SOCIALIST REPUBLIC OF VIET NAM
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SUMMARY OF DOCTORAL THESIS

Thesis title: **Research on drift forcasting and optimal search route planning for SAR operation in Ninh Thuan - Kien Giang sea**

Major:	Marine science
Sector code:	9840106
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Formation course:	2016
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1. Thesis summary

Vietnam is a coastal country, the East Sea has an important strategic position, due to subjective and objective conditions, maritime accidents and incidents have increased recently. The southern seas of Vietnam, from Ninh Thuan to Kien Giang (Vung Tau MRCC's responsibility), is up to 44% of the total number of accidents in the Vietnam's sea. However, the application of science and technology to SAR operation is limited and limited in use of supporting by smart solution, technology.

Therefore, the study of the thesis research is necessary in order to improve the SAR's competence at sea, meeting the requirements of economic and social development, serving the industrialization and modernization of the country, orientation of marine economic development, simultaneously contributing to the protection of sovereignty, rights national sovereignty as well as ensuring national defense, security and environmental protection.

There have not any studies on the optimal search and rescue route for SAR vessels to sweep the area with the shortest possible time of drifting of the object in distress. The current software using in the SAR operation (eg SAROPS..) is commercial software that does not know the algorithms and reliability of weather data. On that basis, author has conducted research on the thesis with two main research:

- Studying the influence of external factors such as wind, currents of in the sea area from Ninh Thuan to Kien Giang on the object, thereby determining the degree of drift and developing an algorithm to predict the drift trajectory of the object in distress.
- Developing an algorithm to calculate the optimal search route, based on the actual weather conditions, maneuvering characteristics of the search vessel and the predicted area of the object in distress to approach the object in time with time. shortest time, increasing the efficiency of SAR operation for the area.

In this thesis, in order to carry out the drift forecasting and compute the optimal search route for the SAR vessels, the author does:

Aggregate, calculate and evaluate the accuracy of wind and current information sources in the sea area from Ninh Thuan to Kien Giang for purpose of forecasting the drift of distress objects at sea; Comparative analysis of reliability, easy access to data sources, it is possible to use Grib file wind reports of Kyoto University - Japan and OSCAR current data of the Earth and Space Research for the purpose of drift forecasting and searching for objects in distress at sea in real time after calculating standard deviations; Using a Monte Carlo simulation with a Median-Filter filter to remove noise define a 95% probability search area of a drift object with real-time weather data;

The author used the Search and Rescue Support Soft software, the program to support and monitor the rescue operation to simulate the drift area for 4 scenarios and identify the search area for distress objects under the impact of real-time wind and current. The simulation results of the 95% probability drift area show quite consistent results with the windy conditions in real time in the southern sea of Vietnam.

On the basis of the identified search area for distress object, the author research and calculate the optimal search route from the standby position to the edge of the specified search area and then sweep the entire area with the shortest time. Develop an objective function to optimize the multi-directional design for a SAR vessel and the option for two SAR vessels to coordinate the search. Applying the adaptive BFO algorithm, developing a multi-directional SAR plan for a SAR vessel and two SAR vessels coordinated base on the BFO algorithm is highly reliable, capable of calculating and suggesting the optimal route even in the case of complicated weather conditions;

Developing a software using BFO algorithm, easy to use, ensures fast calculation, can be applied in actual conditions. Using software to simulate the multi-directional search and rescue plan for one SAR vessels and the search coordination plan for two SAR ships taking into account the maneuverability of the SAR ship for 4 scenarios:
   - Life raft (no canopy, no drogue): Multifier: 0.057/Modifier: 0.21 kts/Dev: 24^0
   - Life raft (canopy, w/ drogue): Multifier: 0.03/Modifier: 0.00 kts/Dev: 28^0
   - Fishing vessel (Side-stern Trawler): Multifier: 0.42/Modifier: 0.0 kts/Dev: 48^0
   - Fishing vessel (Vietnam): Multifier: 0.38/Modifier: 0.0 kts/Dev: 45^0

Result: The drift area is suitable for wind, surface currents during the month. The fast calculation time ensures the search planning, the convergence speed of the algorithm is guaranteed. The search area of the two SAR vessels covers the specified search area appropriate to the IAMSAR manual.

