seakeeping simulations of a survey vessel.

A CFD APPROACH

AUTHOR: IVOR CLEINE
+31 (0)88 - 115 20 20
demcon.com/multiphysics
CONTACT US

Goal

Work vessels that operate on sea must be able to function under a wide variety of conditions. Waves impose a limit on the operational capabilities of ships.

Together with Demcon Unmanned Systems, we evaluated V2500 (3M) USV, a small unmanned survey vessel. In this case Demcon Unmanned Systems had three separate questions related to the development of this vessel.

The boat contains a sensor package mounted in a fairing on the keel. This sensor package will only function properly in water. A limiting factor in the vessel's operability is the entrapment of air beneath the vessel. The goal of this analysis is to determine whether air forced beneath the vessel while sailing at operational speed in waves of 1 m height.

Besides this main goal, the customer also wanted to be sure that the thrusters were properly aligned with the incoming flow.

Also, the customer performed their own spectral seakeeping analysis. In order to improve the accuracy of these calculations the roll damping coefficient of this vessel needs to be determined.

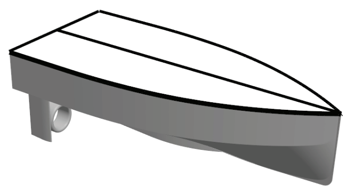


Figure 1. The small unmanned survey vessel, 3 m.

DEMCON MULTIPHYSICS
DEMCON UNMANNED SYSTEMS

Approach

For seakeeping simulations two approaches are possible. To analyze the motion of a vessel in a wave spectrum for various sailing directions, it is customary to make use of a panel method as these are numerically efficient for these types of calculations. However, panel methods cannot give insight into flow details around a vessel, as viscosity is neglected and an irrotational velocity field is assumed. A more accurate result is obtained using a CFD simulation, in which effects such as viscosity, damping and turbulence are modelled. A CFD simulation comes at the cost of increased calculation times, however. To analyze the air entrapment beneath the vessel, a CFD analysis has been performed with the vessel sailing into a regular wave with a height of 1 m. In this type of analysis, a volume of fluids (VOF) approach is used with two separate components: air and seawater. These two components were tracked throughout the simulation with each cell containing a fraction of air and a fraction of seawater.

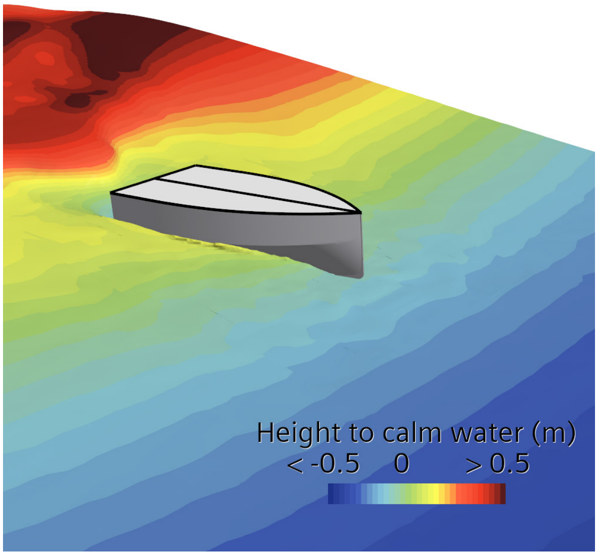


Figure 2. Seakeeping simulation in one meter head waves.

The vessel was given two degrees of freedom: pitch (rotation around y-axis) and heave (movement along z-axis). Movement of the geometric body within the mesh was accounted for by using an overset mesh approach.

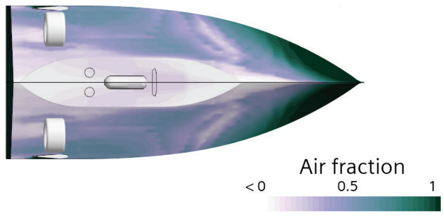
For the analysis of the thruster orientation a steady state resistance calculation has been performed. Again, the vessel was allowed movement in pitch and heave. Surface flowlines were used to judge the orientation of the thrusters.

For the roll damping a transient calculation has been performed in which the vessel was released from an inclined position. In this case the vessel had two degrees of freedom: roll (rotation around x-axis) and heave.

Results

In this analysis the fraction of air beneath the vessel was tracked. In these conditions it could be seen that the bow of the vessel came out of the water just after reaching the crest of each wave. Air was entrapped beneath the vessel, also reaching the location of the sensors.

As a result of this analysis the shape of the fairing and the location of the sensors were changed. As a result of this change, the air trapped beneath the vessel no longer reaches the sensor package.



