



Identification of tugboat operations in ports using AIS Data

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Keywords: tugboat, AIS data, operational modes, commercial vessels

Topic: Environment

Abstract

Tugboats are essential support vessels in port operations, providing different services. Each service cycle—including free sailing, pushing, pulling, and escorting—imposes different engine loads and speeds, which in turn lead to varying levels of emissions released into the environment. Consequently, optimizing tugboat operations is crucial to reducing emissions while maintaining safe practices (Chen et al., 2021; Ribet et al., et al., 2024). The aim of this research is how accurately operational modes of a tugboat can be identified using AIS data. This study examines more than 22,000 records from 46 commercial vessels and an equal number of tugboat records, spanning a four-month period from April to July 2024 in the Port of Barcelona. The procedural steps of this study are illustrated in Fig.1 The initial methodology is based on the framework presented in the studies of another research (Chen et al., 2020; Chen et al., 2021) and is subsequently adapted to our research through an examination of the relevant chart.

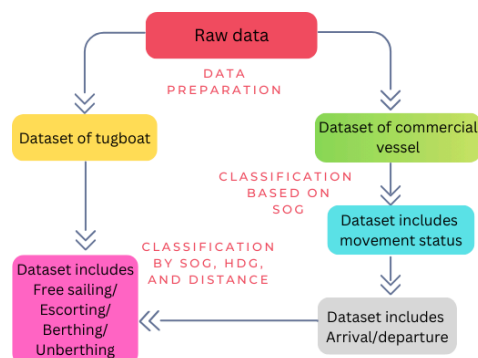


Fig.1. Methodological workflow for identifying tugboat behavior

The main results of the research demonstrate that, based on AIS data, it is possible to identify and predict different operational characteristics through the analysis of speed, speed difference, distance, and heading charts. On the one hand, the type of service: arrival, departure, and shifting; and, on the other hand, the mode of operation: manoeuvring and free sailing (Fig. 2). Throughout sailing, while tugboat is escorting commercial vessels, tugboats and commercial vessels maintain closely aligned SOG. The tugboat almost consistently maintains a distance within the commercial vessel's LOA, ensuring safe proximity. Free sailing phases is characterized by greater separation and wider SOG ranges, clearly distinct from manoeuvring behaviour.

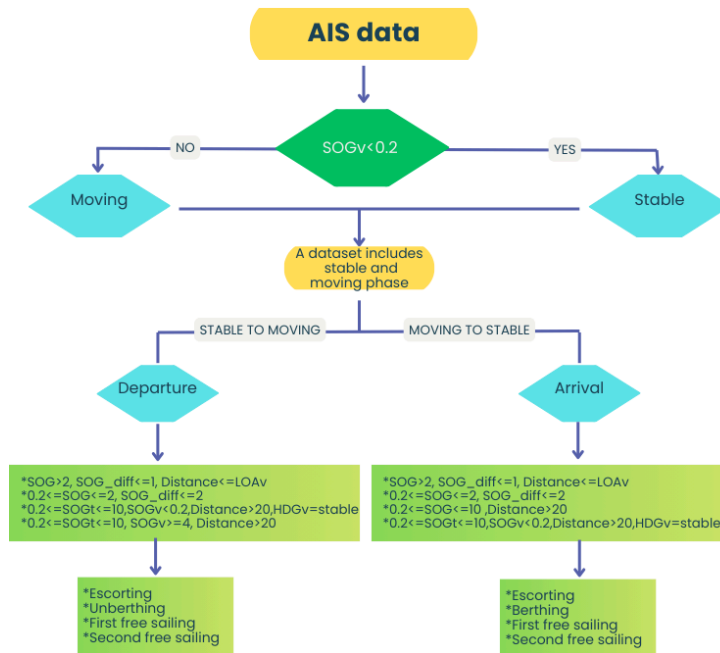


Fig. 2. Overview of the operational mode's condition. Note: SOG_v (Speed Over Ground of the commercial vessel), SOG_t (Speed Over Ground of the tugboat), HDG_v (Heading Over Ground of the commercial vessel) and LOA_v (Length Overall of the commercial vessel)

The determination of waiting time and its distinction from the onset of manoeuvring still requires further investigation.

Acknowledgements

This research is part of the R+D+I project/ PID2022-140497OB-I00, funded by MCIN/ AEI/10.13039/501100011033/. Special thanks to the P&O Repasa tugboat company staff and the Barcelona Port Authority for their assistance and collaboration throughout this work.

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