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SCALE-RESOLVING MODELLING OF COMPLEX TURBULENT FLOWS

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ABSTRACT

While industrial CFD simulations have been and are still dominated by Reynolds Averaged Navier-Stokes (RANS) models, there is an increased recognition that scale-resolving methods are required to satisfy the broadening needs of the user community. There are two major scenarios behind this trend. The first comes from the well known limitations of the RANS approach for flows far outside its calibration envelope. The second driver is the need for spectral information in diverse areas like acoustics, unsteady structural excitation or combined physical effects like vortex cavitation. Historically, the two approaches for the simulation of unsteady flows have been U(nsteady)RANS and Large Eddy Simulation (LES). Unfortunately, both concepts have only limited value in industrial CFD simulations. Classical URANS does only produce single scale/single mode large scale unsteady structures, which are often unphysical and which do not provide the reliable increase of accuracy required in the first scenario nor the spectral information required in the second. LES on the other hand has never been able to overcome its excessive resolution requirements for near wall flows even at moderate Reynolds numbers. LES has therefore had its successes in industrial CFD simulations largely for free flows, like observed in combustion chambers or free jets behind aircraft engines etc. Obviously, most industrial designs involve walls and boundary layers play a major role in there performance, excluding pure LES as a viable solutions strategy.

Spalart [1] was the first to recognize the potential of combining RANS and LES components in a single flow domain. The resulting Detached Eddy Simulation (DES) approach was eagerly absorbed into aerodynamic and commercial codes and allowed for the first time the combination of high-Reynolds number boundary layers with the scale-resolution of large separated regions in one simulation. On the downside, DES has resulted in a multitude of variants [2], with often only subtle differences making it increasingly difficult for industrial users (and code developers) to decide on the optimal approach for a given technical application.

The presentation will give an overview of how the authors' organisation approaches the complex area of RANS/LES combined modelling. It will cover diverse approaches like Scale-Adaptive Simulation (SAS) [3], various forms of DES all the way to the explicit interfacing of RANS and LES [4] regions in a single domain. Numerous applications will highlight the pros and cons of the different concepts.

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