Integrated performance prediction tool for wind-assisted ship design with a routing case study

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The interest in studying alternative methods for ship propulsion including wind energy has increased in recent years along with the demand for lowering carbon-based fuel consumption. However, studying the performance of wind-assisted ships requires expensive and complicated setups because it involves multi-variate and multi-dimensional problems to be analysed simultaneously for both hydrodynamics and aerodynamics. We combine data based on real conditions for aerodynamics using Computational Fluid dynamics (CFD), hydrodynamics results from tow-tank tests, and manoeuvring mathematical model into a fast performance prediction tool to predict the overall performance of a wind-assisted cargo ship for a whole voyage. We include the real voyage data including route and wind condition as a complete digital-twin ship model.

The prediction tool demonstrates the potential for significant fuel savings, particularly under steady conditions with specific wind and ship speed parameters. Leveraging open-source databases of routing and average wind data, we estimate the optimistic fuel saving potential for realistic ship voyages. Cost-benefit analysis indicates that the fuel savings from wind-assisted propulsion could lead to significant daily profit and a substantial reduction in CO_2 equivalent emissions. Applying this method, we anticipate obtaining valuable insights into the potential economic and environmental benefits, particularly under specific wind speed conditions. This study underscores the potential economic and environmental benefits of integrating wind-assisted propulsion into ship design and operation. The case study uses performance data for an in-service ship, hydrodynamically tested at model scale in the 138 m Boldrewood tank in variety of self-propelled conditions and leeway angles. Aerodynamic performance of a wing sail will use validated CFD results. The performance prediction tool uses well established approaches from yacht velocity prediction programmes along with methods for evaluating ship powering. Results from a series of voyage routes in differing environmental conditions will allow the variability of the performance gains to be assessed. The tool development is funded through a clean maritime demonstration competition phase 3 project.