Summary of the AWAHL project

The AWAHL project comprises wing and high lift design of a regional turbo jet aircraft. It has been carried out within the Green Regional Aircraft (GRA) ITD of Clean Sky JU. AWAHL has three partners, FOI (Swedish Defence Research Agency) in Stockholm, the university Polimi in Milan and the company ASCO Industries in Belgium. The current periodic report covers the entire duration of the project which was 19 months after project extension. AWAHL responded to the first batch of of open calls 2010 within JTI, no. JTI-CS-2010-01-GRA-02-007. The total budget of the project has been 450,000 €.

The work is divided in four work packages (WPs) where the wing is first aerodynamically designed by in-house CFD and optimization tools in the first work package WP1 with optimal performance and constraints. The optimized wing is then used as input to WP2 in which an aeroelastic wing is designed minimizing the weight of the wing based on CFD defined loads distributions. The high lift design is carried out in WP3 which is closely connected to WP4 where the mechanical kinematic design is made to ensure its feasibility.

The design of the wing was eventually carried out in 3D using gradient based optimization. The performance of the wing was then evaluated with the wing attached to the fuselage and with the pylon/nacelle wit flow through conditions. The aerodynamic performance constrains were fulfilled at all design points leaving sufficient margin for additional losses due to tails, flap installations etc. The performance of the wing can be seen in Figure 1 below in which the required targets are displayed as well for the four defined design points. The size of the wing was increased above specification, which was agreed in the project, so that a sufficient amount of fuel could be loaded into the wing. Due to this, some additional investigations were carried out on a down-scaled wing due to discussions about the size of the wing; the performance is still above required targets at the higher Mach numbers.

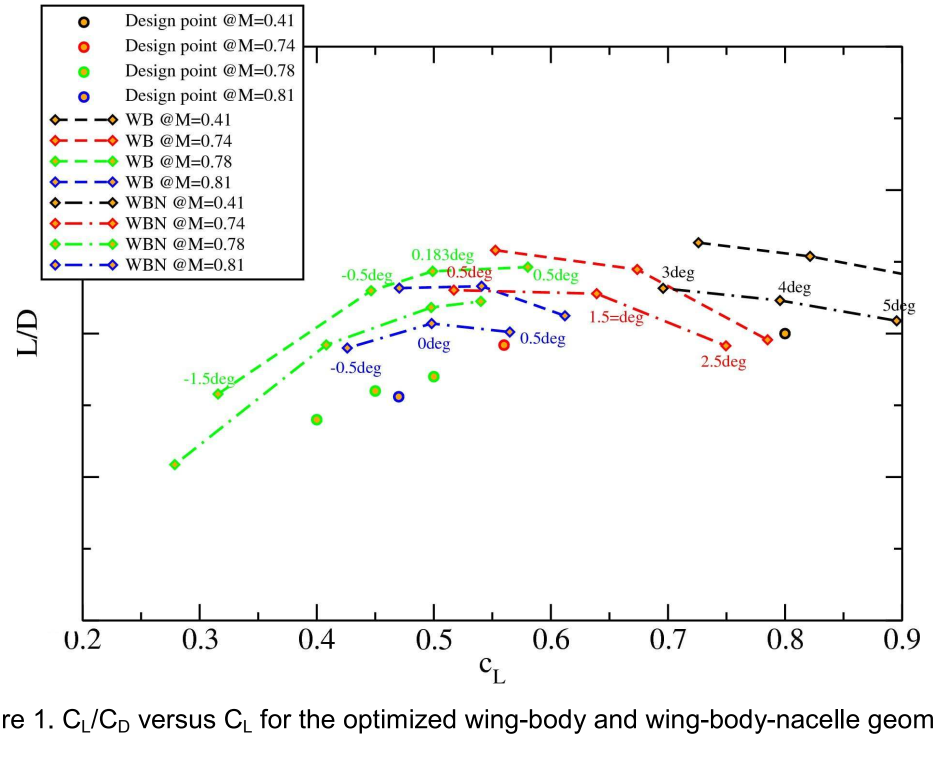

Figure 1. C_L/C_D versus C_L for the optimized wing-body and wing-body-nacelle geometry.

