WASPP: WIND ASSISTED SHIP PERFORMANCE PREDICTION

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Wind assist technology may hold the answer to unlocking a clean, free, and abundant power supply for the future world fleet, but the full implications of such technology are still poorly understood. To address this complex issue a Wind Assist Ship Performance Prediction software package (WASPP) has been developed. WASPP accounts for all aerodynamic and hydrodynamic forces acting on a ship, and includes not only the forces generated by the wind assist technology itself, but also the resultant heel, yaw, and rudder angles, changes to propeller inflow, and numerous other factors which combine to affect the total ship resistance and powering. Using WASPP the power, fuel consumption, or any other variable of interest can be plotted for any combination of wind and wave angle and severity to produce a complete performance profile for any given ship.

Performance Prediction

WASPP is based on a conventional sailing yacht velocity prediction program (VPP) and follows methodology described by (Philpott et al. 1993). A VPP can be described as a force balance model governed by Newtons second law: “For any body which is not accelerating the sum of forces in each coordinate direction and the sum of moments around each coordinate axis must be zero”. WASSP solves for up to 4 degrees of freedom by considering surge, sway, roll and yaw, and finding the combination of engine rpm, heel, leeway, rudder angle, and sail trim controls to ensure all forces are balanced. This process is repeated for every combination of wind speed, wind angle and ship speed. If desired added resistance from waves can be included in the calculation, in which case wave height and wave angle is added to the calculation. In many cases multiple combinations of input variables may result in a successful solution, in which case WASPP will attempt to optimise for minimum fuel consumption.

Analysis

Bare hull calm water resistance is obtained using (Holtrop 1984), and added resistance due to waves is obtained using a modified kwons method described in (Lu 2014). The additional drag due to heel is approximated via a change in wetted surface area as it is assumed that for small heel angles viscous resistance is largely unaffected. Drag due to leeway is included in the form of hydrodynamic coefficients from the testing of British Bombardier as described in (Journee & Clarke 2005) and used in (Naaijen et al. 2006). Drag due to rudder angle is calculated along with standard aerofoil theory assuming a NACA0018 section. Finally aerodynamic drag of the topsides and superstructure is calculated according to (Blendermann 1994) to find the total resistance of the ship.

Scaling

WASPP can accept dimensional inputs for area and configuration for sails, or if needed it can also create an assumed 'ideal' sailplan. Traditionally sailing yachts make use of two principle methods for initial sizing of sailplans. The first relates to stability at large heel angles which is ignored here since our previous experience suggests that heel angle under sail will never challenge static stability for this application. The second method relies on key design ratios: principally *Sail Area/Displacement* and *Sail Area/Wetted Surface Area*. Since published figures for Displacement and Wetted Surface Area figures are hard to come by for reference craft, Sail Area/LOA is used as a reference to calibrate a regression equation derived from a database of sailing yachts. Configuration, including number of masts, aspect ratio, etc are derived from reference craft.

Output

Results can be analysed within WASPP or exported to either the popular .CSV (comma separated variable) format, or alternatively into multidimensional matrix file known as .netCDF as specified in (Howett 2015). This allows further analysis and interpretation of results within a wide range of programs. Raw data can be viewed and further analysed in Microsoft Excel, or Matlab. Software libraries to read .netCDF files exist for a wide range of common programming languages and they may be read directly by the Voyage Optimisation software developed by (Tong et al. 2016) and by Voyage Level Model (Howett 2016) for fleet-wide global analysis of results

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