EUROPEAN TRANSONIC WINDTUNNEL

NEWS 18

AUGUST 2016

Setting the scene for the next decade

ETW has now been fully operational for more than two decades and during this period the capabilities and test techniques have been continuously and rigorously developed to match customer requirements. The current capabilities enable highly accurate and reliable prediction of flight performance ahead of first flight. As a result ETW is able to provide a cost and time effective alternative to flight testing. This complements state-of-the-art numerical simulation techniques by providing reliable data even at the corners of the flight envelope. Coupled with the need to acquire reliable absolute performance data at flight conditions specialist techniques continue to be developed to enhance the understanding of the detailed flow physics and, significantly, many of which have been developed with support from both national and European agencies.

The future will undoubtedly be even more demanding in terms of accuracy and reliability. The maximisation of time-cost-quality will form a focus for the continued development of ETW as an essential strategic facility. Targeted investments are currently being progressed to upgrade the facility, to improve productivity, and to provide new capabilities aligned to the needs of existing and future customers.

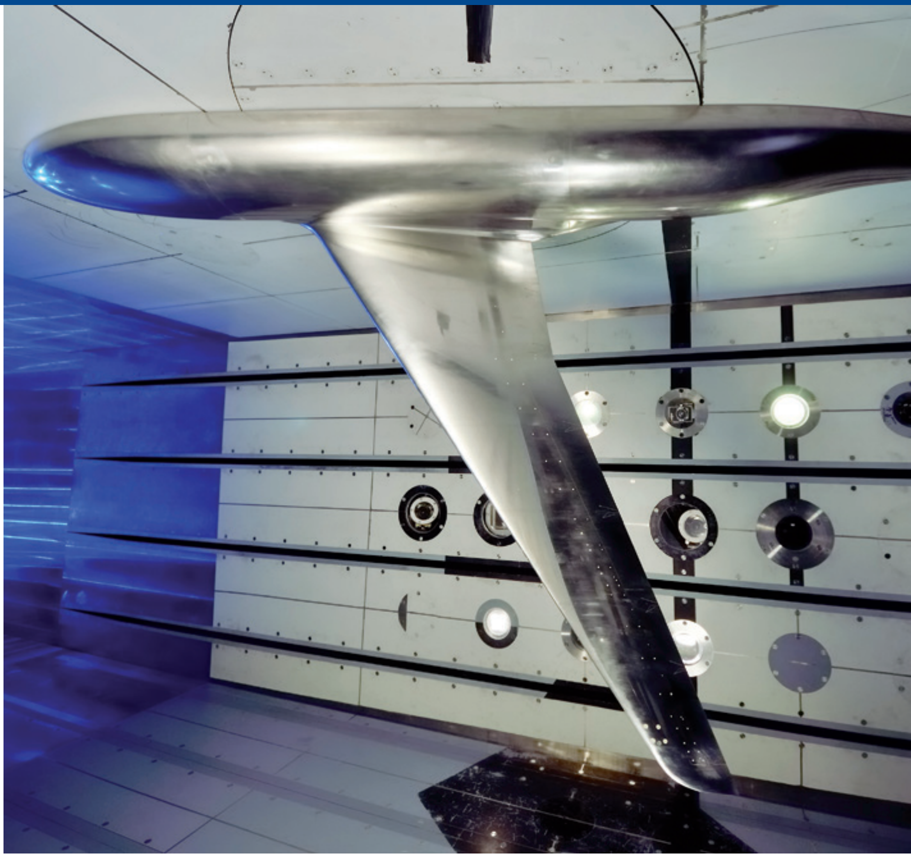
ETW manages an active web site www.etw.de and all readers are recommended to check the regular updates which reflect the most recent activities.

