Summary. The project NHLRes ([1], [2]) is concerned with the simulation of aircraft aerodynamics and thus belongs to the research field of computational fluid dynamics (CFD) for aerospace applications. NHLRes comprises the numerical simulation of the viscous flow around transport aircraft high lift configurations based on the solution of the Reynolds-averaged Navier-Stokes equations. The project NHLRes consists of five parts representing the analysis of complex 3D-flow features, wake vortex simulation, optimization for three-dimensional high lift flow, aerodynamic interactions between the propeller and high lift wings and finally the usage of large eddy simulation (LES) of the flow around high lift configurations.

1 Introduction

1.1 Overview of the project NHLRes

The HLRS project “Numerical High Lift Research” - NHLRes belongs to the research field of computational fluid dynamics (CFD) for aerospace applications. The project objective has been to push forward three-dimensional numerical investigations related to transport aircraft high lift configurations based on methods for the solution of the Reynolds-averaged Navier-Stokes equations. The report presents the results obtained in the second part of NHLRes II and the initial phase of NHLRes III. The preceding results of NHLRes can be found in [1] and [2].

The follow-on project NHLRes III, which started in 01/2004 continues the preceding investigations in the areas of analyses of wing root aerodynamics, numerical optimization, and wake vortex studies of high lift aircraft configurations. In addition, two new sub-activities which also belong to the area of high lift research been included in NHLRes III: First the detailed aerodynamic investigation of the aerodynamic interactions between propeller, wing and high lift systems and the evaluation of the potential for an optimized integration. Second the applicability of large eddy simulation (LES) for the
flow around a high lift configuration will be assessed to improve the physical modeling of the high lift turbulent flow.

All five research fields are characterized by very high requirements of computational resources. The analyses task due to the high total grid point number, the optimization task due to the fact, that the analyses is embedded in an optimization procedure and thus is repeated several times within an optimization run. The wake vortex investigations due to the time-accurate viscous computations, the propeller-wing interaction due to time dependent simulation and finally the large eddy simulation of high lift airfoils due to the required small scale resolution and also time dependent simulation.

In the following sections the results of the second part of NHLRes II are described. Further on, because of the early stage of NHLRes III, only preliminary results of the sub-task "propeller-wing interaction" are shown.

2 Wing-Root Aerodynamics at High Lift

2.1 Introduction

The preceding activities within NHLRes in the year 2001-2002 are concerned with a systematic numerical study (of the wing/fuselage intersection) and variation of geometric features, especially slat end plate devices and the wing/root fairing. The objective has been to determine the impact of such type of devices on the maximum attainable lift and the validation of numerical results against wind-tunnel data.

After a detailed analyses of simulations with geometry variations, differences between measurement and simulation remained, that could not be explained on the basis of available results. In the last two annual reports ([1], [2]) some possible reasons are investigated: differences between semi-span and full-span model tests, vortex motion of the slat-horn- and body-vortex, improvement of the solution resolution with preconditioning, improved CAD-model of the wind-tunnel model and turbulence modeling (SARC) to improve vortex resolution.

A special example for the usage of preconditioning for high lift flows, even so with interesting results is presented here: the simulation of a static aircraft in high lift configuration with a running engine. Beside the direct usage for jet blast simulation, clearance areas around the engines or recirculation problems this case shows the capabilities of preconditioning for flows near stagnation, which can be essential for high lift flows (e.g. flow separation, cove flow).

Further on as an outcome of the investigation of the peniche influence on the flow field in [2] and due to the huge wind-tunnel model dimension of the ALVAST high lift configuration compared to the test section of the used wind-tunnel (DNW-NWB) it appears now to be necessary to simulate in addition to the wind-tunnel half-model on its peniche also the complete