2. Research purpose

Studying the influence of external factors such as wind, currents of in the sea area from Ninh Thuan to Kien Giang on the object, thereby determining the degree of drift and developing an algorithm to predict the drift trajectory of the object in distress.

Developing an algorithm to calculate the optimal search route, based on the actual weather conditions, maneuvering characteristics of the search vessel and the predicted area of the object in distress to approach the object in time with time. shortest time, increasing the efficiency of SAR operation for the area.

3. Research Content

- Analyze, evaluate the accuracy of the main weather factors, oceanographic affecting the SAR operation;
- Simulate the drifting area of the distress object according to the wind and current in the sea area from Ninh Thuan to Kien Giang;
- Develop the algorithm's objective function for determining the optimal SAR route;
- Research and apply algorithms to calculate the optimal route for searching areas with the highest probability, with the shortest time on the basis of factors influence the flow, weather.

4. Research objective and scope

Research object: Drift trajectories of distress objects at sea and optimal SAR route.

Research scope of the topic: Sea area from Ninh Thuan to Kien Giang (Responsibility area of Vung Tau MRCC). Study the theory to predict the Drift Trajectory of the distress objects and calculate the optimal SAR route, then use software to simulate the results.

5. Research method

- Theoretical methods: Statistically modeling the motion of the object in distress under the impact of waves, using functions to predict the drift trajectory of the object; calculation and construction of supporting software;
- Analytical methods and expert methods: determine the factors to be concerned with, develop the objective function for the route calculation problem;
- Simulation method: to test and verify.

6. Scientific and practical significance of the research

Scientific significance of the research:

Research on the scientific basis and practice of calculating the moving trajectory of the distress object in the sea area from Ninh Thuan to Kien Giang and setting up the optimal search route for many SAR vessels to conduct the search.

Practical significance of the research:

Improve the efficiency of search and rescue operation at sea through the study of predicting the drift, the movement of the object in distress, on that basis, calculating and setting the optimal search route with the highest probability of finding the distress object, while the searching duration of the SAR vessels is minimal and ensures that the area of probability of drift is covered;

Assist seafarers on the SAR vessels or the search unit in charge to develop an optimal search plan according to actual hydro-meteorological conditions and specific object characteristics, thereby contributing to improving the efficiency of SAR work in the southern

sea of Vietnam belonging to Vung Tau MRCC and contributing to ensuring the protection of security and sovereignty at sea.

7. New contributions of the Thesis

- Aggregate, calculate, evaluate the accuracy and select the source of wind and current information on the sea area from Ninh Thuan to Kien Giang to use for the purpose of predicting the drift of objects in distress at sea;
- The thesis uses Monte Carlo simulation to predict the drift of objects in the sea area from Ninh Thuan to Kien Giang based on wind and current information sources that have been analyzed and evaluated for accuracy.
- The thesis has built an algorithm to calculate the optimal multi-directional search route for the option of two SAR vessels to search at sea in case of complicated weather conditions;

8. Structure of Thesis

The structure of the thesis includes an introduction, 4 chapters and a conclusion as follows:

Introduction

Chapter 1: Overview of SAR operation in Vietnam sea

Chapter 2: Principal drift forcassting and weather information

Chapter 3: Drift forcasting for distress object by Monte Carlo Simulation

Chapter 4: Bacterial foraging optimization algorithm for search route planning basing on real-time weather information
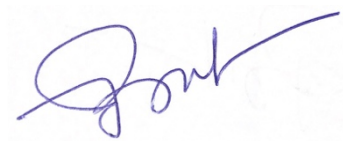
Conclusions

Ho Chi Minh City, October 10th, 2021

Science supervisors   **PhD candidate**

Assoc Prof. Dr. Nguyen Minh Duc   **Dr. Le Van Ty**   **Pham Ngoc Ha**