01 | CLIENT TESTING

Business as usual

Airbus

Airbus performed test campaigns at high speed conditions with a generic research model to assess performance data for new high speed configurations designed for high Reynolds number conditions. Test points included several high Reynolds number conditions at cryogenic temperatures to provide a substantial database to validate design methodologies and establish the effectiveness of a particular flow control technology at high speed. The ETW deformation system was used throughout each test series to measure the twist and bending of the complete wing for each test configuration whilst at the same time acquiring performance and loads data for an extensive range of conditions.



Boeing

The Boeing Company performed an extensive series of high speed tests at ETW using a 4.5% scale 787 half span model to acquire force and pressure data at transonic conditions for a large range of Reynolds numbers including flight conditions. The test conditions were selected to provide a unique link between established wind tunnel databases and flight test data.

The model incorporated a high speed wing equipped with extensive pressures instrumentation to enable the acquisition of high quality loads data up to and including the boundaries of the test envelope. The model included design features to enable configuration changes to be performed quickly resulting in high levels of productivity.

01 | CLIENT TESTING

Business as usual

Bombardier

The new Global 7000 and Global 8000 business jets from Bombardier are scheduled to enter into service in 2018 and 2019, respectively. In the early design process of these new aircraft types Bombardier conducted two consecutive wind tunnel test campaigns at ETW. Testing of a Global Express (GX) model included the assessment of flight Reynolds data at cruise conditions to obtain a reference data base for the Global 7000 and Global 8000 project.

The tests of the new aircraft configuration were performed directly after the GX test campaign, requiring a period of 3 days for the model change. Both models were tested over the entire temperature envelope of ETW including cryogenic conditions together with high transonic Mach numbers. The individual test points were arranged to provide data on pure Reynolds number effects and the model deformation effects, which are important for highly accurate cruise performance predictions.

01 | CLIENT TESTING

Business as usual

Dassault

Dassault Aviation recently unveiled the Falcon 5X, which features a brand new wing. This includes flaperons, active deflection control surfaces that can act both as flaps, ailerons or airbrakes. The most advanced methods of testing at ETW have been used to design this new business jet. "The Falcon 5X is the new benchmark for the creative use of advanced technology in business aviation," said Eric Trappier, Chairman and CEO of Dassault Aviation.

Crédit : © Dassault Aviation - E. de Malglaive

The main objective of Dassault's recent test campaign at ETW was to investigate Reynolds number effects at cruise conditions in order to optimise the performance data at flight conditions of the Falcon 5X aircraft. Aero-elastic effects and buffet onset boundaries were determined over the complete transonic Mach number range. The wings were heavily instrumented to assess both dynamic and static pressure measurements simultaneously at all test conditions. Horizontal tail plane effects were successfully measured using a remotely controlled electric motor drive mechanism developed by ONERA, covering the complete ETW test envelope. The actual wing shape at flight Reynolds numbers was assessed using the ETW deformation measurement system SPT allowing investigations of wing deformation effects in flight conditions. Several configurations were tested in 12 test days using the complete temperature range of ETW from 300 K to 122 K.

02 | FACILITY UPDATE

GADE progress

Sustained Improvement

The Green-Aircraft Design Enabler (GADE) upgrade project at ETW officially kicked-off on 1 April 2014 and comprises preservation efforts as well as upgrade investments to adapt to current and foreseeable client demands. The key goals of the project are to maintain ETW's world-leading position as the most advanced research and development wind tunnel facility for testing aircraft in model scale at real flight conditions and to increase ETW's reliable accuracy, productivity and effectiveness.

Among several of the ongoing work-packages, the following improvements are currently being implemented:

