European Transonic Windtunnel GmbH
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News

Issue No. 3, August 1995

First Three Client Tests Completed

Aerospatiale Avions of Toulouse, France, British Aerospace Airbus of Filton, United Kingdom, and Daimler-Benz Aerospace Airbus of Bremen, Germany, are ETW's first three clients each having executed a test programme with their specially made cryogenic models. Beside the opportunity to familiarise themselves with the facility these first tests offered them a unique experience to explore the aerodynamic characteristics of their models at high Reynolds numbers exceeding those of all previously carried out wind tunnel tests.

After the mechanical completion in 1992 and the subsequent inauguration of ETW in June 1993 most of 1993 and 1994 was spent on commissioning and calibration of the facility. To get an impression about the magnitude of this task it is necessary to realise that some 300 contracts were placed for design, fabrication, construction and installation, each with its own specific requirements and time schedule. Calibration activities comprised performance and flow quality measurements with various measuring devices over a wide range of Mach numbers, pressures, and temperatures representing a matrix of test conditions of a size that will require continuation even in the years after 1995.

The first model tests were carried out in October 1993 with a conventional model designated "F-4 On-loan" provided with an ONERA balance. The results of these tests were very encouraging combining high productivity with excellent data quality and showing good comparison to other wind tunnel data.

More tests followed with ETW's own F-4 cryogenic reference model with different cryogenic balances to explore the tunnel's

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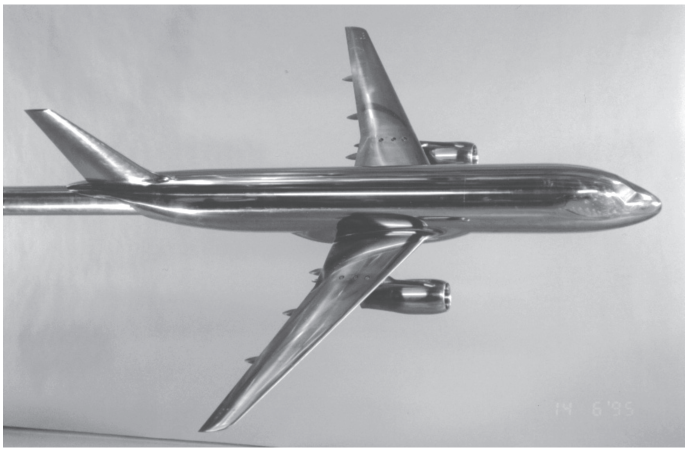

A 320 Model in Final Preparation

Third Customer

British Aerospace Airbus Ltd. of Filton was the third customer to explore ETW's testing capabilities. Their model of the A320 allowed for combined force/moment and pressure plotting measurements on a number of configurations. In addition to the large number of pressure tappings on the wing (over 250), the model instrumentation included dynamic pressure sensors, temperature sensors and strain gauges to detect buffet onset. The tests were conducted in May of this year under a cooperation agreement between ETW and the customer for these early exploratory tests.

The 1/22nd scale A320 model is the result of a Cryogenic Technology Programme funded jointly by British Aerospace, the Department of Trade and Industry, and the Aircraft Research Association Ltd. of Bedford, where the model was designed and manufactured. The ETW test spectrum covered a range of pressures and temperatures equivalent to a maximum Reynolds number of 24.5 million at a cruise Mach number of 0.78.

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First Three Client Tests Completed

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envelope and check out the balance/ sting combinations. In November 1994 this resulted in a series of tests during which 225 polars were realised in 6 days and Reynolds numbers were achieved in excess of 21 million.

The first three client tests were executed between December 1994 and July 1995. The Daimler-Benz model, a 1/30 replica of an Airbus A310, was the first after having been tested in DLR's KKK low speed wind tunnel at cryogenic temperatures but ambient pressure. The programme enabled comparisons of tunnel to tunnel and tunnel to flight data. The Aerospatiale model, a 1/39 scale A340, was also used to explore ETW's infrared imaging system at temperatures down to 200K by applying a special coating to the model for boundary layer transition position detection. Both tests provided highly valuable information on model/ support vibration interaction, overall mean flow quality, data repeatability during a run and reproduceability between runs. In addition, new experience was obtained with cold model handling and filler behaviour.

A 340 Model in the Test Section

The test for BAe added to these experiences the option of combined force/moment and pressure measurements. The model, a 1/22 scale A320, incorporated over 250 wing pressure tappings distributed over 9 spanwise stations, some of them only a tenth of a mm diameter, plus some additional instrumentation. The programme contained up to 9 different configurations including comparisons to other wind tunnels and saw some of the smallest transition fixes ever applied to verify boundary layer tripping at intermediate/high Reynolds number conditions. The maximum chord Reynolds number realised during this test with free transition was 24.5 million, very close to the full scale flight value of 25.7.

For those who are familiar with wind tunnel testing it goes without saying that testing in a novel facility with brand new models is always a bit of an adventure and has in many respects lots in common with testing a new aircraft prototype. Despite some initial problems it can be stated that the execution of those first three tests in close cooperation with the three abovementioned Airbus partners has demonstrated ETW's "Proof of Concept". This justifies the expectation that future tests of new aircraft configurations will provide invaluable information about the flow characteristics and thereby the performance and behaviour of those aircraft at flight Reynolds numbers at a cost level which is only a fraction of the development price of an aircraft.

News in Brief

ETW is the subject of a feature in Lufthansa-Bordbuch magazine provided in the back-rest pockets of Lufthansa passenger planes. Mr. Claus-Peter Sesin who recently spent a few days at ETW is the author of the article with Mr. Henning Christoph providing the photographs.

The ETW Model Design Handbook has been published. It gives guidance on design, construction, analysis, quality assurance and documentation of test assemblies and components for testing in the facility.

