Aerospace Defence Technology

Center Aerodynamics – Newsletter 15

Editorial

Dear reader,
It is an exceptional and rather seldom experience in the lifetime of an aerospace engineer to receive the chance to design a new aircraft from scratch. Therefore the opportunity to head the full aerodynamic design of a tactical UAS (unmanned aerial system) was proudly welcomed. Based on detailed handbook methods and the close input from the structural and system groups, a preliminary design was selected. In a very short time, a wind tunnel model in the scale of 40% was designed and manufactured. Wind tunnel tests provided valuable insight for further design refinement and increased the confidence level of the initial layout work.

In our recent activities, you can see yet another example of our involvement in race car testing for Mygale Formula 3 as well as our most recent publications covering both experimental and numerical aerodynamics.

Enjoy our second newsletter of 2007. Please fell free to contact us for further information regarding our services.

Sincerely,
M. Guillaume
Michel Guillaume
Head Center Aerodynamics

Aircraft Design to Specs, Time and Cost

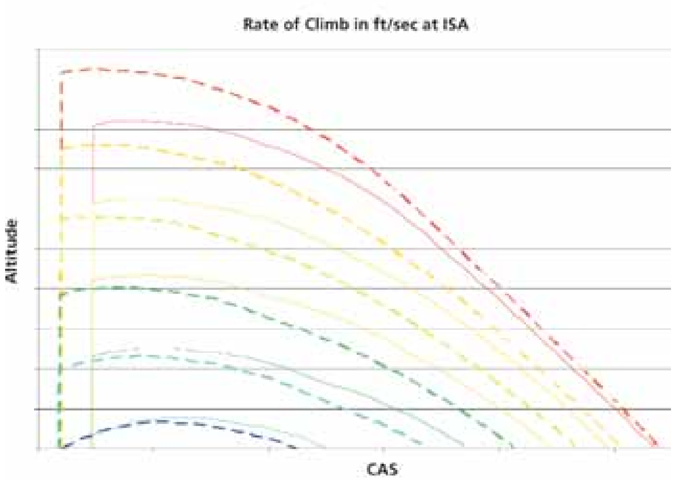
Next to the RUAG Aerodynamics Center core competences in subsonic wind tunnel testing for the aerospace and automotive industry, additional design and engineering skills complement our portfolio to support the development of customer projects. As illustrated by this article, the Center's work scope widely outreaches the field of testing. The article describes the aerodynamic development of an airborne vehicle for a reconnaissance UAS, which was entirely completed within the Center Aerodynamics.

Preliminary Sizing

Starting with the customer's mission specification, summarizing the major technical demands and the applicable certification standards, the preliminary sizing is performed. The preliminary sizing gives a first indication as to the viability of the aircraft concept. It is based on a matching plot and estimation for the aircraft take-off weight. The matching plot allows the definition of a maximum wing area loading [N/m^2] and power loading [N/kW] for which the required flight performances are obtained. In conjunction with the take-off weight estimation, the wing area and power loading figures lead to first estimations for the size and power demand of the aircraft. The preliminary sizing was performed with the software AAA (aircraft design, stability and control analysis software developed by DARcorporation).

Preliminary Design

At the beginning of this design stage, the configuration (the «layout») of the airframe is defined. This includes the relative positioning of the main aircraft components like wing(s), propulsion, payload space allocation (i.e. fuselage), undercarriage and empennage not solely on aerodynamic considerations but also in close collaboration with the customer. A full scale mock-up of the vehicle fuselage was accordingly built by the Center model shop.



The SEP chart derived from APP

Once the configuration of the aircraft was finalized, the aircraft components were designed. This process is based on the very fundamental information defined by the preliminary sizing. This engineering phase was also supported by the AAA software. The output of this design step is twofold. A geometrical definition of the airframe is derived, which includes all major aerodynamic parameters like wing span, taper, size of the empennage as well as the size and maximum deflections of all control surfaces. And a complete set of aerodynamic data is compiled. The second group of data covers the stability and control derivatives and an estimation for the drag polars. Whether the design fulfills the requirements in terms of flying qualities was analyzed within AAA with tools such as the trim diagram for the longitudinal control characteristics.

The drag/lift polars are used to estimate the flight performance. In addition to the drag, a thrust model is also needed to analyze the flight performance. Since the aircraft will be powered by a piston engine driving a fixed pitch propeller, an estimation of the thrust depending on flight speed and atmospheric condition is not straight forward. A MATLAB script was developed in order to combine propeller data with engine data. Both the AAA estimated drag polars and the thrust model were introduced in the flight performance software APP (aircraft performance analysis software developed by ALR and RUAG) to calculate the preliminary flight performances. Point performances, like climb rates, as well as mission performances, considering fuel burn over time, were calculated.

