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# Variational Multiscale Large Eddy Simulation and Anisotropic Mesh Adaptation for Transient and Turbulent Flows

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Aerodynamic characteristics of various geometries are predicted using a finite element formulation coupled with several numerical techniques to ensure stability and accuracy of the method. First, a simple edge based error estimator and dynamic anisotropic mesh adaptation are used for detecting sharp gradients, inner and boundary layers under the constraint of a fixed number of elements, thus controlling the computational cost. Then a Variational MultiScale (VMS) stabilized finite element method is employed to solve the incompressible Navier-Stokes equations [1]. The basic idea is to consider that the unknowns can be split in two components, coarse and fine, corresponding to different scales or levels of resolution. By solving first the fine scales and then replacing their effect into the large scales, we obtain a new system that acts as an implicit Large Eddy Simulation (ILES). However, it requires tuning of the stabilization coefficients in both the convective and diffusive terms to take into account highly stretched elements with an anisotropic ratio of the order of $O(1:1000)$.

Finally, the interested part of this talk, we want to verify how accurate may become combining anisotropic unsteady mesh adaptation with the ILES method and how the solution behaves in particular near the boundary layers when compared to DNS results. Therefore, several test cases and confrontation with literature are proposed. The simulation of flows past a 3D F1 car, a large scale airship and a drone with complex geometries will highlight the capability of the proposed techniques (see Figure 1).

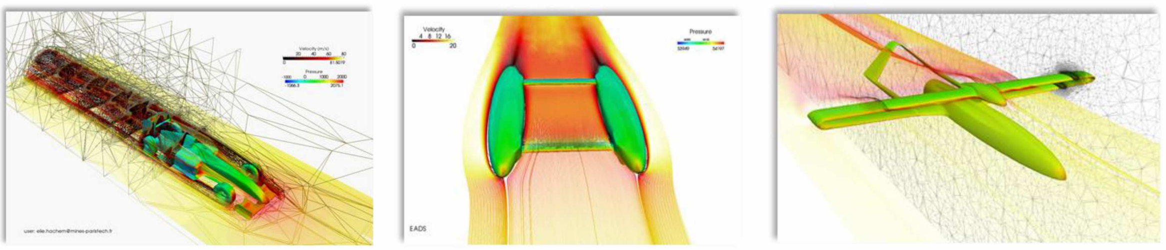

*Fig. 1 Turbulent flows past different immersed complex geometries*

## REFERENCES

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