ETW NEWS

EUROPEAN TRANSONIC WINDTUNNEL

Issue No. 12 | December 2004

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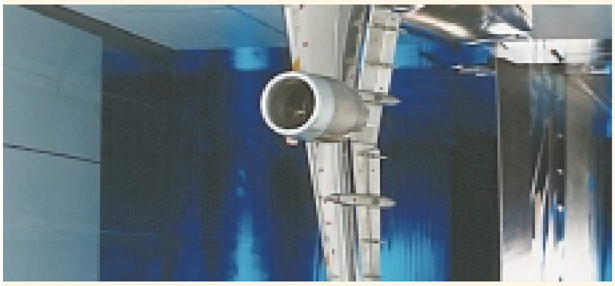

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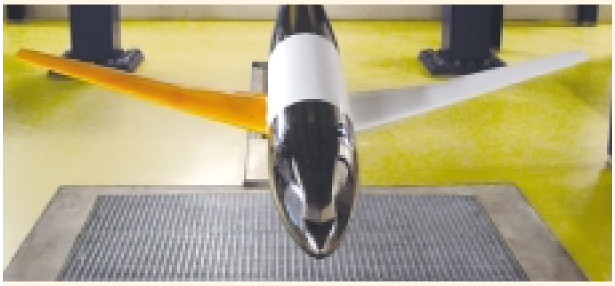

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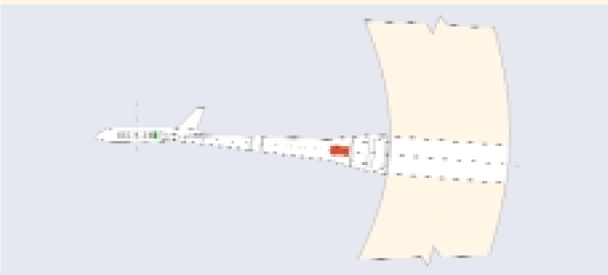

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EXHIBITIONS 2004

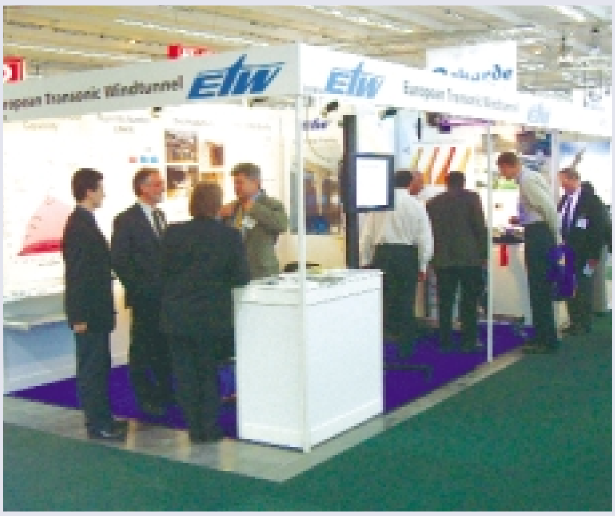
Report on "Tag der Raumfahrt 2004"

For the third time, ETW participated in the "Tag der Raumfahrt" organized every two years by the German Aerospace Center DLR, this year on 18^{th} and 19^{th} September. The event was a great success. 100,000 visitors were counted at the Cologne Research Center of DLR and of these, 3,500 visited the neighbouring ETW. Groups of 30 to 50 persons were guided through the ETW plant, the major points of interest being the Main Tunnel Control Room, the Client Areas, the Tunnel Hall and the outdoor facilities such as the storage for liquid nitrogen, the blow-off of gaseous nitrogen and the production of dry air. In spite of waiting in queue for about an hour, most visitors expressed their high satisfaction at the end of the tour.

