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| **Problem Chosen** B | **2024 MCM/ICM Summary Sheet** | **Team Control Number** 2423654 |

**Safety Assurance of Deep-Sea Exploration**

**Study on Position Prediction and Emergency Response Strategy of Submersible**

**Summary**

Maritime Cruises Mini-Submarines (MCMS) aims to use submersibles for Ionian Sea explorations. This requires models for predicting submersible locations, managing pre-emergency communications, recommending search equipment, and developing efficient search patterns, while considering expansion to other locations like the Caribbean Sea.

**Problem 1**: We developed a **Long Short-Term Memory Network** (**LSTM**) model, with **close integration of particle tracking** and **fluid dynamics incorporating ocean physics data** and **historical trajectories** to predict submersible positions. Utilizing TensorFlow and data normalization, the model shows high accuracy in future position predictions, demonstrating the potential for enhancing safety procedures.

**Problem 2**: Recommended additional search equipment for the rescue ship, focusing on remotely operated vehicles (**ROVs**), side-scan sonar, and autonomous underwater vehicles (**AUVs**). Cost, maintenance, and readiness were key considerations, ensuring a balance between advanced technology and practicality.

**Problem 3**: Created a model that uses **LSTM predictions** to define search areas and patterns, employing Monte Carlo simulations and the **A\* algorithm**. This approach optimizes search efficiency, dynamically updates based on real-time data, and increases the probability of locating lost submersibles over time.

**Problem 4**: Adapted the model for the Caribbean Sea, adjusting for regional oceanographic conditions and the presence of multiple submersibles. Employed **multi-agent simulation and high-resolution seabed mapping** to address unique challenges, ensuring model versatility and effectiveness.

Evaluation & Improvement: The model's foundation on Newtonian mechanics and validated data sources like NASA Earth and NOAA underpins its strength. However, assumptions regarding constant seawater density and sensor accuracy highlight areas for refinement. Future enhancements could include variable environmental parameters and machine learning techniques for continuous model optimization.