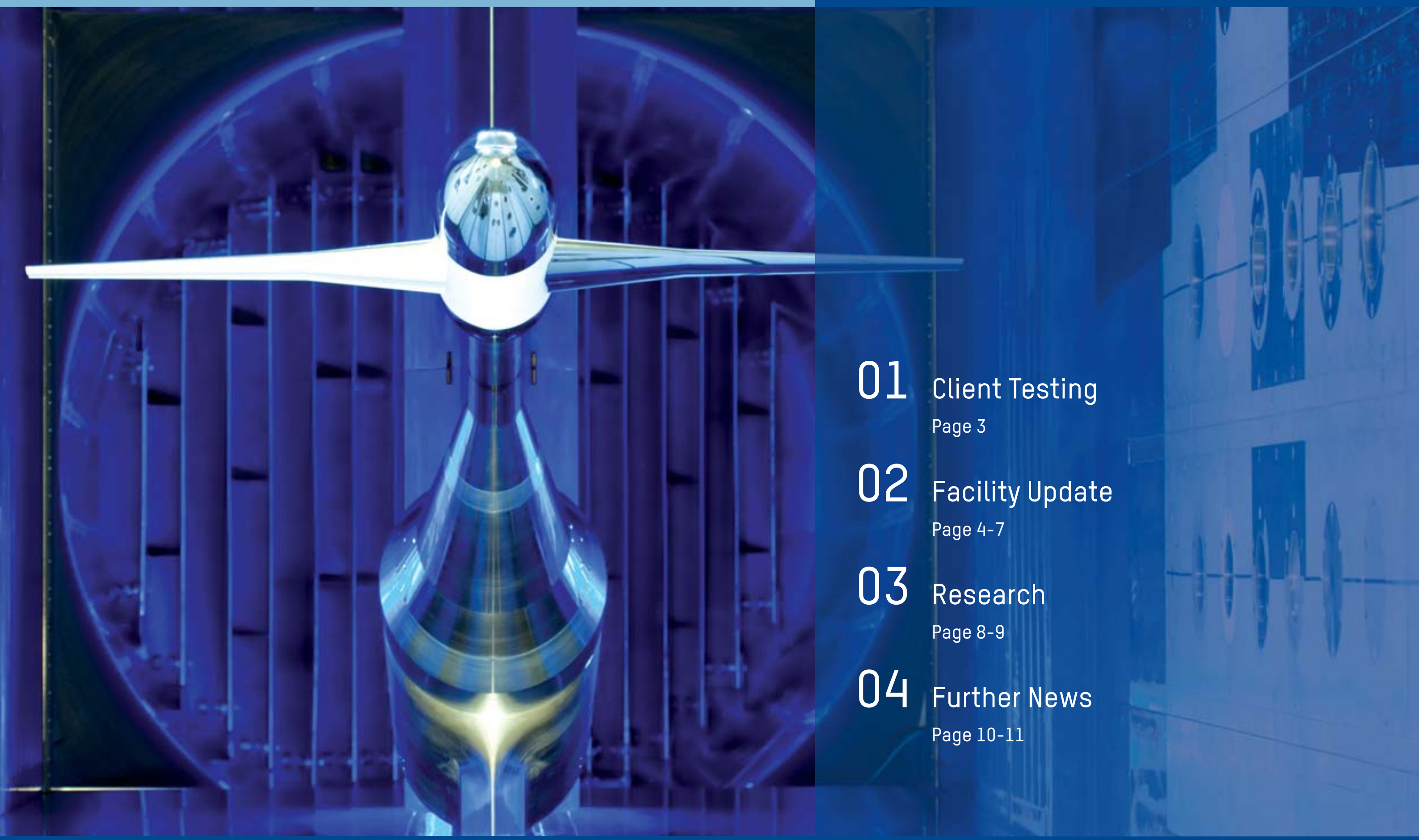
EUROPEAN TRANSONIC WINDTUNNEL

NEWS 17

NOVEMBER 2012



ETW's Unique Service

Turning research progress into successful innovation is a risky task. Any new aircraft design is challenging in terms of aerodynamic performance and handling qualities. Modifications or introduction of new technologies arise crucial questions: Do we get the expected performance improvement, and thus the planned return on investment? Can we be sure that the configuration change does not have a detrimental effect? Have we chosen the best way right from the beginning? Brand new designs feature even greater risks: Do we reach the planned (and committed) performance level? Are the handling qualities OK? Can we prevent or at least minimize any hidden risks of late surprises? It is essential to get all these answers as early and as precise as possible. During flight tests the final proof will come under real conditions, but it could be disastrous to find out bugs at this stage of a program.