AEROSPACE TESTING EXPO 2004

30^{th}, 31^{st} March & 1^{st} April 2004, Hamburg, Germany

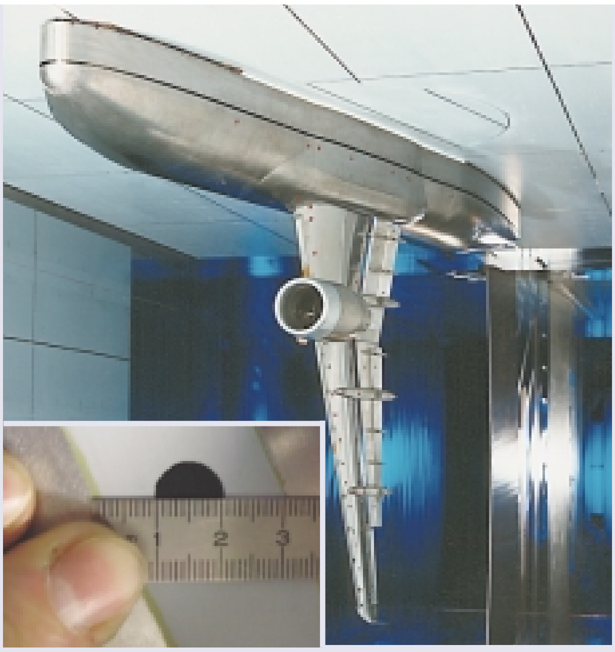
Again this year, ETW was represented with a stand at this fair in Hamburg. Alongside information posters, a typical aircraft model suited for tests under cryogenic conditions was displayed. Equipped with a live balance, infrared thermography, minitufts and deformation markers, the model attracted many interested visitors from all over the world. ETW used the Aerospace Testing Expo for general communications, presentation of achievements and detailed discussions with clients. The visitors to ETW's stand were impressed by the quality of the measurement techniques and test results that were presented.



Dieter Schimanski, Manager Test Projects & Operations, presented a paper in the Open Technology Forum on 30 March on the high productivity and cost effectiveness of ETW as a cryogenic high Reynolds number wind tunnel.

WING DEFORMATION MEASUREMENT WITH A STEREO PATTERN TRACKING SYSTEM

The first Client test was performed at ETW in autumn 2003 with a new model deformation measurement device, the Stereo Pattern Tracking System. The system was developed in co-operation with FIBUS, Germany. In this test campaign several high lift configurations and a clean wing configuration of a half span model were used at low speed conditions in the complete temperature range of ETW and up to a total pressure of 3.6 bar.



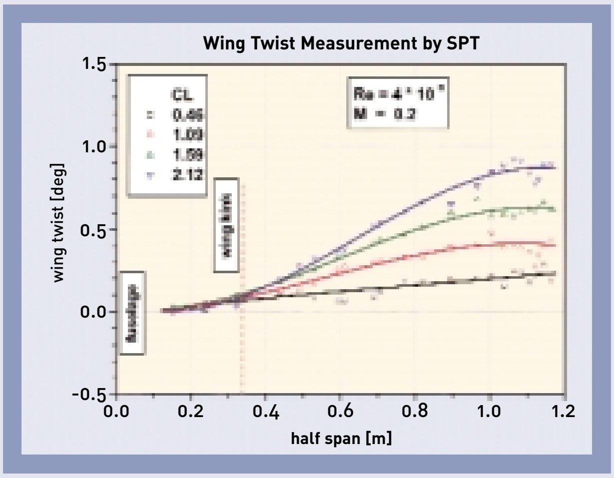
In total, 32 markers were applied at the lower surface of the wing. Black dots of 10 mm diameter were used on a painted surface. The paint was necessary to increase the contrast for each marker and to avoid reflections during the pitch traverse. For half model measurements, the cameras are installed in the side walls of the test section under viewing angle of about 70°. The lighting set-up for the complete model incidence sweep has to be carefully adjusted prior to the measurement to allow maximum intensity and to reduce model surface reflections as far as possible.

The system is based on two CCD cameras equipped with lenses selected for the required image size of a typical half span model assembly. The wing fills the image from one corner to the diagonally opposite corner giving an image resolution of about 0.08 mm. With a marker distance of 150 mm, an angular resolution of 0.05° is achievable at the wing root. To compensate for inaccuracies due to the reduced cord length at the wing tip the number of markers in this region has been increased. The requested twist measurement accuracy of 0.1° can therefore be guaranteed over the full span.

After installation of the cameras, a calibration has to be performed. In this case a calibration frame is installed together with the model on the turn table cover plates, occupying the complete wing volume. Computer controlled light bulbs allow an automatic calibration procedure. If the cameras stay in the selected side wall position, different models can be measured without a new calibration.

The measurement starts with a wind-off traverse, which is used to determine the axis of rotation of the model and marker positions in relation to incidence. The image acquisition is triggered automatically and runs for a predetermined time, typically 5 seconds. The cameras take images at a rate of 7 Hz. The 3D marker positions and the effective wing twist are evaluated in real time. The standard deviation of 3D coordinates is in the order of 0.1mm. All measurements on one incidence are averaged (typically 35 observations).

The final data, twist and bending are available at each marker position (twist based on a single marker and its neighbours) and at arbitrary spanwise positions based on nonlinear fitting and interpolation between all markers.



Future development of the system includes high speed application and model component deformation measurement.