- To preserve existing capabilities and to reduce the risk of facility interruptions several obsolete Local Control Systems (LCSs) systems were replaced by a common control architecture. In addition the Emergency Power Generator and obsolete Uninterruptable Power Supply battery packs were exchanged such that the risks of negative facility impacts associated with an electricity supply loss are significantly reduced.
- The overall facility patch-work Video Monitoring System (VMS) was upgraded by a common and flexible state-of-the-art system. The Site- and Operations-VMS is essential for personnel safety, safe operation and client security, whereas the new Test Monitoring System enhances testing efficiency, capabilities for optical monitoring and image visualisation opportunities.
- Two ambient air vaporizers were installed and a new piping infrastructure was integrated for the Tunnel Pressure Booster (TPB). With this new capability, the productivity during low-speed high lift testing, where the energy of the compressor is restricted to the allowable dynamic pressure determined by the high lift configuration of Client models, can be increased.
- Obsolete computer hardware was replaced and the Wind tunnel Main Control (WMC), Model Handling Control (MHC), and Monitoring System (MOS) were seamlessly transferred to run on virtual computers. The High-Level Control System is running on an emulated environment while maintaining the current software unchanged.
- An advanced optical fibre test-systems backbone is available for high speed point-to-point connections, which will be used for high-bandwidth data transfer. The implemented optical fibre architecture enhances the testing preparation efficiency and accelerates data handling especially for the increasing number of instrumentation channels requiring high speed dynamic data acquisition.
- Several new workshop tools have been procured to enhance the workshop service capabilities, responsiveness and quality to ensure that clients receive quick and high quality rigging support whenever needed e.g. to fix model deficiencies using on-site capabilities and thereby avoid any costly test delays.
- An Active Tunnel Drying (ATD) system has been installed and successfully operated during client tests. The tunnel circuit dew point can now be further reduced with resulting improvements in flow quality, which is particularly important for tests featuring laminar flow.
- A particle counter was installed showing the successful effect of different measures such as cleaning and drying procedures, access limitations and other tunnel handling features.

The GADE process is ongoing and has a total time span of seven years.

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Unique Wind Tunnel Tests for Slower Landing Approaches - HINVA

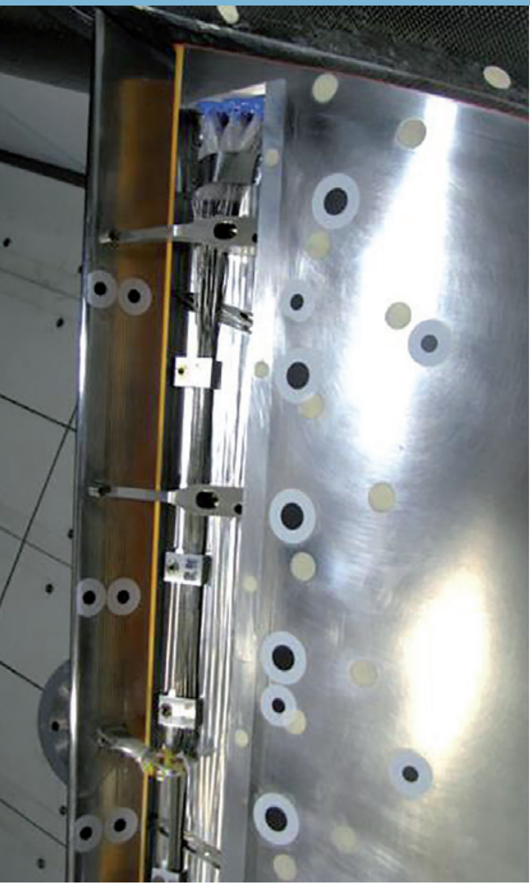
Slower landing approaches by aircraft leads to less noise, shortened flight duration, reduced landing speeds and thus shorter runways. The question how slow, how steep and hence how quiet a modern commercial aircraft can arrive at a destination airport is determined by the performance of the high lift system with its retractable slats and flaps on the wings.

The aim of the project HINVA (High lift INflight VAlidation), carried out by ETW, the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) and Airbus, was to combine computer models and wind tunnel tests to substantially improve predictions of high lift performance and therefore pave the way for slower and quieter approach flights. In February 2014, wind tunnel experiments at cryogenic temperatures took place at ETW. Equipped with laser measurement technology and other advanced measurement systems, the researchers are now able to detect with high precision the flow field around an Airbus A320 with extended landing flaps and slats under flight-representative conditions. The researchers had constructed a high precision wind tunnel model specifically for the tests, based on flow measurements performed during flight tests with the DLR A320 ATRA research aircraft.