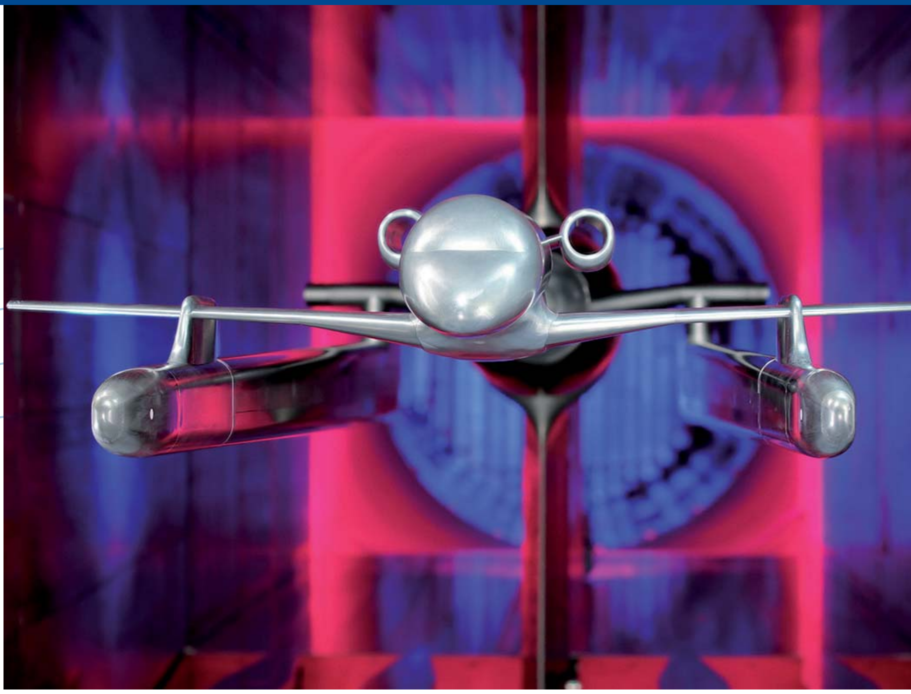
ETW enables a demonstrated unmatched data accuracy of 99% compared with flight test results. It complements the flexibility of numerical simulation by outstanding reliability and productivity. Reducing the need for costly and time consuming rework, and its implication on the industrial cost-at-completion and program lead time makes it worthwhile to invest early in ETW testing – early in the industrial design process, but also further upstream in the innovation chain.

Striving for less drag and weight is in the focus of today's aircraft researchers and designers. Due to its flight Reynolds number testing capability the ETW offers an excellent opportunity for testing future generation lifting surfaces e.g. featuring laminar flow characteristics. The present ETW News will provide you some insights into the ETW team efforts to tailor our capabilities even better to your future research and development needs.

01 | CLIENT TESTING

Business as usual

Embraer



The Legacy 500 model was tested in 10 configurations using the advantage of increased Reynolds numbers within a limited temperature range down to 253 K (-20° Celsius) due to material characteristics. The model was originally built for ambient testing in conventional facilities. After detailed analysis of the material properties the final model approval was based on a design acceptance for this limited temperature range. Within this Reynolds number variation it was possible to determine also wing deformation effects at a constant Reynolds number making use of the available temperature difference. The ETW deformation measurement system SPT was used at discrete test conditions with markers attached to the lower side of the wing. Flow visualization on the wing surface was done by application of the minituft technique. A dedicated twin sting test was performed subsequently to the single sting test in order to determine sting corrections suitable for the single sting database.

Wing deformation measurement

Airbus

With a 4.31% half span model of the A350XWB aircraft Airbus has performed a test campaign to assess the maximum lift and stall characteristics. At a tunnel temperature range from 115 K (-158° Celsius) to 273 K (0° Celsius) and a pressure level up to 398 kPa resulting in Reynolds numbers up to 25 million. The model featured exchangeable leading edge and trailing edge components for the variation of slat, flap and spoiler settings. Overall model forces and moments were measured combined with 267 wing and cavity pressures. The ETW model deformation system SPT was applied to assess the wing deformation at selected conditions. Fluorescent minitufts were attached to the wing upper surface for flow visualisation. The testing has confirmed that the design has matched or bettered its targets.

