URANS and Hybrid RANS-LES Simulations for Ship Hydrodynamics

M. Visonneau*

* Ecole Centrale de Nantes, LHEEA, CNRS UMR 6598
1, rue de la Noe, 44321 Nantes Cedex 3, France
e-mail: michel.visonneau@ec-nantes.fr

ABSTRACT

Although ships and submarines are designed to develop attached flow at cruise conditions, they also routinely develop separated flows within their broader operating envelope. Separated flow effects cause cruise performance penalties, and can often restrict vehicle operating conditions. More particularly, for the Navy fregate DTMB5415 at various static drifts studied in NATO/AVT-183 and NATO/AVT-253, it was noticed that the computations failed to reproduce saliant flow characteristics in the core of longitudinal vortices. For instance, the computed levels of turbulence kinetic energy in the core of the averaged longitudinal vortices were four to five times smaller than what was measured. To understand the reasons why statistical turbulence models fail to reproduce some fundamental features of vortex-dominated flows, this plenary lecture will provide a detailed comparison of RANS and Hybrid RANS/LES simulations of flows characterised by the presence of intense longitudinal vortices. A canonical example is provided by the US Navy frigate DTMB5415 at model scale (1:46.6 scale). The hull is un-appended except for port and starboard bilge keels. The Reynolds number is Re = 4.65×10^6 and the Froude number is Fr = 0.28. The local flow measurements performed by IIHR ([2]) provide very accurate and rich tomographic PIV (TPIV) information at several stations and, in particular, in the close vicinity of the sonar dome of the surface combatant DTMB 5415. They offer a unique opportunity to understand the local characteristics of a turbulent open separation. A systematic comparison of simulations performed with ISIS-CFD (worldwide distributed by NUMECA Int. as FINE^{TM}/Marine) ([1]) on very fine flow-adapted grids provides a rigourous assessment of RANS and hybrid RANS-LES turbulence models for the DTMB 5415 at various static drift angles. This study will be completed with a detailed flow physics analysis in the core of the main SDTV vortex, comprising tke budget, Lumley anisotropy maps, turbulence anisotropy indicators. It will be shown that the use of hybrid RANS-LES models offers a significant advantage over RANS models, particularly for the prediction of the turbulence kinetic energy in the core of the vortices, which come essentially from the resolved eddies contribution.

REFERENCES

[1] P. Queutey and M. Visonneau. “An interface capturing method for free-surface hydrodynamic flows”, *Computers & Fluids*, vol. 36(9), pp. 1481–1510 (2007).

[2] H. Yoon, L. Gui, S. Bhushan, and F. Stern. “Tomographic measurements for a surface combatant at straight ahead and static drift conditions”, *30th Symposium on Naval Hydrodynamics*, Hobart, Tasmania, Australia, 2-7 November 2014.