

The Roughness Induced Drag-Penalty of an Operational Ship

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ABSTRACT

It is well-known that roughness on the hull of a ship can substantially increase the resistance to motion (or drag), leading to considerable penalties across the global fleet. However, currently, it is not possible to accurately predict the vessel performance penalty due to an observed roughness state. This naturally limits industry action to mitigate the problem. Though there are established practices for reducing hull roughness, these remedies are all expensive. In the absence of reliable data on the performance penalty due to rough hulls, it is difficult to make a compelling economic case to ship operators or a compelling regulatory argument for government.

The principal aim of this work is to address these issues, using field and laboratory experiments to improve empirical relationships for the estimation of the equivalent sand-grain roughness height (k_s) for realistic ship hull roughness, and to validate the efficacy of full-scale ship drag predictions. To this end, the hull-state (roughness) and skin frictional drag of an operational vessel have been monitored during regular operation since it was sand-blasted and fully re-coated in March 2022. During dry-dock, a window was added to the flat underside of the vessel, 69 m downstream of the bow, which permits us to measure the turbulent boundary layer profile formed over the hull using an outward facing traversing laser Doppler anemometer (LDA). These measured profiles provide an estimate of the local skin friction drag penalty due to hull roughness, which can be directly related to hull observations. The hull state after cleaning an re-coating

during dry-dock is recorded using imprints. Subsequently, the hull is monitored through regular dive inspections using the in-house developed AQUAMARS (Advanced Quality Underwater Mapping and Analysis for Rough Surfaces) device. This is an image-based diver-operated underwater scanner that can capture the roughness topography on the hull.

To date, five measurement campaigns have been conducted. For the first 2.5 years since re-entering the water, the vessel has operated with an approximate 26% skin friction drag penalty as compared to the ideal smooth hull case. This period of near-constant drag penalty is corroborated by the dive-inspections and surface scans carried out over this period which show no build-up of fouling. This drag penalty is assumed to result from baseline roughness on the hull due to 1) paint application, 2) docking-blocks (areas not cleaned during dry-docking), and 3) weld-seams, with the former responsible for most of the measured penalty. The contribution due to the paint roughness has been determined from laboratory studies detailed in a separate submission to this session.

During the most recent measurement campaign, dive inspections and hull scans show a degradation in the antifouling coating accompanied by an increase in fouling coverage and slight uptick in measured drag. At the meeting, we expect to be able to report on results from further measurement campaigns, detailing the increasing drag penalty as biofouling takes hold on the hull.