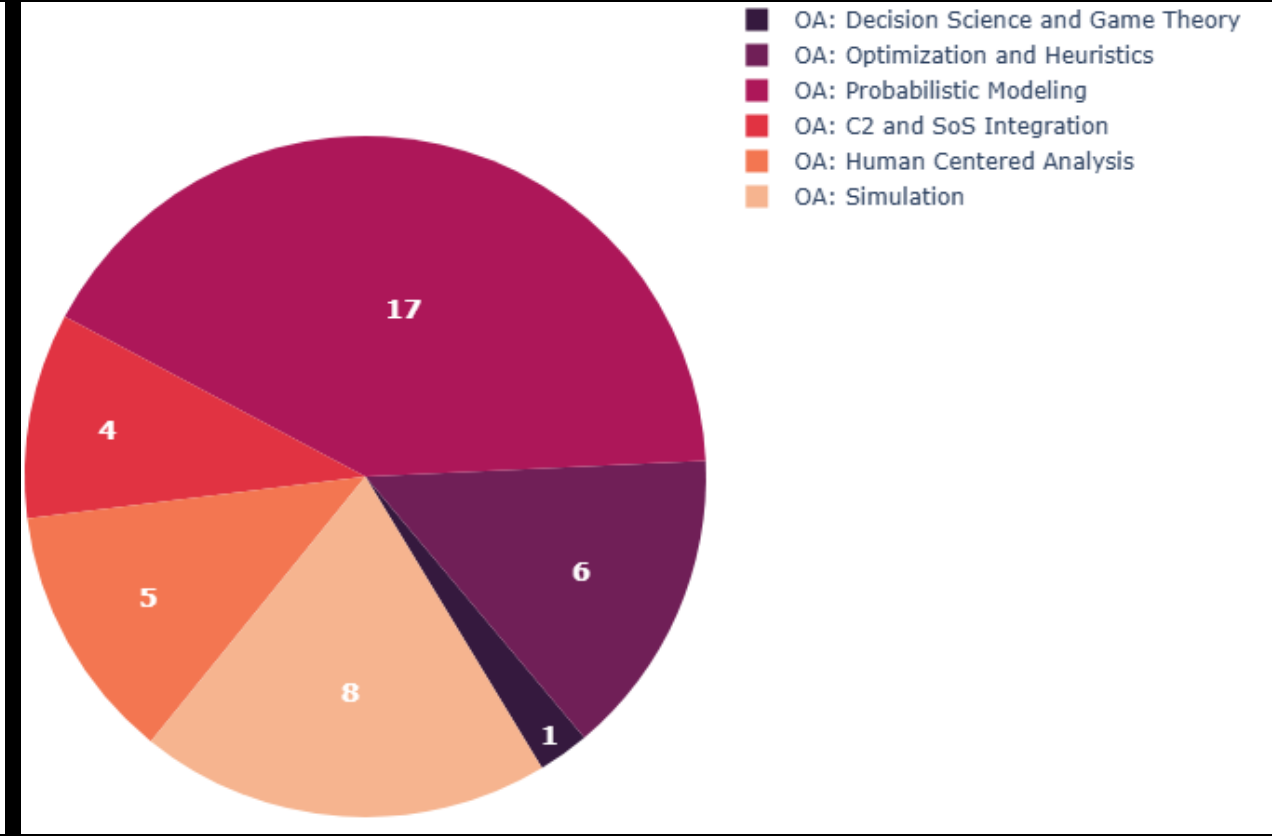


Autonomy is about engineering functions that enable a system to be more or less autonomous, generally it focuses on real-time simulation and modeling in order to be used in a real-world application.

The purpose of OA is to evaluate and study the performances of a system used in an operation. It often favors low fidelity models and fast computing.

RQ1: What is the current state of the naval mine countermeasures field with respect to operational analysis through modeling and simulation?





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RQ2: What modeling and simulation methods are most commonly used to support operational analysis of future naval mine countermeasure systems in terms of measures of effectiveness, risk analysis, and cost analysis?