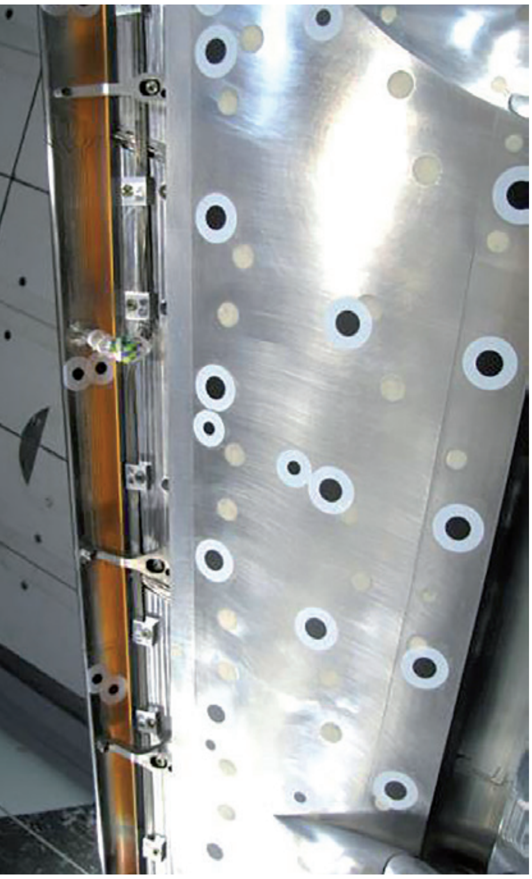
This unique approach was supported by Airbus as part of its research activities because the desired accurate prediction of the flow features during take-off and landing are an essential contribution to the optimisation of future aircraft developments. The results of these experiments are important for the entire aviation industry. "When it comes to new products, the sector will be in a position to plan in greater detail, assessing the deviations between predicted high lift performance and the actual values," emphasised Rolf Henke, a member of the DLR Executive Board and responsible for aeronautics research. "Aeronautics research will acquire valuable insight into how combining the three methods – simulation, cryogenic wind tunnel testing and in-flight testing – can deliver an unprecedented level of precision in aerodynamic analysis and development for commercial aircraft."

The world's leading wind tunnel ETW, unique in Europe, offers the capability for testing aircraft under realistic in-flight conditions. The researchers used their measurement equipment to put a dedicated newly manufactured, cryogenic half model of an A320 through its paces. Using the newly developed Particle Image Velocimetry (PIV) detailed analyses of areas where vortex formation and flow separation occurs were able to be performed. The airflow is not ideal in these zones, prompting complex aerodynamic interference effects that limit the high lift performance. "The laser measurement technology PIV was developed by our colleagues in Göttingen. We are now able to conduct simultaneous measurements of the flow velocity in many critical areas of the wing," says HINVA Project Coordinator Ralf Rudnik from the DLR Institute of Aerodynamics and Flow Technology. "Therein lies one of the keys to acquire a better understanding of where and why lift breaks down."

This work received funding from the European Union FP7/2007-2013 under grant no. ACP8-GA-2009-233607 (DeSiReH).



Detailed views of the SPT markers on the lower side of the wing and Krüger flap



Revival of Krüger Flaps for Laminar Wings - DeSiReH

New concepts for fuel saving and drag reduction require a new design of laminar wings, especially for high lift configurations. Therefore, European aerodynamicists are revising Krüger flaps as a high lift device for laminar flow wings on next-generation aircraft. The objective is to avoid sharp edges, gaps and rivet heads as found in conventional slat designs in the leading edges of aircraft wings, which would disturb the air stream around a laminar-flow aerofoil even when the devices are retracted.