Preparing for the test: Installation of pressure scanners

Update of Local Control Systems

HARDWARE:

- Commercial off-the-shelf components with high long-time availability for spares
- Industrial standard interfaces

SOFTWARE:

- Identical architecture for different sub-systems
- Commercial off-the-shelf software
- Easy to apply, configure and maintain

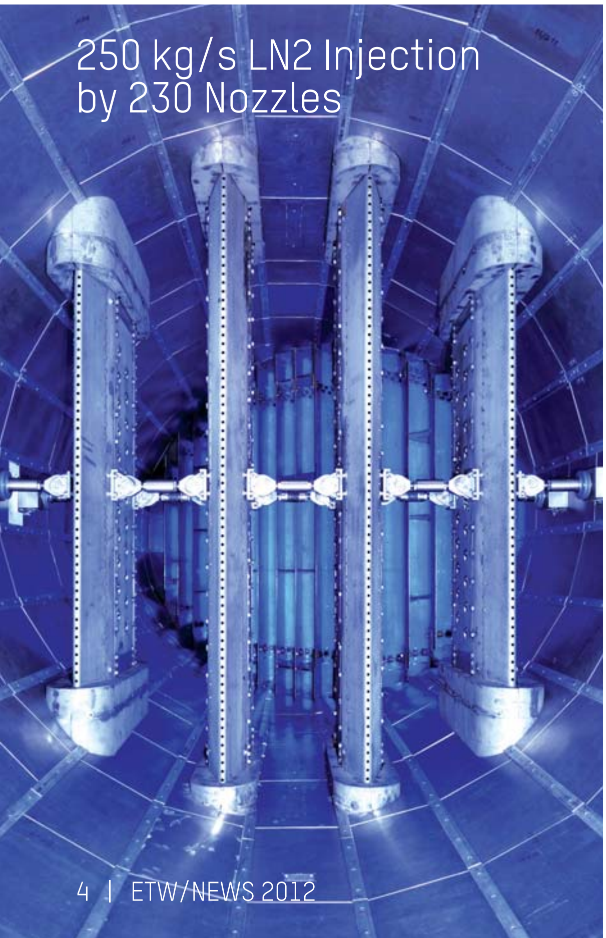
⟹ Reduced operation costs
⟹ Improved availability
⟹ In-house service possible

ETW has been operational since 1993 and serves the scientific and industrial clients' needs since 1995. After almost 20 years of reliable operation, the local wind-tunnel control systems (LCS) are being replaced by current state-of-the-art technology. This effort is performed during a period of six years within the standard maintenance schedule to guarantee short- and long-term service availability.

As the first work packages, the nitrogen and the model-cart LCSs have been replaced. E.g. the nitrogen LCS ensures the desired low temperature of the wind-tunnel flow by controlling the injection of liquid nitrogen with a temperature of 77 K (-196° Celsius) through four rakes with some 230 spray nozzles in the short leg of the circuit upstream of the compressor. This liquid nitrogen vaporizes immediately and thus forms the cold gas flow. The corresponding gaseous nitrogen exhaust is located in the other short leg of the circuit upstream of the stilling chamber and the same LCS controls the blow-off valves to maintain a constant pressure inside the tunnel circuit.

Most of the new LCSs are based on the same hardware components and use the same control-software architecture. The main drive however requires specialized electrical components and its LCS update will be performed by the original supplier. Thanks to the modular design of all ETW LCS work packages and the new common hard- and software concept, the updated LCSs will reduce operational costs and further improve the facility availability: Repair and maintenance are eased and can often be carried out by in-house ETW staff.

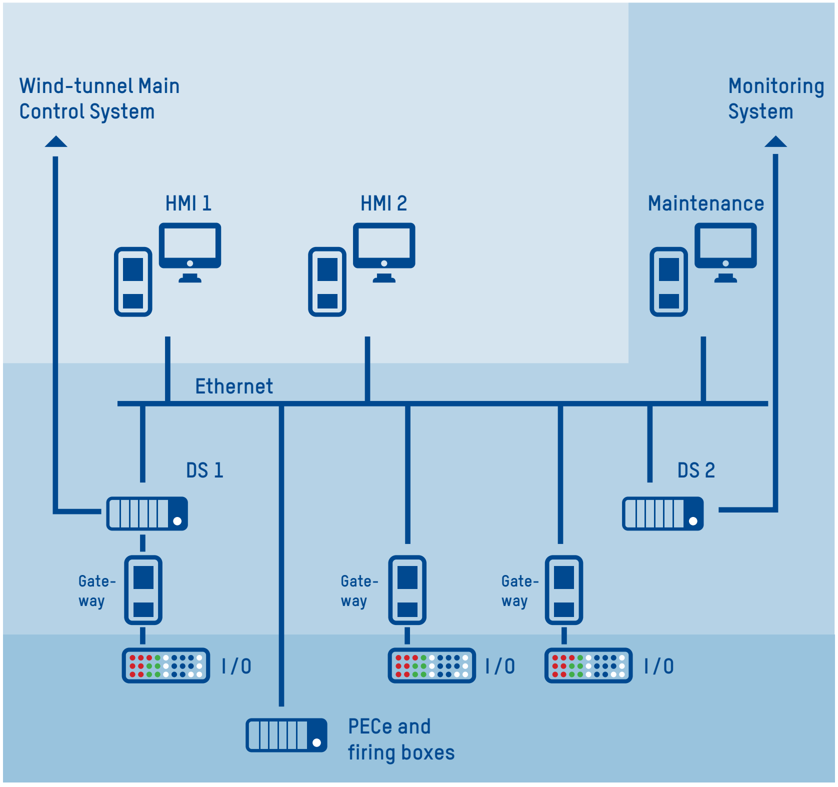
The next work packages to be updated are the second-throat and the main-drive control system.