MoE:

Percentage Clearance

Percentage Prosecuted

Area Coverage Rate

Cost:

Acquisition Cost

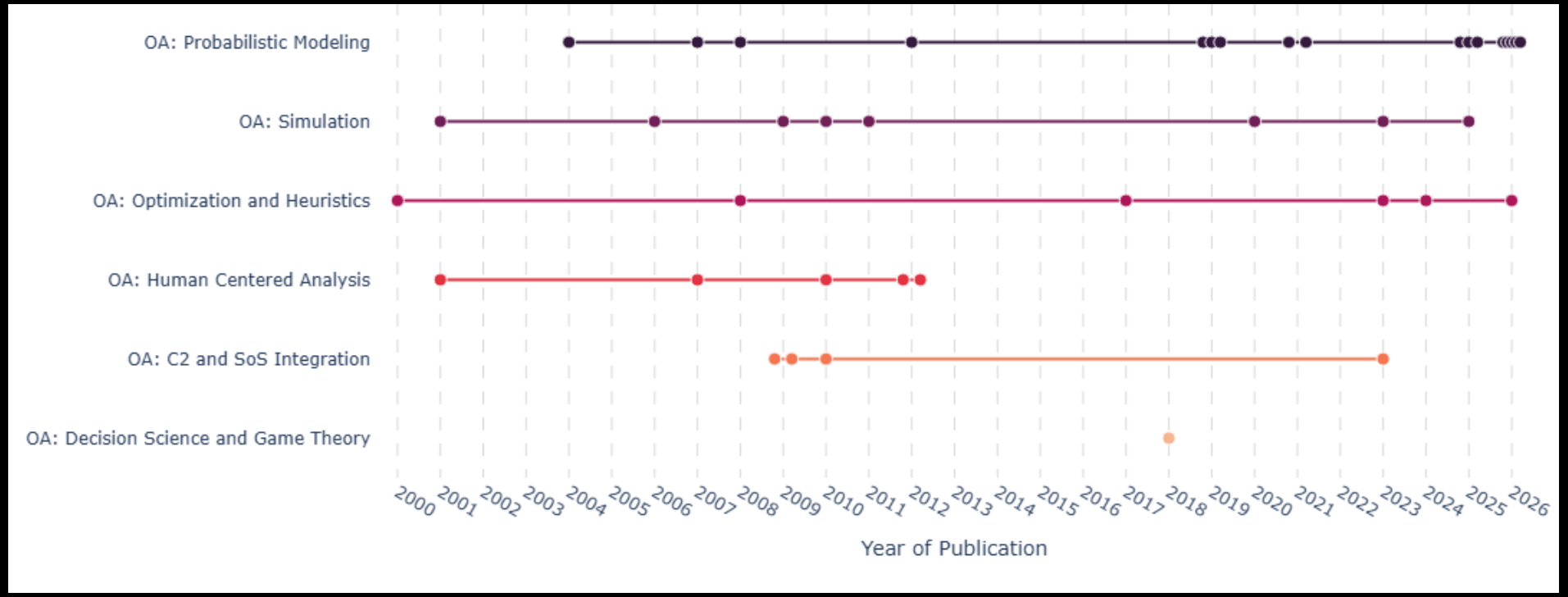
COTS

Operational Cost

Risk:

Number of Remaining Mines

Probability of Mine in cell



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Limitations

- Absence of Research
  - Only Scopus Database
  - No snowballing step
  - No Technical Reports published at local Research agencies and Institutes
- Selection Bias
- Judgment Bias

Future Strengths

- Absence of Research
  - Established workflow to include more papers
  - Visualization in Dashboard - github
- Selection Bias
  - Possibility to let different LLM select
  - Involve more Authors
- Judgment Bias
  - Possibility to let different LLM categorize
  - Involve more authors

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RQ3: What are the key challenges in applying modeling and simulation for operational analysis of naval mine countermeasure systems during conceptual design?

- Absence of Diverse mine threat analysis
- Scarcity of Design Space Exploration studies on SoS level
- Scarcity of Cost and effectiveness trade-off studies on SoS level
- Holistic view of future NMCM capabilities



Research Gap

Future Work

1. Overall view of future diverse mine threat
   - Evidently exists a lot of research within subsurface autonomy
   - Already exists planning and evaluation support for static mine counter
2. Outline Archetype Scenarios for NMW
   - Span Static to Dynamic mine threat
3. Compile Modelling techniques for OA
   - Design Space Analysis
   - Trade-space Analysis
   - Comparison of Alternatives in different scenarios

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Please, do reach out to us if you think NMW and UWW is important for our future capabilities

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