

Japan Bulk Carrier Model

Exploring the impact of wind and wave dynamics on ships' energy efficiency to improve the operational effectiveness of wind-assist propulsion technologies



Vessel Description

The Japan Bulk Carrier (JBC) is a benchmark design for large bulk carriers developed in Japan for naval research. Used worldwide as a standard model in experiments and computer simulations, it has been essential for studying ship resistance, propulsion, and energy-saving technologies such as stern ducts.

Project Purpose

This model is part of a project investigating the performance of wing sails under **natural wave-induced ship motions**. In wind-wave experiments, the JBC model simulates realistic ship behaviour to better understand how sails generate thrust at different wind and wave conditions.

Project Details

PhD student
Rukai Chen

Supervisors
Prof. Alessandro Toffoli
Prof. Jason Monty

Design and Fabrication Support
Andrew Kogios

Experimental Setup

The model is mounted on a bespoke fixture that allows two degree-of-freedom motions, namely **pitch** and **heave**. Controlled wind conditions are applied to measure the forces produced by the wing sail at **varying wind speeds**, while sea-state waves generated by a mechanical paddle produce realistic operating conditions.

Model Length	1.4m
Model Scale	1:200

Test Facility

Extreme Air-Sea Interaction (EASI)
Michell Hydrodynamics Laboratory

60 metre wind-wave tunnel:

- Simulate up to category 1 hurricane (30m/s wind, 280kW)
- Excellent flow quality & uniformity
- Wind & programmable mechanical waves (JONSWAP)
- Gust generator (active grid)
- Sloped beach to dissipate waves
- Computerised traversing system
- High-speed laser and cameras for detailed turbulence measurements, in both air & water
- Motion tracking in air & water
- 3m/s towing carriage

JBC Fabrication

The model's body was fabricated using 3D printing. While Acrylonitrile Styrene Acrylate (ASA) was first considered for its water resistance, it proved prone to cracking and warping during trials. Polylactic Acid (PLA) was selected instead for its stability and printability. To overcome PLA's limited water resistance, the model underwent a multi-stage finishing process:

- Printed in six sections, aligned with dowel pins and bonded with epoxy
- Surfaces were sanded smooth and refined with filler, spray putty, and primer
- A final coating process provided a waterproof finish