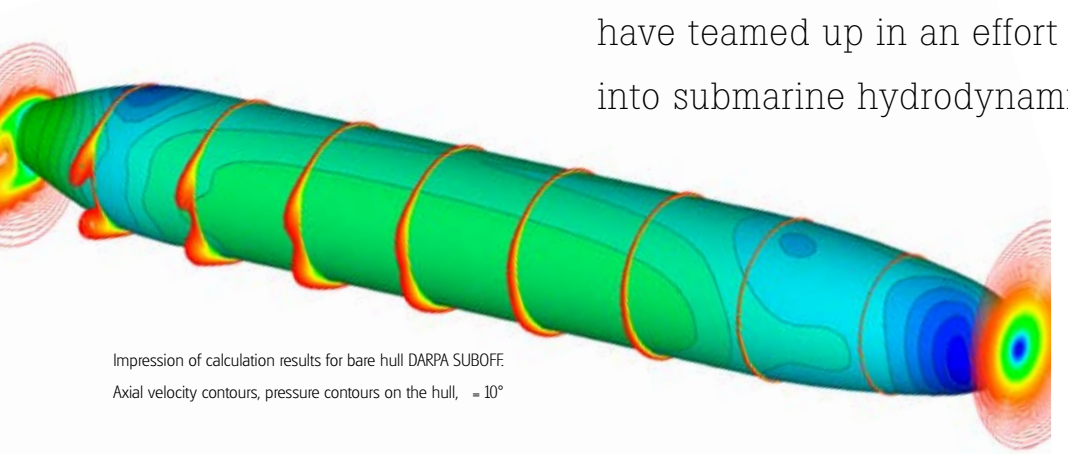
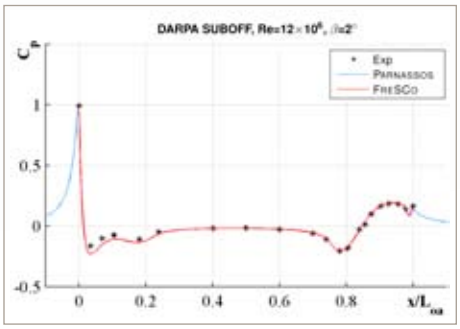
FreSCo successfully predicts **flow around submarine hull**

Safety of a submarine and its crew is paramount. To understand and predict a submarine's behaviour in extreme conditions, insight into hydrodynamics is indispensable. MARIN and the Royal Netherlands Navy have teamed up in an effort to gain more knowledge into submarine hydrodynamics.



Impression of calculation results for bare hull DARPA SUBOFF: Axial velocity contours, pressure contours on the hull, = 10°



Pressure coefficient along the length of the hull (leeward side)

One of the actions undertaken was to investigate the feasibility of accurately calculating the forces on the submarine hull and the viscous flow around the hull for straight flight, for oblique motion and for turning motion. The viscous-flow solver FreSCo is being used to predict the flow around the hull. FreSCo is a new URANS solver for general hydrodynamic purposes being used by MARIN for several different problems, from cavitation on propellers, flow around risers, semi-submersibles, to ships in manoeuvres.

Recently, FreSCo has been used to calculate the flow around the well-known DARPA SUBOFF submarine. For this test case ample validation material is available. Previously, calculations were made using MARIN's code PARNASSOS and this was also used for validation.

FreSCo calculations were conducted for a wide range of inflow angles, even up to 90°, which represents pure sideway motion. Comparisons with the experiments and with the PARNASSOS results show that the forces on the hull can be accurately predicted using CFD. For the straight flight, accurate results were obtained which is important for resistance optimisation studies. Details of the flow and the pressure on the hull were also accurately resolved. Valuable information can be gained from the results. For example, the wake field derived from the calculations can be used as input for propeller designs.

FreSCo has proven capable of reproducing experimental values for oblique inflow, representing drift or pitch angles. The calculated forces and moments can be used to simulate the manoeuvrability of the submarine and to perform Failure Mode and Effect Analysis. These calculations provide quantitative, highly-accurate insight into the flow around the hull. In the next step the calculation of the flow around the submarine with appendages will be made. These viscous flow calculations will be very valuable in supplementing model tests in the design process of submarines.

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