The optimized wing was then used for an aeroelastic design by optimization of the wingbox. Two different materials have been taken into account, aluminum alloy and carbon fiber composite; minimum weight is the objective of the aeroelastic optimization. Two structural models were used based on a stick model of the whole aircraft and on a detailed FEM model of the wing, respectively. Both strength and stability constraints have been included into the minimum weight Nastran optimization. The optimized structural weight of the wing is less than half with carbon fiber composite compared to the weight with aluminum. The performance was then evaluated by CFD investigations using the deformed wing. The higher the tip rotation, the worse becomes the aerodynamic performance.

A conventional three element high lift system with a forward slat and single slotted rear flap was developed from the designed wing in WP1. The design of the high lift configuration is carried out in 2.5D assuming infinite wing sweep with the leading edge sweep angle. The designs are then extended to a 3D wing, the performance of the high lift configurations are assessed from CFD calculations of the full 3D configurations including fuselage and pylon/nacelle. The performance was evaluated for both a landing and take-off configuration. The performance of the landing configuration is displayed in Figure 2. The maximum lift of the landing configuration is just above the required level. This value, however, is obtained by a using a smaller reference surface, the surface is approximately 15% lower than for the surface of the actual wing. With the actual wing surface, the maximum lift is under-predicted with 15%. Some attempts to improve the performance were made by adjusting the deflections of the flap and slat. The maximum lift increases about 12% and can probably be increased even more. The performance is then acceptable regardless of the scaling surface. This also indicates that the design in 2.5D is questionable for a wing with such a high sweep angle.

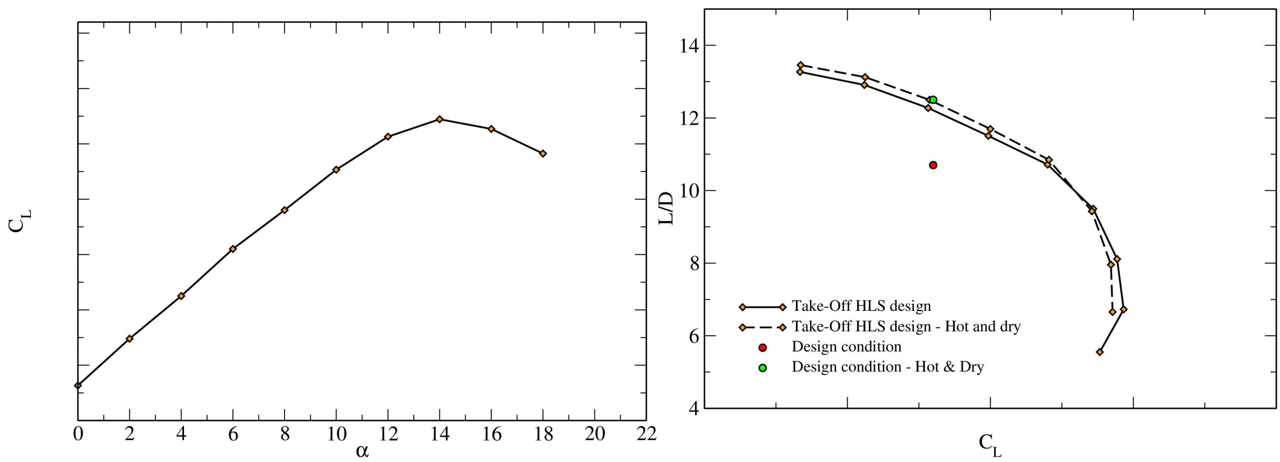

Figure 2. Left: Lift vs. incidence for landing configuration. Right: L/D vs. lift for take-off conf.

Several concepts for the kinematics of actuation of the slat and flap were investigated. For the slat, the only feasible and adequate alternative was the hydraulic actuation option due to the confined space at the leading edge. For the flap a ‘fixed rotating carriage’ concept was selected.

The AWAHL project has been successful and has given the partners new insights and experiences in wing and high lift design. The work has been challenging with many discussions, some parts of the work shown to be difficult and more time consuming than expected which has resulted in extension of the project. Some of the lessons learnt from the project are that some more geometric and structural design constraints would have been useful, the wing and high-lift designs in 2.5D were questionable and that the high lift aerodynamic and kinematic design should have been considered in the beginning of the project.