250 kg/s LN2 Injection by 230 Nozzles


30 MW Heating System


3000 t LN2

Coming Soon: Update of the Main-Drive Control System



ETW is operating a two-stage axial-flow compressor with variable speed driven by a synchronous 50 MW motor. The drive system with instrumentation and controls has been designed in 1989 / 90 and was installed and commissioned in 1991/92. The initial analogue, thyristor-based high-voltage control concept will be replaced. Monitoring and control of the main drive and its auxiliaries will be established around a new PECe (Power Electronic Controller with Ethernet) interface. This interface will manage an entirely new firing chain, which replaces the previous firing boxes. It will be connected through gateways to three I/O interfaces to monitor and manage the main-drive auxiliaries. Two drive systems (DS) will establish the communication with the wind-tunnel main control and the general monitoring system. Two human-machine interfaces (HMI) and one maintenance terminal will be available for direct main-drive operation.

⟹ **Improved equipment reliability**
The new PECe technology requires less components

⟹ **Improved system availability**
Advanced diagnostic and trouble-shooting features

02 | FACILITY UPDATE

EU SUPPORTED ACTIVITIES

Enhancing test capability, quality and productivity of European wind tunnels of strategic importance.

Main Goals

Providing world-class wind-tunnel testing service for European Aeronautical Research

The project **ESWIRP** aims at enhancing the complementary research potential and service capabilities of the **three strategic wind tunnels** in Europe, both in terms of productivity and quality. The concerned wind tunnels are ETW, which is able to replicate real flight conditions for both low- and high-speed testing, the large low-speed DNW-LLF facility, and the large high-speed ONERA-S1MA wind tunnel.

The main ideas leading to the project have been:

- the **identification by ACARE**[1] of the strategic wind tunnels for Europe needed to maintain and enhance the leadership of European aerospace industry and science,
- the **EREA**[2] **recommendation** that the reduction of emissions, noise and fuel consumption by aviation requires the contribution of these infrastructures, and
- the recognition that efforts have to be made at community level, in a targeted and coordinated way, to further integrate these strategic wind tunnels at a world class level.

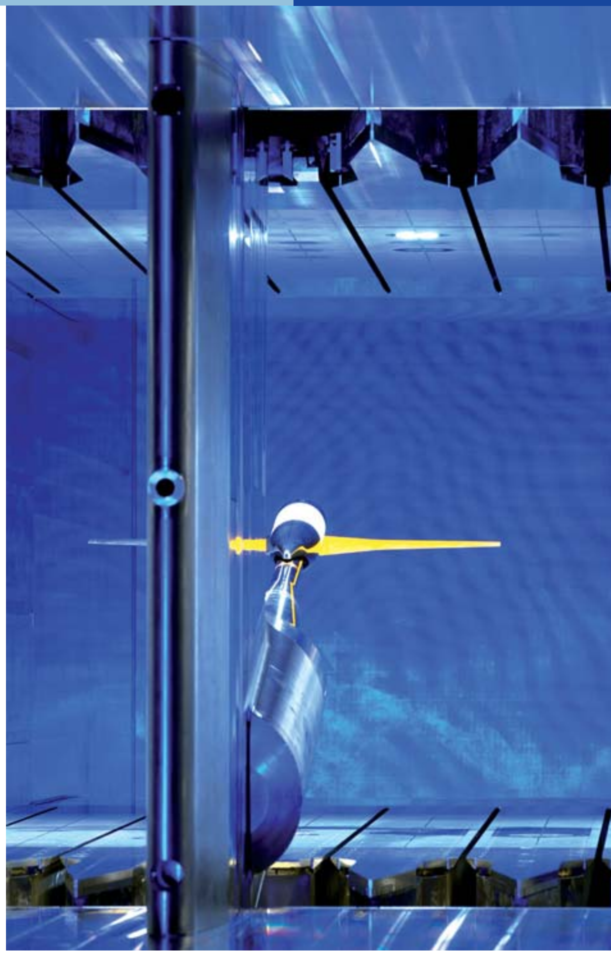
The ESWIRP project is fully responsive to the objectives of the EU-Framework Programme 7 "Capacities Research Infrastructures Programme." It enhances research and innovation capacities throughout Europe and contributes to ensuring their optimal use. The activities aim for **optimizing the utilization** of the three strategic wind tunnels and **improving** their **performance** for the benefit of aeronautical research and development by:

- **networking activities,**
- **trans-national research access and**
- **joint research activities.**

Further details: www.eswirp.eu

[1] Advisory Council for Aviation Research and Innovation in Europe (www.acare4europe.org)
[2] Association of European Research Establishments in Aeronautics (www.erea.org)

ESWIRP Background

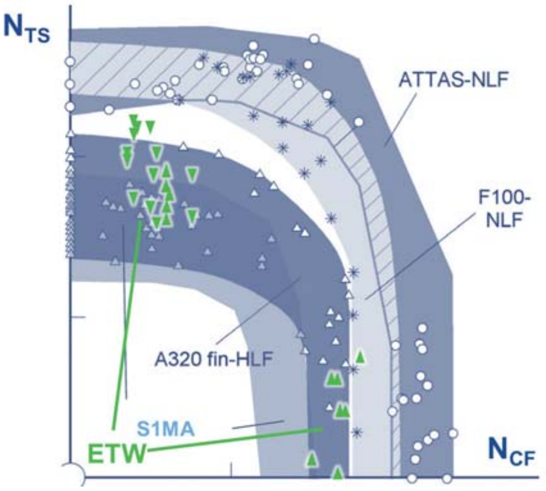


Together the three wind tunnels ETW, DNW-LLF (The Netherlands), and ONERA-S1MA (France) cover essential future aeronautical research and development (R & D) needs by complementing each other in terms of speed, size (LLF, S1MA) and replication of true flight conditions (ETW). The ESWIRP (European Strategic Wind tunnels Improved Research Potential) project is a first step to integrate the wind-tunnel testing services of these strategic tunnels, to provide transnational access and to maintain them at a world class level in order to foster the transfer from research to technological innovation. Following ACARE's Vision FlightPath 2050, the related Strategic Research and Innovation Agenda (SRIA) requests a roadmap for European R&D infrastructures. This roadmap shall result in a network of physical and virtual testing and certification infrastructures. ESWIRP already contributes to these goals by enhancing the interoperability and the complementary use of testing in the S1MA, LLF and ETW.

The demand for modern wind tunnel testing requires wind tunnels of excellent performance and quality as well as sophisticated aircraft models. In order to meet the ever increasing requirements of the aeronautic community in terms of accuracy and repeatability of results, besides up-to-date instrumentation and interference-free flow measurement techniques, most notably highly skilled personnel is vital. Precise investigations of flight physics phenomena in model scale require the correct representation of Mach numbers, flight-relevant Reynolds numbers and a high flow quality in the wind-tunnel. Such capabilities are linked to relatively high investments and operating costs. In recognition of the fact that these resources should be used and exploited by as many scientists and customer industries as possible, the three ESWIRP facilities with different ownership structures face this challenge jointly. Each of these facilities is unique in Europe and their combined test capability covers the complete flight envelope of current and future civil aircraft. The three ESWIRP facilities are indispensable tools to achieve a decisive competitive edge in developing sustainable aviation products and services.

ESWIRP is funded in the EU-Framework Programme 7 with a public contribution of € 7.3 million. The three partners ONERA, DNW and ETW started the project in October 2009 and will complete it in September 2013. A joint wind-tunnel simulation model has been developed to enable the operators and researchers to predict and assess the tunnel behaviour for a better design of experiments. Facility improvements, e.g. for unsteady testing in ETW, have been implemented to better suit research needs. The workshops to prepare the transnational research access (TNA) within ESWIRP were well received, more than 90 researchers attended and engaged in TNA consortia. Eleven Member States as well as nine Associated Countries are involved in the finally elected TNA projects; the largest selected consortium consists of 29 researchers. The associated tests will be conducted in 2013.

The ESWIRP consortium proposes the European Commission to pursue the successful activities of ESWIRP further towards the goals of Europe's Flightpath 2050 vision.