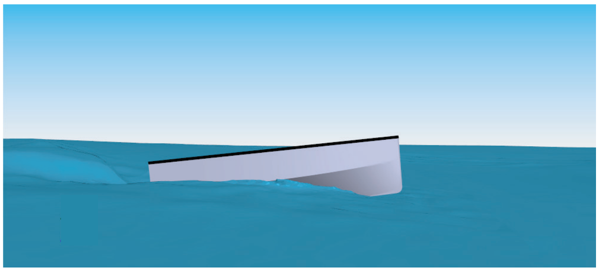


Figure 3. Air fraction close to the hull.

The flow lines from the steady state calculation show that the thrusters could be oriented inwards to achieve better alignment with the flow.

A plot of the roll angle in time was used to determine the roll damping coefficient. This was done by fitting an exponentially decreasing function through the peaks of the roll chart.

Using the results of these calculations the customer was able to refine the design of this survey vessel.

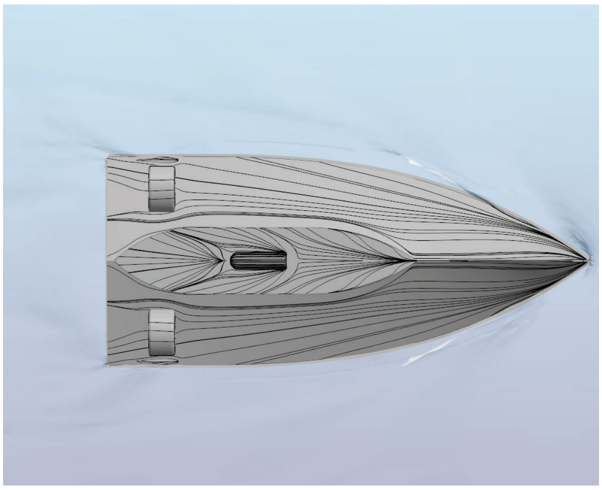


Figure 4. Flow lines of water flow close to the hull.

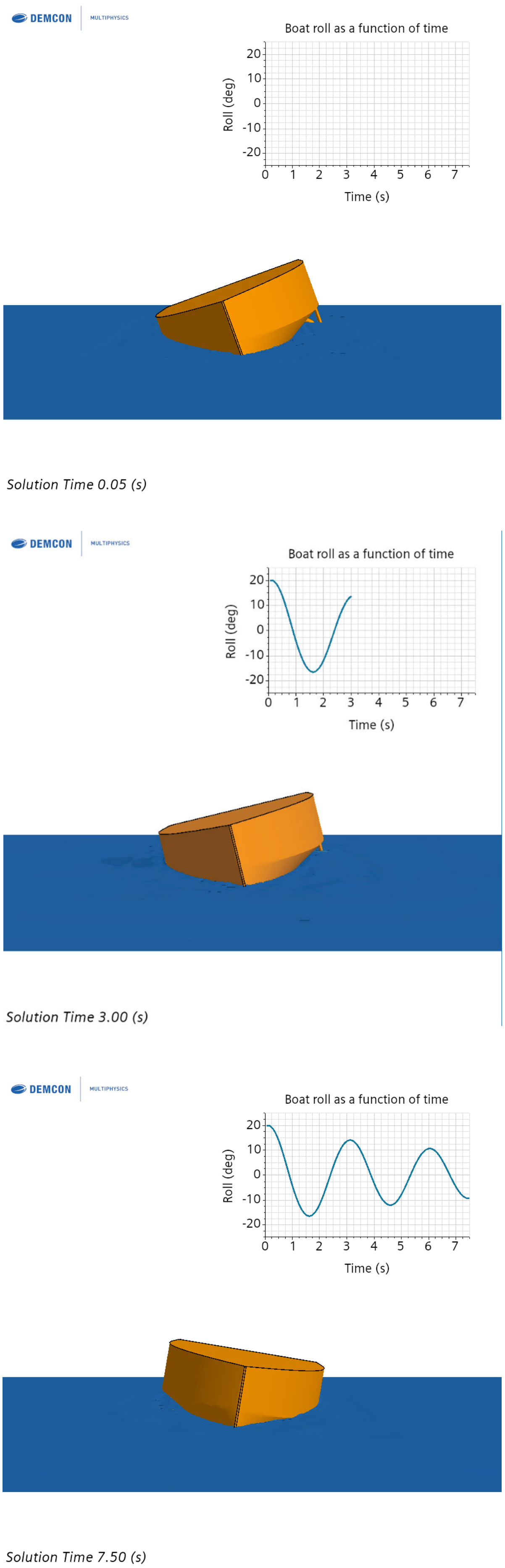


Figure 5. Boat roll and damping over time, starting from an inclined position.