INTRODUCTION

1.1 Problem Statement: PSID–SIH1655

Background:

Oil spills pose a significant threat to marine ecosystems, coastal communities, and maritime operations. They can result from vessel discharges, pipeline leaks, or accidents at sea and have long-lasting environmental and economic consequences. Early detection of such spills is crucial for initiating a timely response, minimizing ecological damage, and enforcing maritime regulations.

Traditionally, oil spill detection relies heavily on satellite remote sensing technologies, such as Synthetic Aperture Radar (SAR), which can identify oil slicks on the ocean surface. While effective, satellite-based methods alone are often limited by low temporal resolution (i.e., infrequent passes) and cannot always provide real-time detection or context on the source of the spill.

On the other hand, **Automatic Identification System (AIS)** data provides continuous, high-frequency tracking of vessel movement, including attributes like speed, course, and heading. Analyzing this behavioral data can help detect anomalous vessel activities, such as loitering or abnormal speed changes, that may be indicative of illegal discharges or oil spill incidents.

This project leverages the **integration of AIS data with satellite observations** to build a robust, intelligent detection system. By training a machine learning model to identify suspicious maritime behaviors and correlating them with satellite-derived observations, we aim to detect oil spills more reliably and in near real-time. This hybrid approach enhances monitoring capabilities, supports environmental compliance, and contributes to global maritime safety efforts.

Motivation:

Oil spills are among the most devastating environmental disasters, with long-lasting impacts on marine ecosystems, coastal communities, and global economies. Traditional oil spill detection methods—such as manual satellite image interpretation, periodic aerial surveillance, or physical water sampling—are time-consuming, expensive, and often reactive rather than proactive.

With the rapid growth of maritime traffic, there is an urgent need for automated, intelligent systems that can monitor vessel behavior in real time and identify anomalies that may signal illegal discharges or accidental spills. The increasing availability of Automatic Identification System (AIS) data provides a unique opportunity to analyze vessel movements and detect suspicious patterns.

At the same time, Sentinel-1 SAR satellite imagery offers high-resolution data for observing marine surfaces, including oil slicks. However, manual analysis of such large datasets is impractical for continuous monitoring.

This project is motivated by the goal to combine AIS behavioral analytics with satellite observation using machine learning to detect oil spill anomalies efficiently and accurately. Such a system not only supports maritime safety and environmental protection but also enables early response and prevention, minimizing ecological damage and supporting compliance with international marine pollution regulations.