N-Factors NCF/NTS from TELFONA (green triangles) compared with flight-test and conventional wind-tunnel data from Horstmann, "TELFONA, Contribution to Laminar Wing Development for Future Transport Aircraft", Aeronautical Days, Vienna, 2006.

Laminar Testing

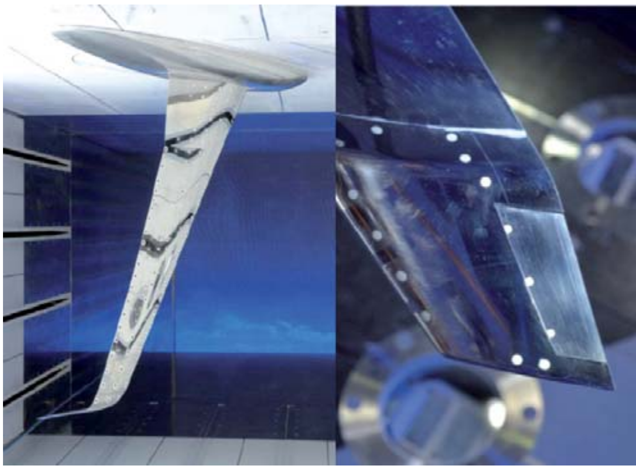
Natural Laminar Flow (NLF) is established as a key technology stream within CleanSky Smart Fixed Wing Aircraft in order to reduce aircraft drag. As part of the process to mature NLF for application, ETW has performed experiments with a large low-sweep half model at flight-relevant Reynolds numbers.

The completed European research project TELFONA (cf. ETW News 16, p. 9), led by Airbus, had investigated the applicability of ETW for NLF wing design. Transition N-factors for both crossflow (CF) and longitudinal Tollmien-Schlichting (TS) instabilities were determined. Measured transition locations were compared with the results of linear stability analyses. The results have shown that experimental data were sufficient to obtain critical ETW N-factors for cases with either predominant N_{TS}-factors or for predominant N_{CF}-factors. TELFONA's results have demonstrated that ETW's flow quality enables laminar testing close to free flight conditions.

Now, ETW has been used within CleanSky to contribute to a wing design methodology aiming for robust laminar performance taking into account different surface imperfections. The transition locations are again measured by the German Aerospace Research Center (DLR) Göttingen using CryoTSP. The data will serve to validate CFD predictions on NLF wing designs including such imperfections as they may occur on a real aircraft. This work has received funding from the European Union FP7/2007-2013 under grant agreement no 323452.

ASDMAD

RWTH Aachen University has conducted a new aero-structural dynamical experiment using an elastic model of a wing with 2 different winglets at ETW. As a follower project of HIRENASD (see ETW News 15, p. 4), the so-called ASDMAD (Aero-Structural Dynamics Methods for Airplane Design) project is jointly funded by the German Research Foundation DFG, Airbus, and the RWTH Aachen as a "transfer project" from research to industrial application. Static and dynamic experiments have been performed in transonic flow at various combinations of Reynolds number and dynamic pressure / airloads. At temperatures down to 123 K (-150° Celsius) and total pressures of up to 3.7 bar, the wing is forced to oscillate by piezo-actuators in the wing root. One larger winglet had a rigid geometry, while the second one had a non-rigid geometry due to an excitable aerodynamic control surface. More than 300 sensors and optical methods measured the unsteady deformation synchronously with the pressure and balance data.

