Mitteilung

Projektgruppe: **Hochagile Konfigurationen**

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Thema: **Validation of computational fluid dynamics simulation methods for turbulent subsonic and transonic flows about missile configurations (GARTEUR AG 42)**

Initial situation:
For the optimisation of the aerodynamic performance of missiles during its design process, it is essential to have codes that are validated for complex flow phenomena such as flow separation, which occur during manoeuvring flight at high angles of attack. Hence, after its predecessor (GARTEUR action group 24, [1]) another action group was initiated in 2004 (GARTEUR action group 42) with the aim of the validation of the CFD-codes of the participating partners and that was finished mid of this year. For the validation of different codes two Tasks were created based on wind tunnel experiments [2] so that validated data sets were available for comparison. For the DLR, the calculations were performed with the internally developed TAU-code.

Aim:
The objective of this action group was the investigation of the applicability of different structured and unstructured CFD-methods employing the Navier-Stokes equations on a missile configuration under different angles of attack ranging from $0° < \alpha < 20°$ and asymmetric roll position of the fins at transonic speed of $M = 0.8$ in Task 1. Here, global and local forces were compared as well as pressure coefficients that were available in cross sectional cuts and along the body's centreline. Task 2 encompassed the flow around a missile at an angle of attack of $\alpha = 45°$ at $M = 0.2$. Also, measured forces and pressures coefficients were available for the validation of the code.

Procedure:
For Task 1 one case was prescribed as mandatory case ($\alpha = 10°$). This case was chosen to do the first comparisons between the experiment and the different numerical calculations. A structured as well as an unstructured grid was provided to keep the number of different applied grids small. Also DLR provided an unstructured grid for other participants. Afterwards the other 4 cases were calculated and compared. For Task 2 also grids were exchanged to see the effect of different grids on a code. The DLR calculated on a grid provided by the FOI (Sweden), which was enlarged in the farfield by Chimera-Technique as the calculation domain was too small for a the calculation.

Results:
Analysis of the results shows that the agreement between the numerical simulations of the pressure distributions as well as global and local forces was very good. The pressure coefficient, here only in the longitudinal cut [Fig. 1] shows that an offset to the experiment existeted which will be discussed in the presentation. Also the normal force coefficient [Fig. 2] shows excellent agreement between the different models. Iso-surfaces of total pressure (not shown here) reveal differences in the grid resolution and that the existing vortices have been captured in different qualities caused by different grid adaptations, but as the forces and pressures agree so well, the influence of the different resolution of the vortices seems to be very small.

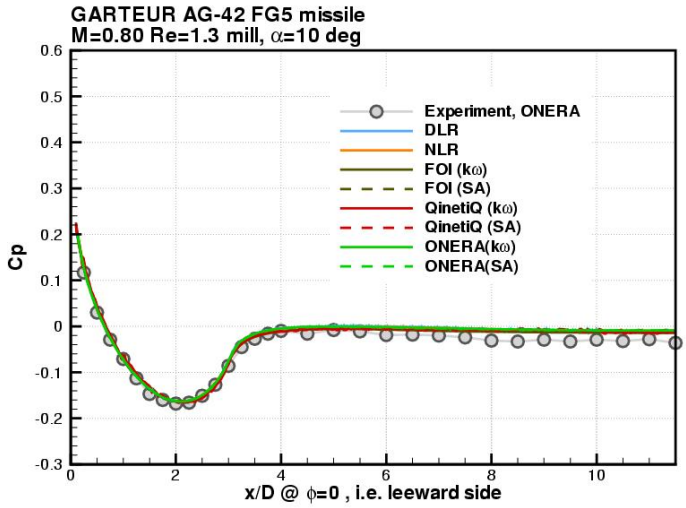

Fig. 1: The diagram of the pressure coefficients of Task 1 along the body shows the comparison of all participants incl. experimental data. The numerical data show an off-set to the experiment but agree very well in the result. Applied turbulence model of DLR was also Spalart-Almaras (Edwards modification).

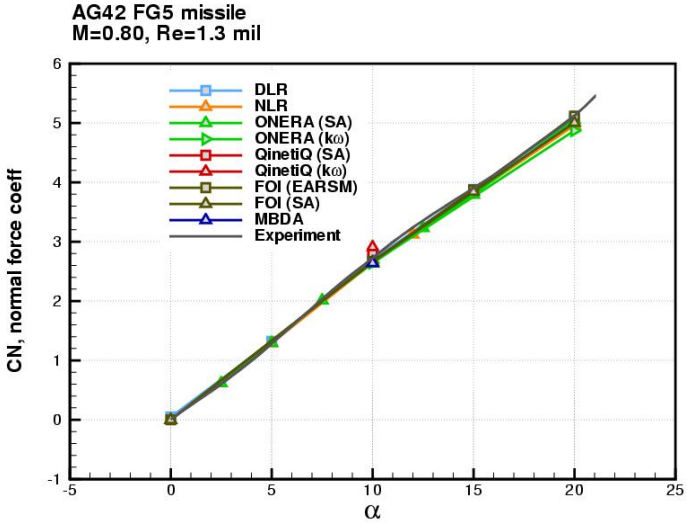

Fig. 2: The diagram of normal force coefficients of Task 1 shows the comparison of all participants incl. experimental data. Applied turbulence model of DLR was also Spalart-Almaras (Edwards modification).

Literature:

[1] P Champigny: "Proposal for the establishment of GARTEUR Action Group on missile aerodynamics: Validation of Navier-Stokes for generic missile configurations at supersonic flow", GARTEUR, 1994

[2] P Champigny, P d'Espiney, M Bredif, H Broussard, JP Gillyboeuf, Y Kergaravat: „Numerical Simulation of Vortex Flows Around Missile Configurations", Proceedings of RTA/AVT Meeting on Vortical Flows and High Angle of Attack, Loen, Norway, May 2001