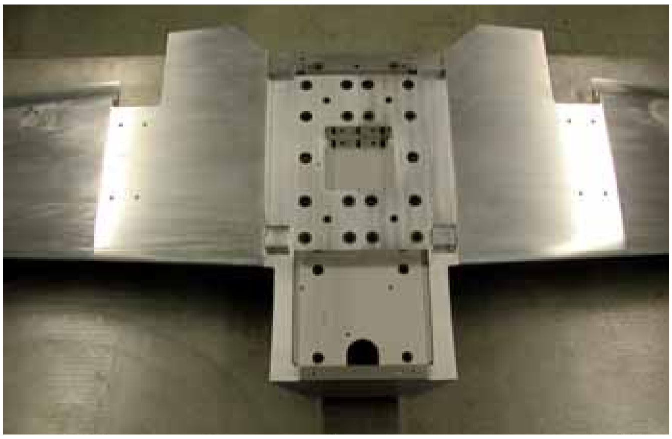
The engineering phase for developing the aerodynamic layout of the aircraft was finalized by a design review with the customer and design-independent engineering. After the successful design review, the geometry of the aircraft was frozen.

Design and Manufacturing of a Scaled Wind Tunnel Model

Based on the geometrical dataset defined in the preliminary design, the subsequent structural design was started. The airframe is designed as a full composite structure. Some minor changes were made at the outer shape for structural optimization. As soon as the digital model of the outer shape was established in CAD, the construction of a scaled wind tunnel model was launched.

The model design was performed by the model design team of the Center Aerodynamics. This allowed the matching of the model size and design specifically to the wind tunnel test requirements – including all aspects of model instrumentation. Based on the AAA results, the most critical aircraft components were identified. For these elements (e.g. the vertical tails) different versions were prepared. This approach reduced the risk of a project delay in case the basic design would show inadequate results in the wind tunnel.

The manufacturing of the model is completely based on CAM methods; wing, central fuselage and empennage are CNC machined in aluminum and the fuselage nose is CNC machined in Cibatool. The model is completed with rapid prototyping parts for the payload dummies, landing gear, engine cowling and the antennas. All control surfaces were equipped with hinge moment balances. The application of the strain gauges and the calibration was performed by the Center electronic laboratory.



Central wing and balance interfacing the model support

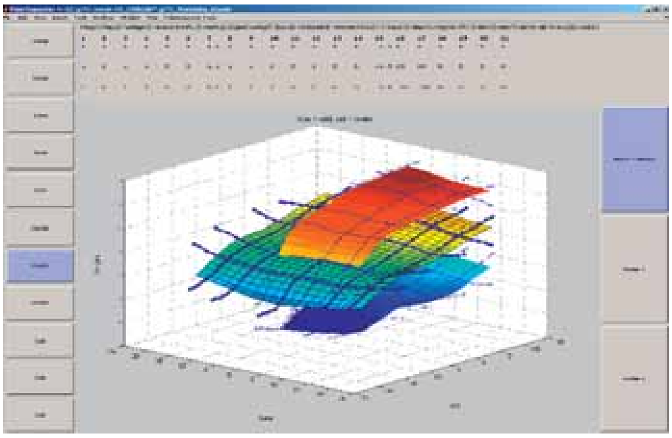
Strain gauge instrumented flap hinge and calibration of hinge moments

Design Validation in the LWTE

An initial wind tunnel campaign was performed to validate the aerodynamic design of the airframe. The crosscheck of the flight performances and flight qualities was performed during the wind tunnel test based on receiving wind tunnel data. This was made possible by the use of **PolarInspector** (wind tunnel data management software developed by RUAG) and an adapted test strategy. In general the agreement between the AAA predictions and the wind tunnel results was good. However some adaptations were needed, which underlines the necessity of a wind tunnel model in an early stage of the development.

Acquisition of the Aerodynamic Data Base in the LWTE

The generation of the aerodynamic data base could be performed shortly after the validation program was completed. The complexity of the aerodynamic data base and thus the wind tunnel time could be minimized by a systematic, quantitative assessment of the cross coupling of different aerodynamic effects, a functionality which also is included in the PolarInspector software.



Screen shot of the **PolarInspector** showing maps for the pitching moment for three elevator deflections over angle of attack and sideslip.

Recent Activities

Mygale Formula 3 Testing in the AWTE

With over 500 cars manufactured and more than 450 victories, the French Mygale is one of the world's leading companies for circuit race cars of Formula Ford, Formula Renault Campus and Formula BMW types.

Recently, Mygale decided to hop into a new category with the development of a Formula 3 race car and is now relying on the long experience of RUAG Aerospace in race car testing for the aerodynamic development of the vehicle. Tests are currently being performed in the AWTE to improve the F3 for the next season.

Formula 3 is a scaled-down version of Formula 1, with smaller cars, smaller engines and smaller budgets, but very similar characteristics and challenges. A lot of famous Formula 1 pilots actually started their career in Formula 3.

The pictures show the model in the AWTE wind tunnel and a Mygale M07-F3 under the colors of the Ultimate Motorsport team for the International British Formula 3 series.

Publications

- M. Guillaume, "Latest Development in RUAG Aerospace's Wind Tunnels and Balance Technology at RUAG Aerospace", 43rd Annual Meeting of Subsonic Aerodynamic Testing Association (SATA), June 10–14, 2007.
- M. Guillaume, Jan Vos et al., "Calculation of Unsteady Loads for the F/A-18 Vertical Tail Buffeting", 1st CEAS European Air and Space Conference in Berlin September 10–13, 2007.
- P. Aschwanden, J. Müller, "Challenges in Wind Tunnel Testing", Progress in Vehicle Aerodynamics and Thermal Management V, Expert Verlag, 2007.

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