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OPTIMISATION OF SUPPORTS FOR HIGH REYNOLDS NUMBER TESTING

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ABSTRACT

High Reynolds number testing of complete aircraft configurations necessitates the use strong supports to buoyancy effect and the interference with the aircraft model requires careful adjustment of the wind-tunnel onset flow conditions to match the anticipated effective freestream conditions. Moreover, the measured data have to be processed in order to correct for the support impact. To reduce the required wind-tunnel corrections supports are desired that show minimized interference with the wind-tunnel model. Within the European FLIRET project different types of supports for high Reynolds number testing were optimized with regard to minimize the interference effects.

In the present paper the CFD-based design and optimization of a minimum size straight sting for application in the European ETW cryogenic wind tunnel are described. To conduct these investigations the institute’s aerodynamic analysis and optimization environment POEM was applied. This process chain involves a RANS solver and a methodology for automated script-based generation of high quality block-structured finite volume RANS meshes. Grid generator and solver are linked via a process integration tool that incorporates several direct numerical optimization schemes and a DOE procedure.

The first phase of the study was dedicated to the investigation of the general interference effects and the derivation of appropriate criteria to assess and to quantify the interference effect. Beside the support impact on the aerodynamic forces on the aircraft model, the influence on the wing pressure distribution and shock location was considered. In a second phase the sensitivity of the interference criteria towards characteristic shape modifications of the support was examined. These investigations clearly showed that the freestream Mach correction, that is introduced to ensure the intended effective Mach number at the model location, strongly depends on the detailed support shape. As a consequence, an individual adequate Mach correction has to be introduced for each support shape of interest to allow for a fair assessment. With the

present parametric support design, therefore, the Mach correction was specified for each individual shape variant based on an inner optimization loop. More precisely, the onset flow Mach number was adjusted such, that the RMS value of the wing pressure deviation of the sting-on compared to the sting-off configuration was minimized. In order to study the impact of different geometric support properties and to obtain insight in their effects on interference a Design of Experiments study was conducted. The final support design shows reduced interference compared to the standard straight support even though the gain was limited as the new design has to meet certain severe geometric constraints and structural requirements. Beside reduced interference drag and less impact on the wing pressure distribution, the new support showed smaller base pressure variations. Meanwhile the new support, denoted MSSS (minimum size straight sting), is manufactured and has been successfully tested in an ETW campaign.

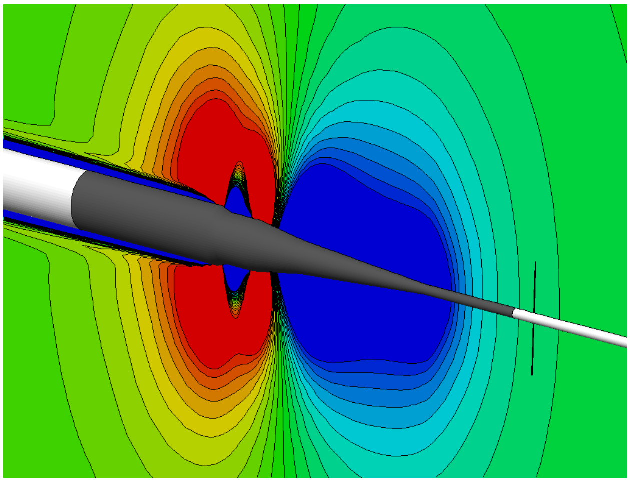

Figure 1: Impact of an isolated support on the flow field

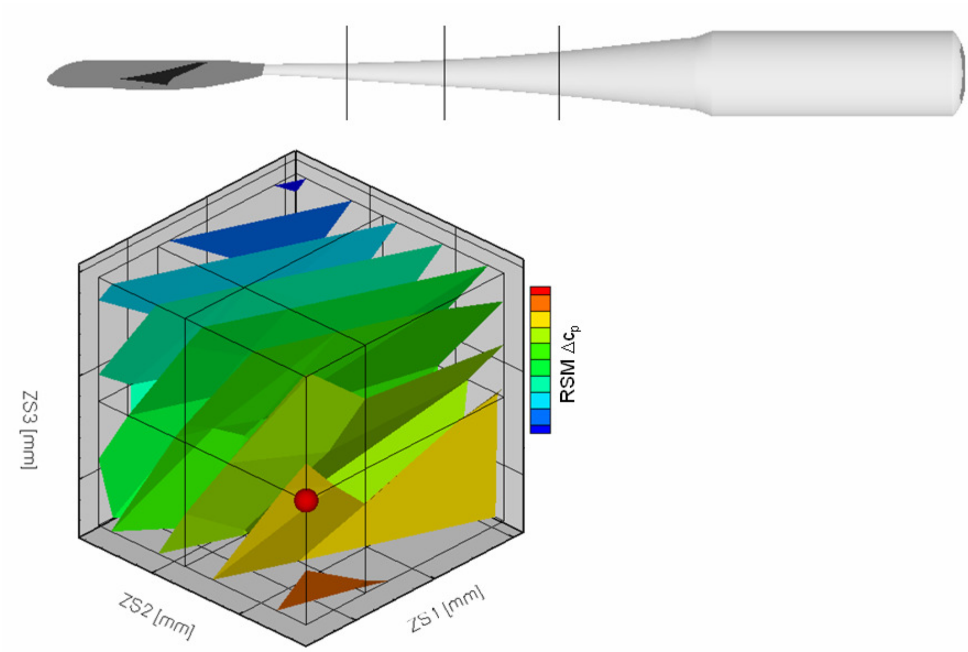

Figure 2: Design of Experiments study on the impact of the support cross section distribution on interference