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A CONSISTENT FINITE ELEMENT APPROACH TO LARGE EDDY SIMULATION REVISITED WITH HIGHER-ORDER ELEMENTS II

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During the European project **ADIGMA** (Adaptive Higher-Order Variational Methods for Aerodynamic Application in Industry) Dassault Aviation extended its stabilized finite element industrial Navier-Stokes code AeTher to higher-order elements. The high-order approach (3rd and 4th order) was carefully assessed using inviscid subsonic and transonic, laminar, and high Reynolds number turbulent flows. First results on a full aircraft configuration were also achieved [3]. They showed that spurious drag was considerably reduced by the use of higher-order elements.

In this paper, we focus on the application of higher-order elements to Large Eddy Simulation. We revisit the results of [1] where a careful second-order accurate LES model was introduced. At that time we established that second-order accuracy was sufficient for the practical utilization of LES in the industry. Today the industrial applications of LES and DES are numerous (see [2] and Fig. 1). We reconsider the use of these models in the light of higher-order elements, possibly reducing the number of grid points required per wave length and increasing the number of resolved scales for a given grid size.

We reconsider the DES of the flow past the QinetiQ M219 open cavity at a transonic Mach number. In Figure 2, we compare the results obtained with the original second-order accurate linear elements against third-order accurate quadratic elements. In both instances time integration is provided by a standard second-order accurate backward difference scheme. Both meshes contain the exact same number of degrees of freedom. One can notice a more rapid transition to 3-D flow and finer turbulent structures in the higher-order solution. Early analysis suggests that higher-order elements reveal the limits of simple subgrid-scale models, such as the underlying Smagorinsky model in DES, in a stronger way than mesh refinement with standard second-order elements. The impact of a selective Smagorinsky model is shown in the light of higher-order elements. Additional gain is expected with higher-order time integration combined with quadratic or cubic elements.

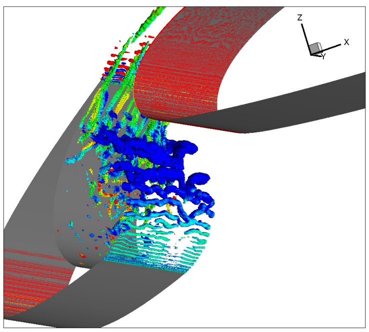

Figure 1: Turbulent structures behind the leading-edge slat of a high-lift configuration.

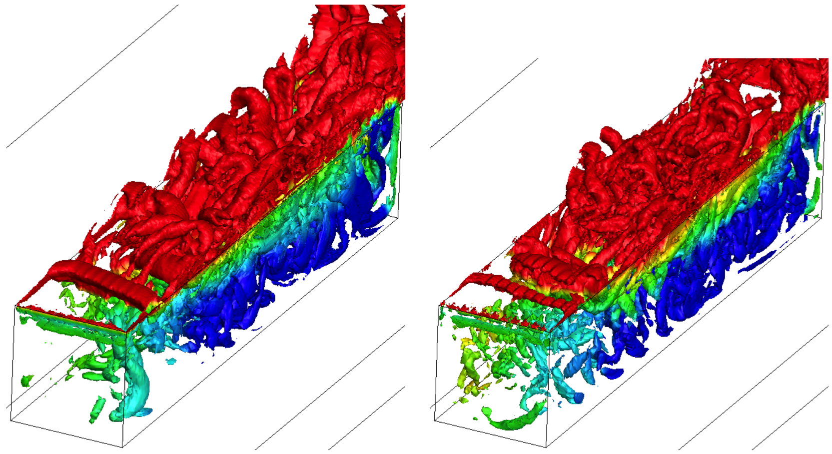

Figure 2: Turbulent structures in the QinetiQ M219 cavity: standard 2nd-order linear P1 elements (left) vs. 3rd-order quadratic P2 elements (right).

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