Simulation Modeling of Multi-Agent Coordination in Maritime Emergency Response Systems

The Seventeenth International Conference on Advances in System Modeling and Simulation
SIMUL 2025

Presenter: Xu Jing
National Defense of Technology University

Lisbon, Portugal, September 28, 2025 to October 02, 2025

Xu Jing

jenniferxu98@163.com

Professional Experience

- Student of College of System Engineering, National University of Defense Technology

Publications & Activities

- 4 SCI-indexed journal articles
- 4 EI-indexed conference papers
- 9 patents/software copyrights

Research Background and Problem Statement

- Multi-party coordination challenges exist in maritime emergency response.
- Traditional methods struggle to capture dynamic adaptive systems.

.....

- Construct a four-type agent evolutionary game model.
- Propose collaborative mechanism design recommendations.

Model Formulation

Four types of boundedly rational agents:

Maritime Administration

Ship Operators

Crew Members

Insurance Companies

Model Construction

Accident Probability Function:

$$P_{accident} = P_B \cdot (1 - \delta_M \cdot \alpha_M) \cdot (1 - \delta_O \cdot \alpha_O) \cdot (1 - \delta_C \cdot \alpha_C) \cdot (1 - \delta_I \cdot \alpha_I)$$

Payoff Functions:

Stakeholder	Payoff Matrix
Maritime Administration	$R_M - C_M(\text{strategy}) - P_{accident} \cdot L_M$
Ship Operators	$R_O - C_O(\text{strategy}) - F(\text{regulation}) - P_{accident} \cdot L_O$
Crew Members	$W_C - C_C(\text{strategy}) + (1 - P_{accident}) \cdot B_C \cdot \delta_C$
Insurance Companies	$R_I - C_I(\text{strategy}) - P_{accident} \cdot P_I$

How Safety Measures Reduce Risk

Risk Transmission Mechanism

Safety measures reduce inter-agent risk transmission probability by interrupting the accident chain, thereby suppressing systemic cascading failures.

Synergistic Risk Reduction

Multi-stakeholder collaboration enhances response efficiency, creates positive externalities, and significantly shortens the accident exposure window.

Risk Transmission Mechanism

The effectiveness of measures is integrated into iterative simulations, driving strategic evolution and achieving adaptive convergence of risk levels.

Research Significance

Summary of Findings

Constructed a multi-agent simulation model to reveal the dynamic gaming behaviors among stakeholders in emergency response, validating the effectiveness of distributed coordination mechanisms.

Policy Implications

Proposed incentive strategies based on evolutionary outcomes to optimize resource allocation and responsibility sharing, enhancing maritime emergency coordination efficiency and system resilience.

Practical Value

Provided quantitative support for formulating adaptive, data-driven safety regulatory policies, facilitating a transition from passive response to proactive prevention and control.

Future Work

Expanding Agent Types:
Introduce more maritime stakeholders, such as port authorities and environmental organizations, to enhance the model's realism and coverage.

Dynamic Parameter Optimization:
Employ machine learning methods to calibrate agent behavior parameters in real time, improving simulation adaptability and predictive accuracy.

Multi-Scenario Validation:
Test the model across different maritime regions and accident types to verify its robustness and generalizability.

THANKS

Simulation Modeling of Multi-Agent Coordination in Maritime Emergency Response Systems

The Seventeenth International Conference on Advances in System Modeling and Simulation
SIMUL 2025

Presenter: Jing Xu
National Defense of Technology University

Lisbon, Portugal, September 28, 2025 to October 02, 2025