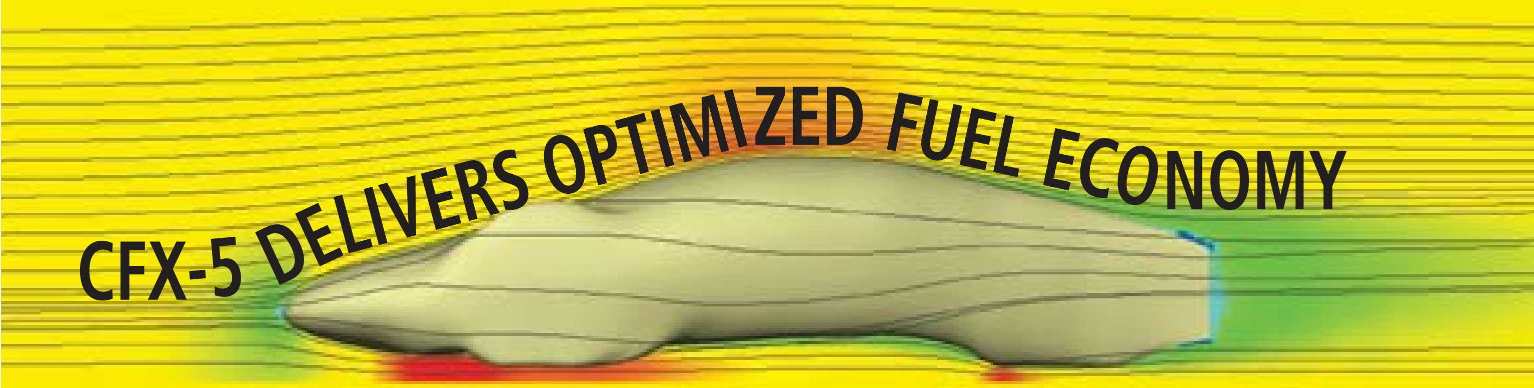
CFX-5 DELIVERS OPTIMIZED FUEL ECONOMY



Lateral view – velocity distribution in the symmetry plane.

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When a single drop of fuel can decide the winner of a vehicle economy competition, excellent aerodynamics is critical. That is what we realised at the Department of Mechanical Engineering of the University of Coimbra when we decided to enter the annual Shell Eco-Marathon contest in 1998. In this event, each prototype must cover six laps of the Nogaro circuit, at a minimum average speed of 25 km/h with only gasoline, diesel or LPG as permitted fuels. The volume of fuel consumed is then measured and an extrapolation is made for the distance the car would travel with one litre of fuel.

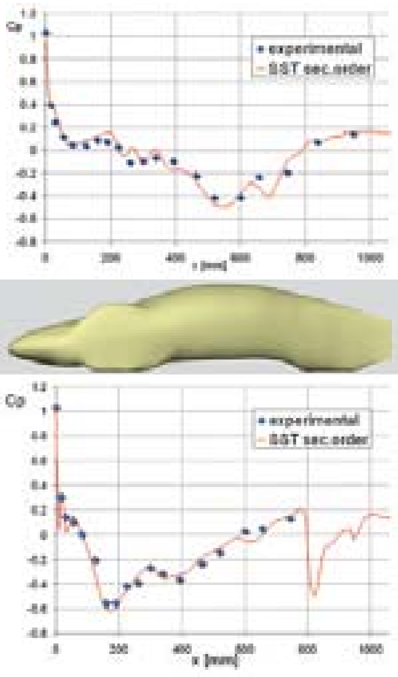
With the overall drag of a vehicle being determined by the small difference between positive and negative forces, numerical prediction is very sensitive to the accuracy of the numerics. Flow separation can compound these difficulties, though in our case, the car shape was designed to avoid any separation.

Originally, the aerodynamic design of our car, named 'Eco-Veículo', was based on our experience in aerodynamics and some numerical simulations using our in-house Navier-Stokes solver on a structured grid to tune certain aspects of the car shape. The limitations of the solver created convergence problems and we could not achieve the expected results. Predictions of the drag coefficient were almost 70 % in excess of what we felt to be the correct figure. We built the car and, in three attempts, achieved 42nd, 30th and 14th places. To improve our ranking, a better aerodynamic design was needed.

We built a 1:2.5 model and measured total force and pressure distribution in a wind tunnel. We then decided to use CFX-5.5 to predict the aerodynamic coefficients of the existing car. The unstructured grid made quite a difference and convergence was no longer a problem. After grid independence tests, where grid inflation parameters played a major role, we studied the role of advection schemes and turbulence models. We found the Shear Stress Transport (SST) model, combined with a second-order advection scheme, clearly produced the best results (calculated CD of 0.09 compared to a measured value of 0.1).

Due to time constraints, we could not realistically build a new car for this year's contest so we made some small modifications to the existing tail and wheel covers based on CFX results. Our participation at the 2002 Shell Eco-Marathon was much more successful; we were third among the universities, with a personal record of 1734km from one litre of fuel. Compared to last year's 1286km/l, this represents an increase in efficiency of 35% as a result of using CFX.

With these encouraging results, we used CFX-5 to design a new car shape. This took almost three months, and we tested some 15 to 20 different shapes. A systematic optimisation was done, starting from the general shape and camberline, ending in the detailed optimisation of the wheel covers and nose shape. This led us to an improvement of 20% in fuel efficiency relative to the previous car. We will see next year how our new car performs in the competition!



Surface pressure coefficient distribution at the car symmetry plane. Numerical values computed with the Shear Stress Transport turbulence model and second-order advection scheme.
Graph above: Top-centreline.
Graph below: Bottom-centreline.

Top view – velocity distribution in a horizontal plane at the nose level.

The "Eco Veículo Mondego XC01".

Streamlines and colour-coded surface shear stress.

'We achieved an increase in efficiency of 35% as a result of using CFX.'