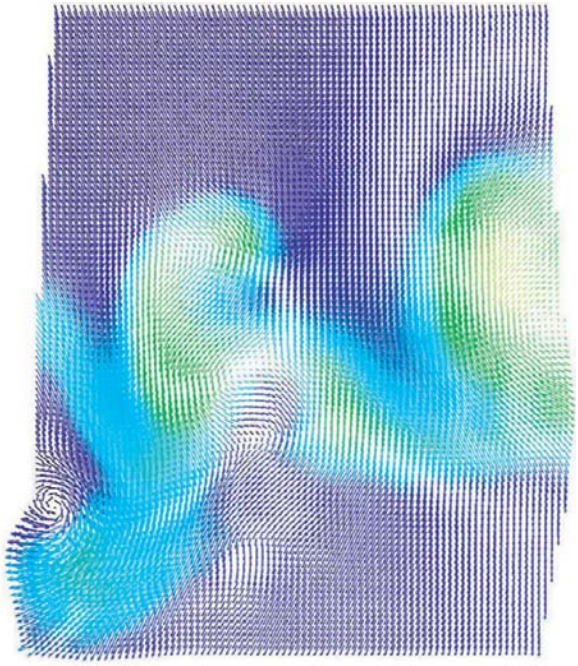


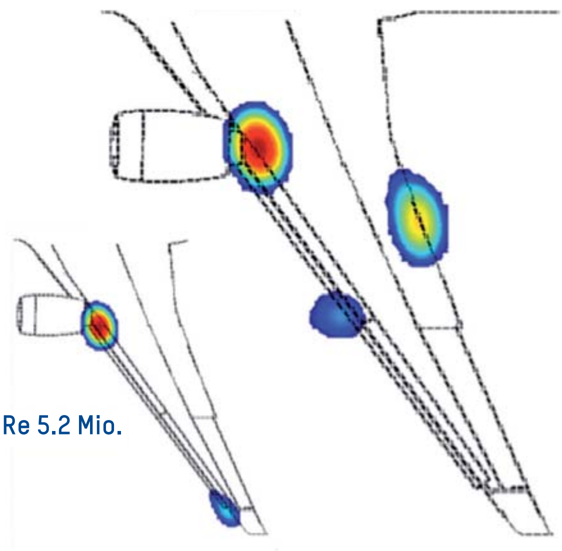
03 | RESEARCH

LuFo - Research supported by Germany

LuFo - CryoPIV

The German "Luftfahrtforschungsprogramm (LuFo)" has supported the development of particle image velocimetry (PIV) for application under cryogenic conditions (cf. ETW News 16, p. 4). The project, a joint effort of DLR Göttingen and ETW, covered preliminary investigations in the smaller Pilot-ETW (PETW), which were finally verified in ETW. Water-ice turned out to be an appropriate PIV seeding to be used in ETW. DLR has developed a computer-controlled setup to provide and automatically maintain a high-quality light sheet in the test section at varying temperature and pressure levels. CryoPIV images were acquired at high-lift, high-speed and flight-relevant Reynolds numbers comprising total temperature levels from 125 K to 220 K and total pressure levels from 125 kPa to 400 kPa. Typically, each PIV data point requires 20 s acquisition time. In collaboration with DLR, ETW now offers CryoPIV for R & D testing.





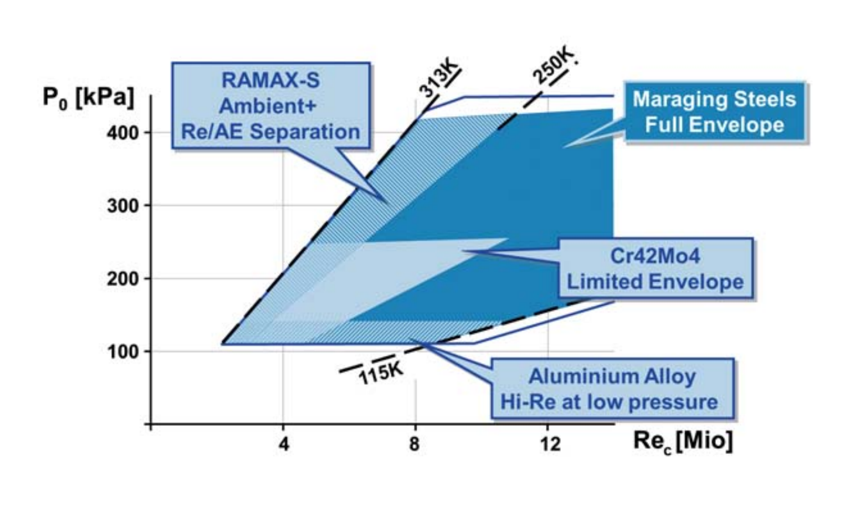
LuFo - ALSA

ALSA (Acoustic Localisation of Boundary-Layer Flow Separation), another research project supported by the German LuFo, supports the development of acoustical testing techniques at ETW. ETW and DLR in cooperation with TU Berlin are heading for an innovative, acoustical method to locate boundary-layer flow separation at the flight-envelope limits in high lift and close to the buffet boundary (cf. ETW News 16, p. 5). The acoustic signature of the detached boundary layer shall be recorded by a microphone array at the wind-tunnel wall, and data processing shall reveal separation locations. In a first step, a microphone array has been successfully used in the Pilot-ETW (PETW). The radiated noise from a cylinder in PETW had been measured successfully. Pressure and temperature dependencies of the micro-phone frequency responses were quantified and decibel corrections were introduced. Acoustic array measurements were performed in PETW and –using a feasibility test array- also in ETW at various total temperatures between 120 K and 290 K and pressure levels from 110 kPa to 400 kPa. The feasibility test at ETW has revealed some Reynolds-number dependency of noise sources at a specific configuration. A final verification test at ETW will be performed in 2013.

