Development of the discontinuous Galerkin method for LES of wall bounded flows in industrial geometry - current status and prospects

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Aeronautical and in particular propulsion industry is looking towards integrating unsteady, scale-resolving approaches to simulating turbulent flows in their design chain. This is motivated by the need to provide better predictions for transitional and separated flows, noise generation and flow instabilities, and fueled by the tremendous increase in available computational resources. Indeed, as these approaches simulate the most energetic of the turbulent structures, high accuracy, and hence high resolution, is required.

Whereas high accuracy codes have been used in academia for this type of simulations, these methods are geometrically not very flexible and hence difficult to use in industry. Current industrial CFD methods on the other hand usually are only second order accurate, which leads to much higher resolution requirements. The advent of novel unstructured high-order discretisation techniques holds the promise of combining academic precision on complex meshes, whilst providing high computational efficiency. As industry still has to define its practices for scale-resolving simulations, there is a window of opportunity for introducing these methods, thereby considerably increasing simulation reliability and capacity of scale-resolving simulations with respect to what could be obtained with state-of-the-art CFD tools.

The introduction and assessment of scale-resolving methods in unstructured high-order methods is currently an important subject of research, even more so due to the strong interplay between model and discretisation. The current paper adresses this topic for the discontinuous Galerkin method, arguably one of the most mature of the new methods. Therefore validation results are discussed on academic benchmarks (plane channel, homogeneous isotropic turbulence, 2D periodic hill) and more practical examples (transitional airfoils, low pressure turbine blades). Some - for the moment - heuristic explanations are given towards the observed results.