America's Cup defence campaign on top form

by Nick Holroyd and Stephen Collie, Team New Zealand

Team New Zealand is the current defender of yachting's premier event and the world's oldest continuously contested sporting trophy, the America's Cup. In its 150-year history it has been contested thirty times and only on three occasions has a non-US team won. Australia II's historic win in 1983 not only ended the New York Yacht Club's 132-year winning streak, but with her 'winged' keel, perhaps more than any other boat, heralded the coming of age of yacht design as a science rather than an art.

New Zealand won the Cup from America in San Diego in 1995 with an unprecedented 5-0 score line, and in 2000, became the first ever non-US team to defend the cup successfully.

'Our results from CFX have been excellent, both in terms of accuracy and robustness of the solver'

Yacht racing is pure fluid dynamics. In fact, a yacht is an 'interface vehicle' that harnesses energy from the velocity difference between the two fluid masses that surround it. The yacht, broken down to its basic elements, has a hull that supports its weight, ballast to make it stable, and some combination of aero and hydrofoils that generate driving forces from the wind.

As designers, our objectives are simple – to design, within America's Cup Class constraints, a hull of required volume that has minimum drag, a ballast package that achieves maximum stability and minimum drag, and a set of foils (keel, rudder and sails) that provide, within the stability constraint, the maximum driving force.

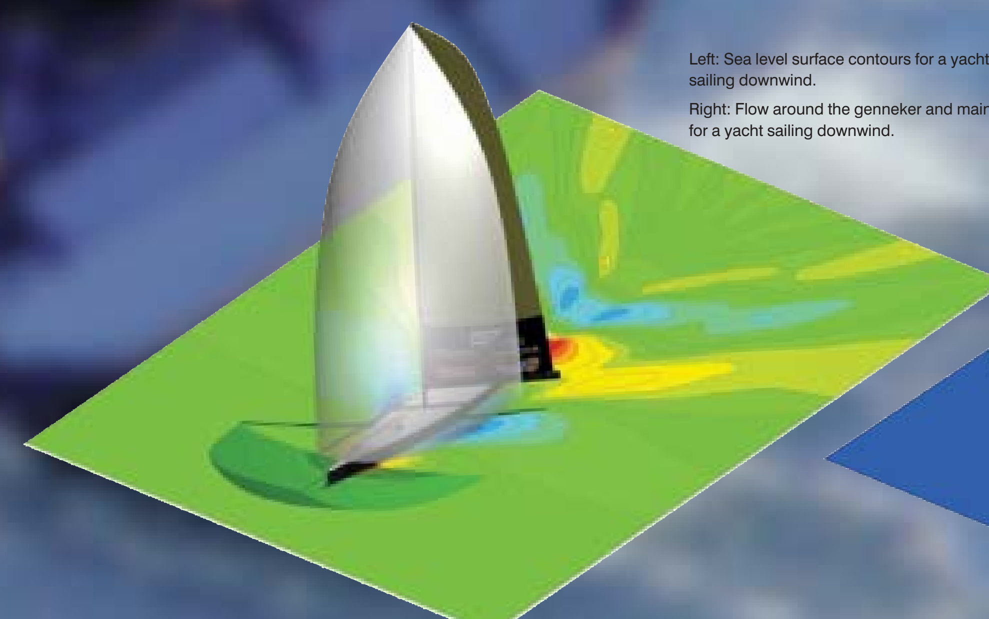
CFD offers a valuable tool to analyze all these areas and provides a level of insight that is unavailable from experimental techniques such as towing scale models. However, the CFD model must account accurately for very complex physics:

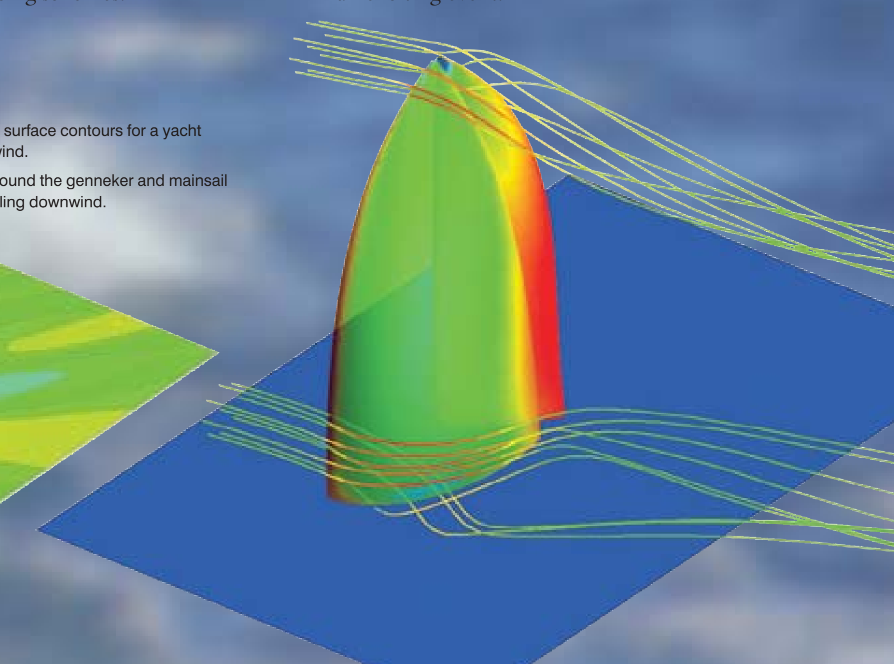
- Multiphase, to model the wave drag of the hull. The viscous region of the boundary layer acts to damp the wave system so the analysis must include these effects. The wave system extends a great distance from the hull so the solver must limit numerical diffusion through higher-order differencing schemes.
- Sophisticated turbulence models, to model the viscous drag, particularly as the keel and rudder operate at Reynolds numbers of laminar/turbulent transition, and to predict the separation points and the thick, highly turbulent wakes of the flow around the sails.

Our results from CFX have been excellent, both in terms of accuracy and robustness of the solver. In particular, we have used CFX-4 to calculate the drag on the keel bulb, experimenting with different keel bulb shapes. We are also using CFX-5 to model the sail aerodynamics and to study the induced drag on the appendages. We have been eagerly awaiting the release of CFX-5.5 to apply its new free-surface capability, in conjunction with Menter's extended turbulence model for external aerodynamics, to simulate the complete yacht.

That being said, sailing skills are huge. Our team is preparing itself by sailing the earlier boats, which we are especially thankful for as they are providing ample benchmark data for CFD validation (coming in the next Update!).

To date, ten international syndicates have issued challenges for the 31st America's Cup regatta in Auckland in 2002/2003. They comprise three American teams, two from Italy and others from the United Kingdom, Germany, France, Switzerland and Sweden. It promises to be an exciting event.





Left: Sea level surface contours for a yacht sailing downwind.

Right: Flow around the genneker and mainsail for a yacht sailing downwind.