Session:

Hybrid RANS-LES study of transonic flow in the wake of a generic space launch vehicle

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Introduction

Strong dynamical loads on the nozzle structure of space launch vehicles during ascent can cause severe deformations and may lead to complete failure of the engine. This phenomenon, known as base buffeting [1], is caused by the abrupt flow separation at the base of the main body and subsequent reattachement on the nozzle.

In order to better understand this phenomenon and to assess mitigation strategies, CFD simulations of a simplified geometry in transonic flow are conducted. Good results for such geometries have been shown in the literature [2] using structured grid approaches.

This work uses different hybrid RANS-LES turbulence modelling strategies to validate this approach on unstructured grids which are more suitable to complex geometries like Ariane 5.

Computational Setup

The computational setup models the wind tunnel experiments of [3] for an axisymmetric afterbody with a diameter D = 100 mm including an attached inner cylinder with a diameter of d = 40 mm (see Fig. 1). The protruding wake cylinder represents the nozzle structure in a realistic launch vehicle.

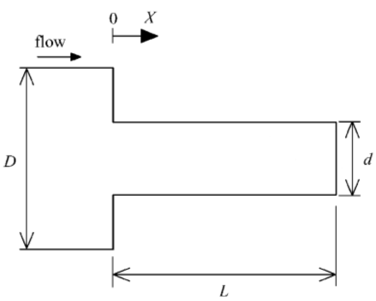

Fig. 1: Geometric setup

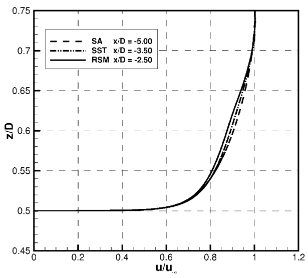

Fig. 2: Boundary layer profile

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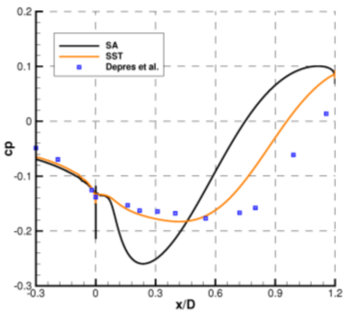
The wind tunnel experiments were conducted using air at atmospheric conditions and a Mach number of 0.7. In order to match the experimentally reported boundary layer structure (see also [4]), a suitable boundary layer profile (Fig. 2) is extracted from precursor simulations and used as an inflow condition.

A hybrid mesh consisting of about 0.9 Mio. grid points is generated. It covers a 15° segment of the domain and uses periodic boundary conditions in azimuthal direction.

All simulations are carried out using the compressible DLR-TAU code [5]. A 2nd order low dissipation central scheme is used together with different DES approaches available in TAU.

Preliminary Results

Previous calculations (Fig. 3) using steady RANS models poorly capture the wake structure. It is expected that a hybrid RANS-LES approach is more suitable for such inherently unsteady flows and that it will give a better account of the recirculation zone.



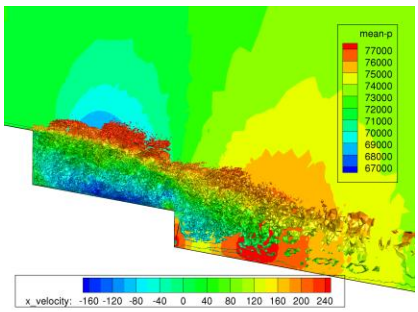


Fig. 3: RANS c_p distribution **Fig. 4:** Q isocontours using SST-IDDES

References

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[3] D. Deprés et al.: Analysis of Unsteadiness in Afterbody Transonic Flows. AIAA Journal, Vol. **42**, No. 12, 2004

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