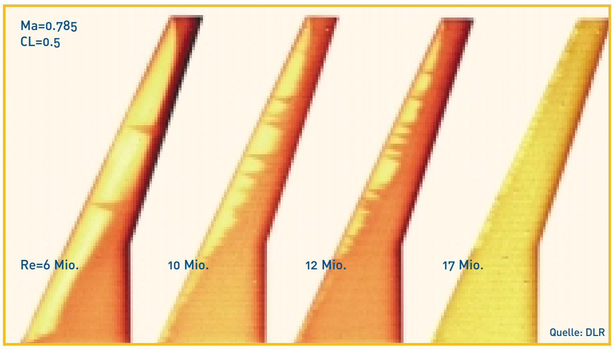
TEMPERATURE SENSITIVE PAINT

High Quality Transition Detection in the Cold

Looking for better ways of detecting the transition line between laminar and turbulent flow, ETW considered temperature sensitive paint (TSP) as an alternative to infrared thermography. Validation tests were carried out on the ETW reference model using a new type of TSP, which is particularly sensitive at cryogenic temperatures. A research team from the National Aerospace Laboratory of Japan (NAL) had composed the paint whereas the other hardware and software elements of the system have been developed by the German aerospace research establishment DLR, in close cooperation with ETW. In a wide range of flow conditions the transition line has been visualized with unmatched clarity, marking this approach as a prime contender for future transition detection works at ETW.

The non-toxic paint is applied to the model wing surfaces in exactly the same way as other coatings used e.g. for visual or infrared imaging. It is then polished to a high quality surface finish. For image acquisition, the paint is stimulated by bursts of high power blue light. This energy, in turn, causes the TSP to emit near infrared light with a temperature dependent intensity. A calibration is done beforehand to quantify the relationship between emitted intensity and temperature. The paint used in ETW produced a linear sensitivity over the temperature range of 110 K to 170 K. A measurement grade CCD camera is utilized to acquire the raw data images, a typical exposure time being 1 second. Some post processing of the images is subsequently done to remove background light by means of subtracting reference images. At the end of this process, the temperature distribution over the entire illuminated and acquired model surface can be quantified.

For the specific task of transition detection, two images are taken at the beginning and end of a rapid temperature step in the flow, respectively. Since the heat transfer rates are different for laminar and turbulent boundary layers, the temperatures seen by the TSP in the second image differ in the laminar and turbulent flow regions of the wing. Using the first image (before any temperature change) as a reference, the two areas can be clearly distinguished. A temperature step of some 10 K is required to produce images with sufficient contrast; the ETW flow control can impose this step in a matter of seconds - well before the temperature gradient in the wing can equalize.



TSP is composed to match the envisaged test temperature range for optimum sensitivity. It thus overcomes the limitations of the – otherwise similar – approach of transition detection using infrared cameras.

TSP has proven to be a viable option for future transition detection works in cryogenic wind tunnels. The technique offers clearer and thus easier to interpret results than was possible before, using mature hardware (UV strobe light, measurement grade CCD camera and associated optical filters) and proven evaluation software. ETW is now able to offer this measurement tool to clients, in particular for application to half models, where the existing IR capability is limited to temperatures above 220 K. The wind-on test sequences and the time required to acquire the images remain virtually identical to those used for infrared thermography. Compared to the IR method the only additional requirement for this technique is an additional layer of paint on top of the standard coating. But this is considered to be a small price to pay for the excellent quality of results obtained from this technique.

THE NEW ANTI VIBRATION SYSTEM

The original Anti Vibration System (AVS) developed in co-operation with ERAS, Germany is installed between balance and sting interface. The system operates on the basis of counteracting vibrations at the eigenfrequencies of the model/balance assembly by exploiting the resonance properties of the system. It consists of an active interface with integrated piezoceramic elements and corresponding power amplifiers and a digital control system using the balance signals for control. This interface, although designed for 5 degrees of freedom, suppresses vibrations primarily in the axial direction and also in the pitch and yaw angular degrees of freedom. The experience from numerous wind tunnel tests shows that strong vibrations which can sometimes lead to interruption of a test are mainly in the pitch angular and pitch heave mode. To overcome some of the limitations of the initial piezo system a second system located downstream in the sting has been produced. This device is located in a stub sting as indicated in figure 1.

In the first trials with the ETW reference model, a significant increase of model incidence could already be achieved. The vibration level in the buffet region at high lift values was limiting the maximum model incidence significantly, especially at higher dynamic pressures. An increase of the incidence was achieved with the original piezo system as presented in figure 2. However, due to decreasing efficiency of the piezo elements at cryogenic conditions the interesting area could not be explored far enough. The new system concentrating on angular pitch and heave pitch modes, working in parallel with the original piezo system, now allows a significant increase in model incidence, as shown in figure 2. In the meantime several client campaigns were performed with the new system and experience was gained with different assemblies.

Further development of the system was performed in spring 2004 when the new system was also used in an "Active Motion Mode". The development work concentrated on the modification of the software to allow both the active excitation of the model and balance assembly and the immediate change from excitation to damping in case of increased vibration levels.