Krüger flaps were deployed on various aircraft in the past, such as the Boeing 747. But now researchers have "newly interpreted" the concept whereby the high lift device is "perfectly" integrated into the wing to minimise any turbulence. While the leading edge is lowered for take-off and landing in a conventional slat design, the Krüger flap involves a section of the wing skin on the underside of the aerofoil swinging forward ahead of the leading edge. The respective skin panel is hinged at its forward edge.

The high lift performance of such modern Krüger flap concepts was investigated within the EU funded research project DeSiReH (Design, Simulation and flight Reynolds number testing for advanced High lift solutions) in ETW. Unlike most projects where scientists usually build a wind tunnel model first to gather data which is subsequently evaluated in computer-based studies, the researchers started with virtual designs to produce a refined test specimen. The model comprised a complete high lift system with representative aerodynamic and mechanical features.

In addition to the standard acquisition of forces and pressures several specialist techniques were applied such as PIV (Particle Image Velocimetry), TSP (Temperature Sensitive Paint) and also SPT (Stereo Pattern Tracking). SPT was used to determine overall model deformation and localised flap deformations. Several modifications on the flap design were tested to verify the features of an optimised geometry.

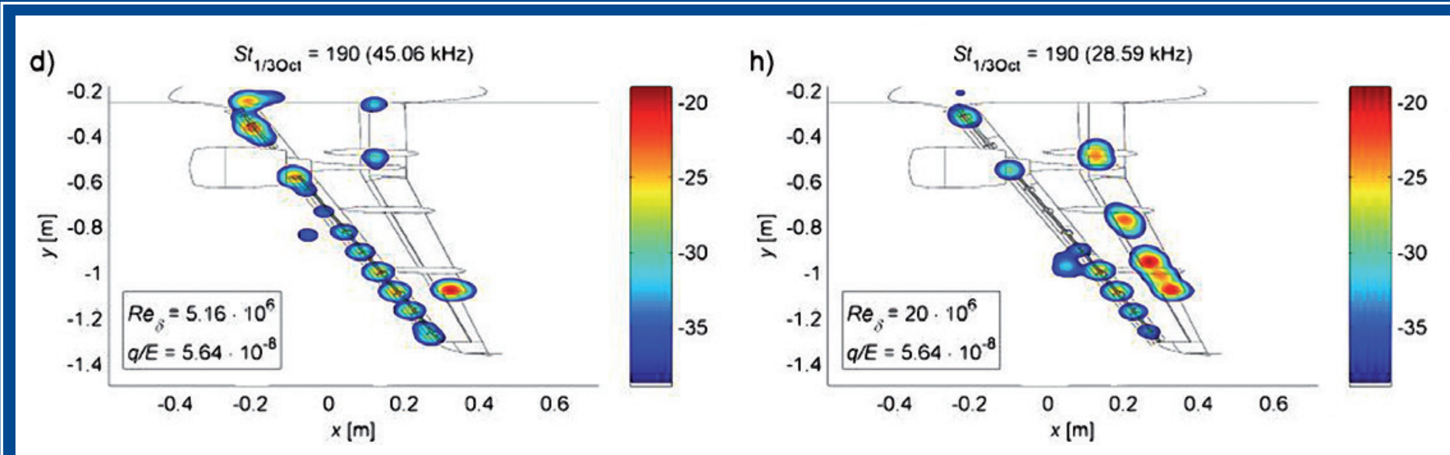
The DeSiReH Project combined the activities from 20 industrial partners, research organisations and universities from the EU and Russia.

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Airframe Noise Detection on Small Scale Models at Flight Reynolds Numbers

