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# Hybrid RANS/LES simulation of a space launcher using an high order finite volume scheme and grid intersections technique

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## Introduction

In this study, we apply a numerical strategy, based on high-accurate finite volume numerical schemes and advanced turbulence models, to calculate efficiently the pressure fluctuations and the dominating frequencies in the recirculation zone of spatial launchers using the FLUSEPA solver, developed by Airbus Defence & Space.

## Hybrid RANS/LES model

In our opinion, there are specifications that a model has to respect to be well suited for massively separated/reattached flows. First, the model must preserve the RANS mode in attached boundary layers, then, the Kelvin-Helmholtz instabilities must trigger without delay in shear layers, also, the model has to be fully self-regulating (user independence) and finally, the model has to be well posed in order to ensure robustness.
After an assessment of different hybrid RANS/LES models we chose a DDES[1] approach based on the Catris and Aupoix[2] “density corrected” version of the Spalart Allmaras RANS model and improved by the flow dependent turbulent length scale of Chauvet[3] that we modified to be suited to general grids[4].

## Hybrid numerical scheme for hybrid RANS/LES strategy

In the aerospace domain, highly compressible flows require the use of robust numerical schemes. On the other hand, the simulation of turbulence imposes high-order low dissipative numerical schemes. These two specifications, apparently contradictory, must coexist within the same simulation. The coupling between turbulence models and discretization schemes is of the utmost importance and must be considered. Numerical schemes should keep their formal accuracy on complex geometries and on irregular meshes imposed by the industrial context. Originally, the numerical schemes used in FLUSEPA are well suited for compressible flows simulations and thereby, possess a too low resolvability related to a

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too high numerical dissipation for RANS/LES simulations. To circumvent this problem, we considered a conditional and local re-centering strategy: in regions dominated by vortical structures, an analytic function provides local re-centering when a numerical stability condition is satisfied. This stability condition ensures an efficient coupling between the numerical scheme and the model. In this way, both the turbulent and the laminar viscosities play a role in regions dominated by vorticity, and also allow to stabilize the numerical scheme[4].

## 3D grids intersections to mesh complex geometries

The CHIMERA-like fully conservative meshing strategy used in the solver FLUSEPA is based on a 3D geometric intersection process[5,6]. In the case of a space launcher, for example, the user meshes independently each part of the launcher, with their own boundary layers, and then, specifies the level of priority between the grids. Refinement patches can be added to increase locally the resolution of the grid in LES regions of the flow.

## Ariane 5 space launcher simulation

We compare a calculation of a 1/60 scale wind tunnel model of the Ariane 5 launcher at Mach 0.8 and 1.2 to experiments: mean and fluctuating pressure but also power spectral density of pressure.

## Reference

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