PhD Project of Clément BOUHOURD

Atmospheric boundary layer turbulence influence on wing-sail performance (funded by MERVENT project)

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The necessary need for drastic reduction in CO2 emissions in maritime transport represents a major technical challenge. Designing hybrid cargo ships combining sails with more conventional engines appears as a valid option. In particular, using "rigid" wing-sails has several benefits. When compared to non-rigid fabric sails, they indeed show longer sail life thanks to the absence of flapping or flogging and more consistent aerodynamic performance, requiring less control input and eventually less drag.

Estimating and improving the performance of aircraft wings has been the subject of extensive research in the aeronautical community. This wealth of results has already been transferred and applied to the design of highly efficient racing sailing boats. In high-speed, typically foiling, racing boats, the apparent wind is mainly due to the high boat speed, the characteristics of the true wind such as the vertical shear, its induced twist and the atmospheric turbulence becoming of minor importance. In this case, the rigid sails acts almost as an aircraft wing in a low-turbulence flow.

When considering large cargo vessels, because of their moderate speeds, the opposite is true : the characteristics of the lower-atmosphere including the wind shear and the high level of turbulence inducing highly unsteady flow become of primary importance and greatly influence the wing performance.

This renewed interest in the wing-sail performance at low/moderate boat speeds and its potential impact on greenhouse-gas emission reduction in maritime transport motivates the present PhD project dealing with the aerodynamic performance of wings immersed in highly turbulent sheared flows such as the lower atmospheric boundary layer, in order to understand how the significant turbulent fluctuations of the wind influence the aerodynamic performance of the rigid sails, their mutual interactions and to characterize the unsteady loads that they experience.

The investigation will build upon the wide range of numerical and experimental tools available in the LHEEA-DAUC team to model atmospheric turbulence and its interactions with natural and artificial structures, including the LHEEA-DAUC large (26 m long, 2 m wide, 2 m high) atmospheric wind tunnel where reduced-scale atmospheric boundary layers can be reproduced allowing us to measure the performance of rigid wings in a realistic atmospheric-turbulence environment.