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Session:

An Automated Zonal Detached Eddy Simulation Method for Transonic Buffet

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We present a new zonal DES approach which automatically determines the RANS/LES interface definition. The aim of this Automated Zonal Detached Eddy Simulation (AZDES) method is to capture the phenomenon of transonic buffet which is possible with URANS simulations, but poses challenges for classical DES-type approaches, as shown by Schulte am Hülse [1]. In contrast to the zonal DES, as proposed by Deck [2], the AZDES requires less effort from the user defining RANS and LES zones, as they are derived from a preceding URANS simulation. This hybrid RANS/LES model is demonstrated using the supercritical OAT15A airfoil as well as on the Common Research Model (CRM) airplane configuration.

AZDES approach

Similarly to Deck's zonal approach [2], we defined a blending function f_a which separates the RANS and LES zones. This function determines the RANS/LES interface based on the presence of separated flow, which is determined using the turbulent RANS length scale L obtained from a URANS simulation. A sketch of this variable is shown in Fig.1. The extent of the LES area can be influenced using a user-defined cutoff value L_{cutoff}. Fig. 2 shows the resulting blending function and the influence of $L_{cutoff.}$

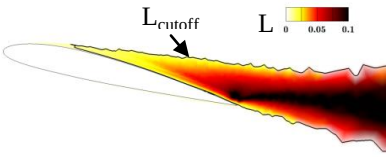

Fig. 1: Accumulated turbulent length scale L from URANS simulation.

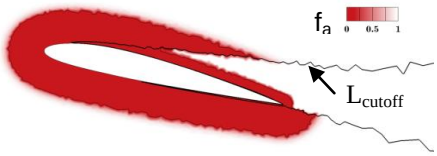

Fig. 2: Blending function f_a.
Red: RANS-area, white: LES area.

Use cases

Investigation of the AZDES model with the OAT15A supercritical airfoil showed only minor influence on buffet frequency and shock motion in comparison to URANS, which is desirable. Furthermore we observed an

increase of three-dimensional turbulent structures in the wake. The CFD results were compared with experimental data of Jacquin et al. [3].

Transonic buffet simulation on transport aircraft

A demonstration of the AZDES model in the context of a practical aircraft buffet use case was carried out using the CRM configuration. Figs. 4 and 5 show the turbulent wake behind an area of shock induced flow separation in means of λ_2 isosurfaces. The increase of three dimensional turbulent content when using the AZDES model (Fig. 5) is clearly visible in comparison to URANS (Fig. 4). The simulations were performed using the SSG/LRR-ω RSM. The benefits of the AZDES approach over the URANS formulation in terms of turbulent wake simulation will be demonstrated.

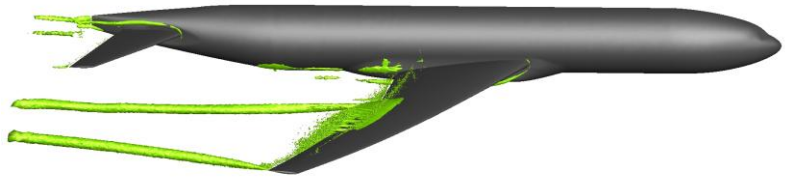

Fig. 3: λ_2 = -1 isosurfaces at the CRM, SSG/LRR-ω URANS

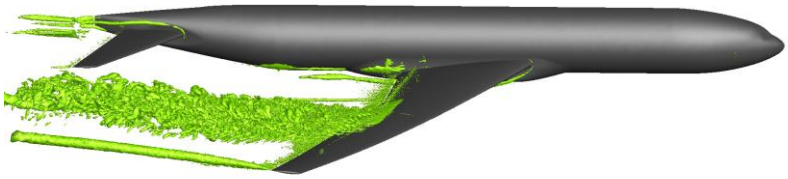

Fig. 4: λ_2 = -1 isosurfaces at the CRM, SSG/LRR-ω AZDES

References

[1] Am Hülse, S. "Simulation transsonischen Buffets an Transportflugzeugen mittels hybrider RANS-/LES Verfahren" Ph.D. thesis, Universität Stuttgart, Aug. 2015.

[2] Deck, Sébastien. "Numerical simulation of transonic buffet over a supercritical airfoil." AIAA journal 43.7 (2005): 1556-1566.

[3] Jacquin, L., Molton, P., Deck, S., Maury, B., and Soulevant, D. "Experimental study of shock oscillation over a transonic supercritical profile" AIAA journal 47.9 (2009) 1985-1994