04 | FURTHER NEWS

Good to Know

Model Materials

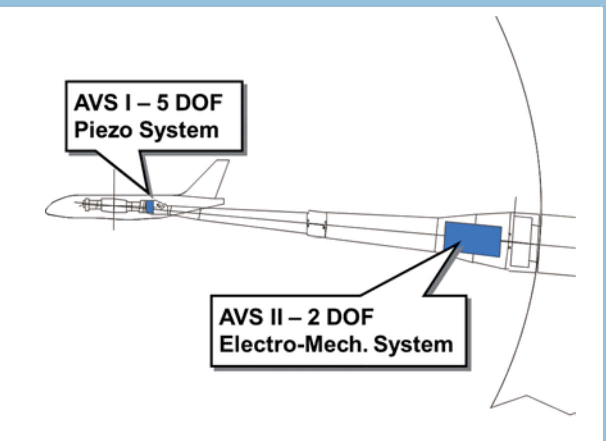


Some tests do not require exploiting the entire ETW performance envelope. If limited temperature or pressure ranges allow achieving the test objectives, material other than high-strength cryogenic compatible maraging steel may be used to either reduce model manufacturing costs and lead time, or to re-use an existing model, which was made for testing in a conventional wind tunnel.

Some examples:

- High Reynolds number, high-lift testing can be performed at temperatures down to 115 K using aluminium alloy up to dynamic pressures of about 30 kPa.
- Business- and small Regional-Jet designs may be tested in a total pressure / total temperature envelope of ETW limited by up to typically 250 kPa and down to 220 K with models made from Cr42Mo4. Within this envelope it is still possible to separate Reynolds-number and aeroelastic effects.
- Typical models, which are used in conventional pressurized facilities and are e.g. made of RAMAX-S, may be used in ETW down to total temperatures of 250 K. In this case, testing at about 30% higher Reynolds-numbers and separation of Reynolds-number and deformation effects are possible unlike in conventional pressurized facilities.

A revised edition of the ETW Materials Guide, issued in October 2012, includes some new material options. It is available on request.



Performance Improvements

ETW's Anti-Vibration System (AVS; cf. ETW News 12, p. 6) is often used to test close to physical flight-envelope limits of a given design. Usually the AVS is applied to damp vibrations, which can lead to the interruption of a test. Alternatively, it can also be used to excite model vibrations so that the unsteady aerodynamic responses can be measured. The existing system has been further improved. Higher availability and reliability is achieved by using standard-size piezo stacks for the AVS I module, which is also applicable for after-body installations. The damping / excitation power of the AVS II module has been increased by 33%. Higher productivity and cost-efficiency is achieved by advanced tuning, which reduces the tuning-time by 70% to 20 min-40 min per configuration at ambient conditions. Further tuning at cryo-conditions is typically no longer required.

Furthermore, pressurization during high-lift testing has been accelerated by 17% due to smart wind-tunnel control law adaptations. A newly installed GN2 purge system reduces the conditioning time in the test section after configuration changes by about 50%. Additional thermal insulation of some facility components allows continuous high speed / high-pressure testing at cryogenic temperatures for up to 5 hours.

04 | FURTHER NEWS

Public Appearances

Visitors

During the past months, several distinguished guests have visited ETW. Amongst these were the European Commissioner for Research, Innovation and Science Máire Geoghegan-Quinn, the German Federal Minister of Economics and Technology / Vice Chancellor Dr. Philipp Rösler, the German Parliamentary State Secretary Peter Hintze, the North Rhine-Westphalia's Science Minister Svenja Schulze, and the Chief Scientific Adviser to the EU President Prof. Anne Glover. "The ETW is a significant strategic research facility for the European aeronautical industry. The special competences of this institution and its workforce are recognised worldwide. It is very important that the associated nations are working closely together to safeguard the future of the ETW", commented Dr. Rösler on his visit.

Movie Set

The atmosphere at ETW has already several times inspired the popular German television series "Alarm für Cobra 11 – Die Autobahnpolizei" (Alarm for Cobra 11 - The Motorway Police) . ETW's control room, the tunnel building and the nitrogen tank area have been used as background for hot pursuits and dramatic shootings. Recently, also the German-Norwegian co-production "Zwei Leben" (Two Lives) starring actress and Oscar-nominee Liv Ulmann, has used ETW as a set location. The movie, a mix of family drama and spy thriller, will be released soon. Naturally, these kind of activities take place during weekends and do not interfere with ETW's client service.

Photographic Art

Thomas Ernsting, a famous photographer who has already received the World Press Award four times, was excited to take pictures of the ETW Test Section. The picture shown here has been used in the 2012 Ferchau calendar.

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