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Numerical simulations of fully-appended BB2 submarine at high-Reynolds number flow at 0° and 10° yaw

We study hydrodynamics of a fully appended submarine using numerical simulations. First, we solve the Reynolds Averaged Navier-Stokes (RANS) equations, and successively we use Large-Eddy Simulations (LES). The Reynolds number of the flow is ReL =9.57 x 106 and we consider two angles of yaw, 0° and 10°. The wall-layer approach is used to skip the direct solution of the thin viscous sub-layer. Numerical simulations are carried out using OpenFOAM framework. In RANS, the k-omega SST closure is adopted; in LES, the Lagrangian dynamic subgrid-scale model is used. The main differences between the two methodologies consists that RANS solves a flow field which, on average, is steady, whereas, LES provides the possibility to achieve a better understanding of the intrinsic unsteady nature of this flow, including three-dimensional turbulent vortical structures, wake and induced noise. On the other side, LES can be computationally much more expensive than RANS. Here we show the advantages and drawback of the two methodologies, in terms of accuracy and computational cost; the flow field over the submarine will be then fully characterized, quantifying the unsteady submarine's footprints in terms of their statistics, intensity and location.

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