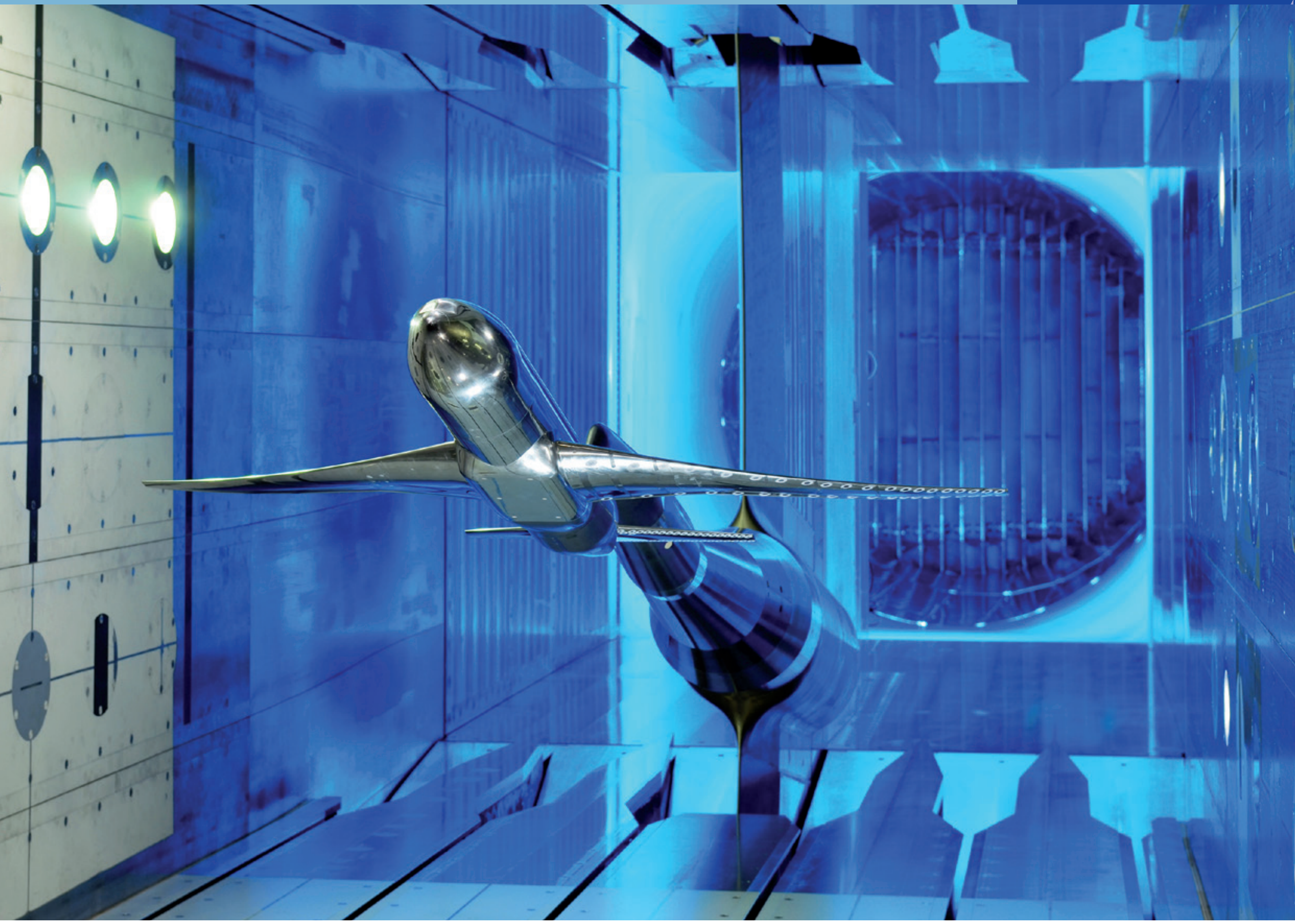
For the first time successful localisation of airframe noise sources on a small aircraft model at real-flight Reynolds numbers was carried out at ETW. The unique capabilities of an independent adjustment of Reynolds number, Mach number and total pressure provide a deeper insight in the aeroacoustic behaviour of airframes and provides the possibility for significant noise reduction of commercial aircraft. Such testing can be performed as a piggyback to high lift performance testing in order to gather valuable information for preparing acoustic testing in dedicated facilities.