The first test campaign in this set-up was performed with a model assembly equipped with horizontal tail plane. Due to its aerodynamic damping effect the increase in vibration level was relatively small. However, a sufficient level of excitation was generated to enable the influence of unsteady effects on the wing aerodynamics to be measured. Figure 3 presents the increase in vibration level.

Figure 1

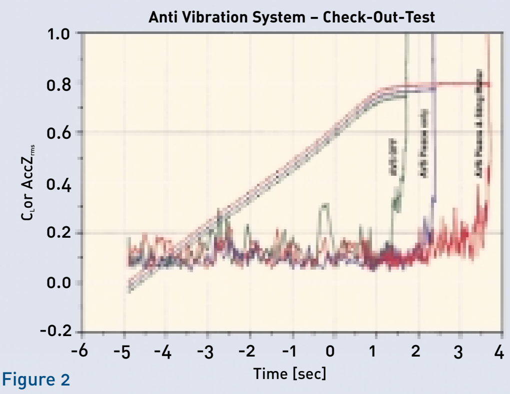


Figure 2

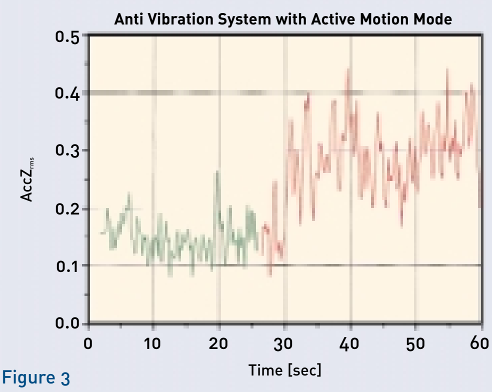


Figure 3

ETW SYMPOSIUM
29th March 2004

The ETW Symposium on 29 March 2004 started with a welcome by the Managing Director Wolfgang Burgsmüller and an overview on the current capabilities of ETW by Dieter Schimanski.

The main session was reserved for Clients´ presentations, in which the speakers reported on the achievements, experiences and developments in the flight Reynolds number test campaigns performed at ETW during recent years. The importance of the unique results achieved over the broad range of the ETW test envelope was pointed out in detail. A presentation on the latest development in Pressure Sensitive Paint for cryogenic application completed the session.

Wolfgang Burgsmüller and Allen Kilgore, Head of the National Transonic Facility (NTF) in USA, concluded the presentations with an outlook to the important role of cryogenic wind tunnel testing in the development of future aircraft projects.

The Symposium attendees then had a chance to visit the facility and discuss further details during an extensive tour. The ETW Symposium was attended by 22 visitors from Europe and 14 visitors from USA and Japan.

The presentations are listed below :	
Welcome and introduction to the symposium	Wolfgang Burgsmüller, Managing Director, ETW
Flight Reynolds number testing at ETW current capabilities	Dieter Schimanski, Manager Test Projects and Operations, ETW
The development of cryogenic Pressure Sensitive Paint (PSP) for application in ETW (Part1, Part2)	Rolf Engler, DLR
Achievements from the HiReTT high Reynolds number wind tunnel testing in ETW	Tom Gibson, Airbus UK
The use of ETW in EUROLIFT first experience of the test facility for high lift configurations	Heinz Hansen, Airbus Germany
Business jet type configuration testing at ETW	Pascal Bariant, Marc Rapuc, Marc Stojanowski, Dassault Aviation
The role of ETW in the development of Airbus aircraft A380 and the future	Paul Phillips, Airbus UK, Joelle Willaume, Airbus France
Closing remarks	Allen Kilgore, Head NTF, and Wolfgang Burgsmüller

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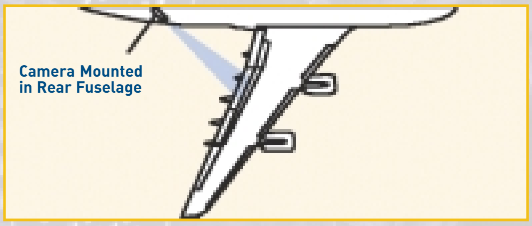
Flap Gap Deformation Measurement using an on-board miniature CCD Camera

In the high lift, low speed configuration mentioned in the article of the wing deformation measurement system, the flap gap deformation was also measured using an on-board miniature CCD camera.

The installation of the camera and the viewing angle are presented below.



To establish the required quality of the images, the contrast at the trailing edge of the flap and a defined line on the wing centre was increased using a fluorescent marker. Since UV lights were used for Minituft images the flap gap deformation images were taken at the same time.

The images showed two lines, which were analysed in comparison with the relevant wind-off images. A typical example is presented below.

The resolution of the measurement has been determined to be about 0.1 mm.