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3D viscous flow analysis on wing-body-aileron-spoiler configurations ☆

Dreidimensionale reibungsfreie Strömungsuntersuchungen an Flügel-Rumpf-Querruder-Spoiler Konfigurationen

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Abstract

The paper presents the configuration requirements and the strategy of mesh generation for wing-body configurations including spoilers and ailerons. Samples of final mesh features are shown, convergence issues are addressed and a number of sample solutions are discussed with respect to varying incidences, spoiler and aileron deflections and Reynolds numbers. The effects are discussed and compared with measurements.

Zusammenfassung

Der Beitrag beschreibt die Konfigurationsanforderungen und zugehörige Vernetzungsstrategien im Fall von Flügel-Rumpf-Konfigurationen mit Spoilern und Querrudern. Exemplarisch werden Details von Rechennetzen gezeigt, Konvergenzfragen angesprochen und einige Beispielrechnungen bei unterschiedlichen Anstellwinkeln, Spoiler- und Querruderausschlägen sowie bei variierenden Reynoldszahlen vorgestellt. Die erzielten Ergebnisse werden diskutiert und mit Experimenten verglichen.

Keywords: HiReTT; Aileron; Spoiler; CFD; Chimera

Schlüsselwörter: HiReTT; Querruder; Spoiler; CFD; Chimera

1. Introduction

Complete understanding of active wing control elements such as spoilers and ailerons is a considerable challenge in modern aircraft design. These elements are used for aerodynamic load alleviation of a transonic wing. Consequently, reliable CFD prediction capabilities are needed for this class of complex configurations in industrial aerodynamic design.

This challenge is tackled within the European aeronautics project "HiReTT" [13] (High Reynolds Number Tools and Techniques) co-ordinated by Airbus UK. In the HiReTT project, viscous flow simulations are required over complex geometries such as wing-body configurations including deflected spoilers and ailerons.

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Here, the main objectives are to assess the feasibility of current structured Chimera methods applied on complex aileron/spoiler configurations and to assess the capability of numerical predictions compared with experimental results.

The strategy of mesh generation resembles the following steps:

- A basic (structured) grid of sufficient resolution throughout the viscous flow field domains which defines the baseline wing-body configuration was generated using the grid-generation system INGRID (in-house code).
- A local mesh around a deflected spoiler/aileron geometry is embedded in the basic grid using overset grid techniques (Chimera). This mesh was created using the grid generator MegaCads (DLR).

The 3D Navier–Stokes code FLOWer (DLR et al.) was applied on a variety of wing/body configurations including spoilers and ailerons using the standard Wilcox k–ω turbulence model. Encouraging results were obtained computing for different conditions such as different incidences, different deflection angles and different aileron gap sizes.

The results of this paper are compared with experimental results that were obtained within the HiReTT project in the European Transonic Windtunnel (ETW).

2. Grid generation

Several choices for mesh generation around the configurations of interest were considered. Since it was mandatory to remesh only small areas of geometrical changes as for instance a deflected spoiler while maintaining a grid independent flow solution in the remaining domain, single block unstructured methods were considered to be unsuitable. An unstructured Chimera method unfortunately was unavailable at the time of this study and a true multi-block structured grid generation was too time consuming. Therefore, a structured Chimera technique has been applied that combines a fast local remeshing with a preserved grid in the remaining domain. The applied technique for this method is described in Table 1.

First a "Base Mesh" (CO topology, single block) was generated around a clean wing-body configuration. The resolution of the boundary layers over both, wing and fuselage was controlled in the usual fashion by limiting the non-dimensional near-wall step size to approximately $y^+ < 2$ over the wing depending on the prescribed Reynolds-number. The generation of the base mesh was achieved in a fully automatic manner by applying the in-house mesh generation system INGRID [2]. The resulting base mesh consists of approximately 2.4 million cells within a single CO block.

Table 1
Applied meshing techniques for different devices

	Deformation on single block	Chimera technique
Spoiler	NO	1C- and 2H-Blocks
Aileron	YES	3C- and 4H-Blocks
Inboard Tab	YES	NO

Secondly, a local grid was generated by using the interactive grid generator MegaCads [14], developed by DLR (Deutsches Zentrum für Luft- und Raumfahrt). Here, the local spoiler and aileron meshes are compounds of C and H grid blocks, allowing for minimized cell distortion and by this, resulting in an increased overall grid quality.

The best solution for the local meshes was found by creating a local CH-mesh around either the spoiler or aileron (see Fig. 1) and extending it beyond the side edges of the spoiler/aileron-device in spanwise direction. The resulting grid gaps on each side next to the spoiler/aileron were filled by local mesh extensions of HH topology (see Fig. 2).

In case of aileron meshing, to enclose the entire gap, the wing areas next to the aileron had to be meshed according to the aileron topology. This required introducing an additional CH-block around the wing that extends into the gap area. In addition, it required introducing another HH-blocks

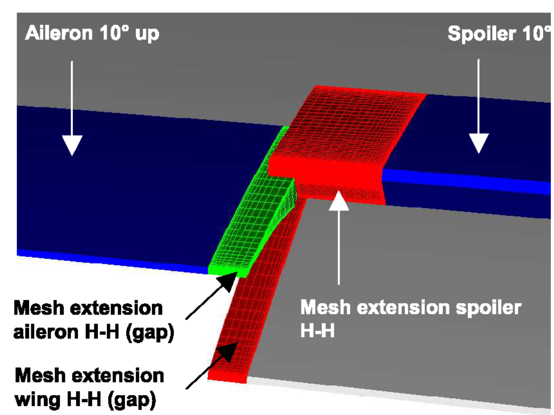

Fig. 1. Embedded spoiler and aileron meshes.

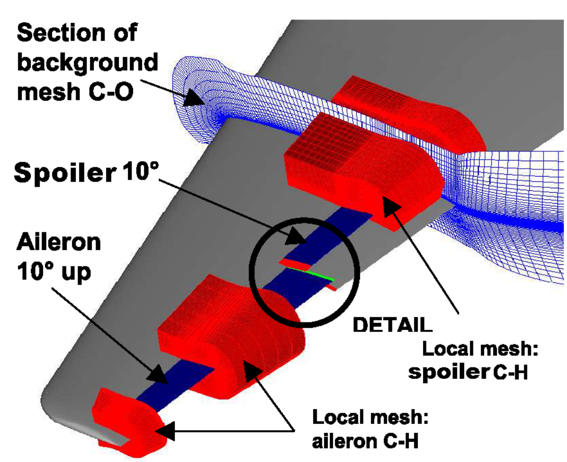

Fig. 2. Detail, view from behind: Local aileron/spoiler mesh extension blocks.