By the arrangement of 96 microphones in the side wall of the test section the sources of acoustic emissions on the wing can be resolved in space and time. By variation of temperature from 110 K to 310 K and pressure levels from 110 kPa to 420 kPa the Reynolds number and the elastic deformation can be individually adjusted and their influence on the acoustic emissions can be studied separately. The observations showed significant Reynolds number dependency for various origins. For example, noise sources on the inboard slat only appeared at mid-level Reynolds numbers of around 5 million, whereas they vanished at Reynolds 1 million and 20 million. In the lower frequency range of Strouhal numbers less than 100 the variation of Reynolds number and deformation had only a slight effect on the overall radiated airframe noise. At the flight Reynolds number of 20 million and higher Strouhal numbers above 100, additional dominant noise sources appeared on the flap.



The investigations were carried out in cooperation with the DLR and have been supported by the Federal Ministry of Economics and Technology (BMWi) within the Aerospace Research Program "ALSA" (Acoustic Localization of Flow Separation). The K3DY half model used for these investigations was provided by Airbus.

This work received funding from the European Union FP7/2007-2013 under grant agreement no. 227816 (ESWIRP).



40 International Scientists Attend Unique ESWIRP Wind Tunnel Tests

In spring 2014, more than 40 international aerodynamic specialists from various European institutions, US NASA, Russian TsAGI and Japanese JAXA met at ETW to attend the experimental test entry of the project "Time-resolved Wake Measurement of Separated Wing Flow & Wall Interference Investigations".

The project, which was selected in the course of the EU funded FP7 ESWIRP program, involved world-wide unique unsteady measurements of the wake flow field by time-resolved PIV (Particle Image Velocimetry) and unsteady deformation measurements for a cruise aircraft configuration at real-flight Reynolds and Mach numbers. The study helped to further the understanding of the occurring phenomena and the validation of CFD codes (Computational Fluid Dynamics). In close cooperation with a team of NASA engineers the tests have been conducted at cryogenic conditions using the NASA Common Research Model.
Three students from Germany, Italy and the Czech Republic complemented the international research project team as observers. They had successfully applied for the participation in this test entry in the course of a call among European

04 | FURTHER NEWS

EU supported activities

universities initiated by the European Union as a stimulus for enhancing international and interdisciplinary competences early on in the academic formation.

"After months of close cooperation within our international consortium and careful preparation of technical details with an experienced ETW team, I really looked forward to the start of this test entry. For many of us it was the first opportunity to prepare and attend a test at such a high scale research facility." said Dr Thorsten Lutz, University of Stuttgart, assistant to the project team leader Jean-Luc Godard, ONERA.

New Movie on ETW's Capabilities

The Clean Sky research project HiReLF (High-Re Laminar-Flow Testing) provided the opportunity to create a video to illustrate the possibilities and capabilities of the European Transonic Windtunnel to scientists and engineers with a technical interest. Several sequences of the testing facility, together with preparation and the experimental setup were filmed and edited to produce a short and informative movie.

Learn more about the fundamentals of ETW in this video:
https://www.etw.de/cms/HiReLF

This work received funding from the European Union FP7/2007-2013 under grant agreement No. 323452 and 641455.

Investigations during the Clean Sky project were dedicated to assess the impact of wing surface quality and manufacturing tolerances on the robustness of laminar flow. The subsequent Clean Sky project NLF-WingHiPer (NLF Wing High Speed Performance) focused on validating a half-model with laminar flow wings for high quality performance measurements of lift and drag in ETW.

EUROPEAN TRANSONIC WINDTUNNEL

Ernst-Mach-Strasse
51147 Köln
Germany
Tel.: +49 (2203) 609-01
Fax: +49 (2203) 609-124
E-Mail: info@etw.de
Web: www.etw.de

Published by: European Transonic Windtunnel (ETW) GmbH, Köln
Editor: Martin C.N. Wright
Pictures: ETW, DLR, Dassault Aviation
Layout and design by: www.design-union.de, Germany
Printed by: Thierbach GmbH, Mülheim an der Ruhr, Germany