Visitors to ETW

Recent visitors to ETW included:

Mr. Yoshio Hayashi, Chief LST, NAL, and Mr. Hideo Iso, Aerodynamic Design, Fuji Heavy Industries, Japan.

Mr. Bachelier, Head of Aerodynamics and Flight Mechanics, Aerospatiale, Toulouse and Mssrs. Jouty, Cordier of STPA, Mr. Robert and Mrs. Martin of DGCA, Paris.

Mr. Anton Adibroto, Director, Dr. Sakya, and Mrs. Hadidjah Modjo, LAGG, Mr. Made Wirata, Deputy Aerodynamic/Technology and Mr. Sardjadi, IPTN, Dr. Pasaribu, ITB. Indonesia.

Prof. A. Kharitonov, Deputy Director, Russian Acadamy of Sciences.

Mr. Zhu Xiayun, President, Mr. Qiu Zubin, Mr. Liu Jinyun, Directors, CAIC, Beijing.

Dr. Jiro Hiraishi, Director General, Mr Takashi Honjo, Director, and Mr. Hosono, MITI, Japan.

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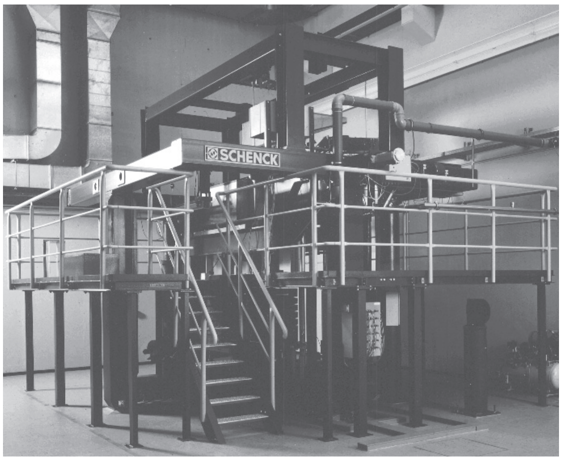
Balance Calibration Machine

The consequence of opting for the cold balance concept is that balances must be calibrated over the complete temperature range. Using classical deadweight techniques this would be an extremely time consuming affair.

Based on an ETW specification a novel automatic Balance Calibration Machine was developed, installed, calibrated and validated. It differs from the usual type of calibration machine by making a clear separation between the functions of load application and load measurement. The load ranges for the different components were adapted to those of the ETW transport aircraft performance balances (see Table). The accuracies stated reflect the differences in importance of the aerodynamic coefficients.

Component	Nominal	Max.	Accuracy	Resolution	Unit
NF	.20,000	.25,000	4.0	0.40	N
SF	.3,000	.3,000	1.5	0.15	N
AF	.2,000	.2,000	0.3	0.03	N
PM	.1,000	.2,000	0.4	0.04	Nm
YM	.1,000	.1,000	0.5	0.05	Nm
RM	2000	2000	1	0.1	Nm

The overall mechanical lay-out is such that the balance has ample free space around it, allowing it to be mounted inside a comfortably sized temperature conditioning chamber. It can be cooled with gaseous nitrogen and heated electrically.



Balance Calibration Machine

The software supplied with the machine produces both second and third order, forward and inverse matrices for use during data processing. It is also unique in the sense that it can deal with any number of components applied simultaneously (combined loads) and come up with a set of optimized coefficients, without undue requirements on the number of points or their sequence. The graphical presentation of the calibration results allows a quick and detailed analysis of the quality of the calibration.

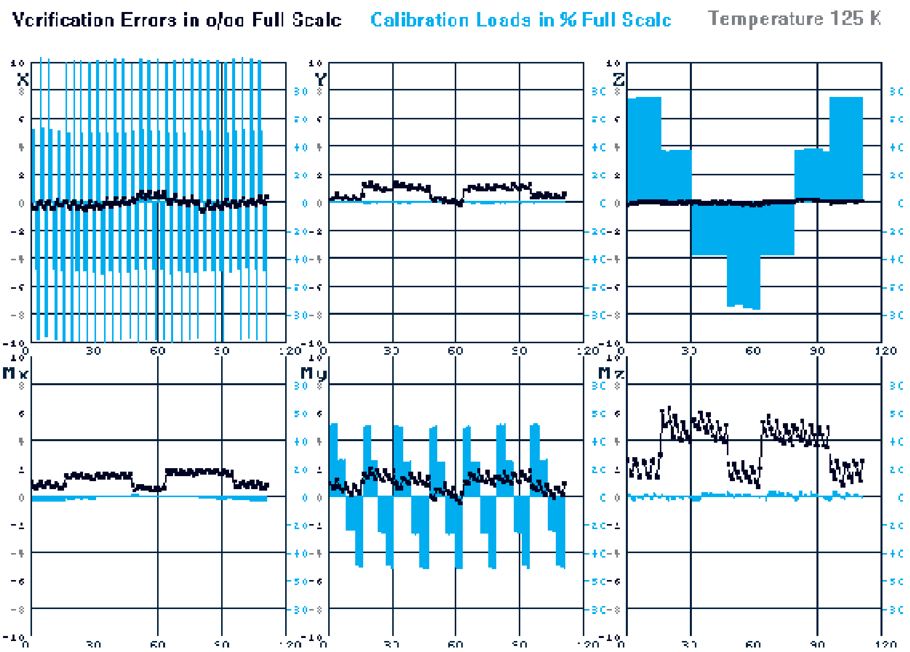
Once programmed for a particular balance the BCM will perform a full second order calibration at one temperature level, involving some 900 data points, in one working day. It is envisaged that the temperature conditioning of a balance is carried out overnight.

Below is an example of the errors attributable to the calibration machine for a typical loading configuration.

This plot represents a typical wind tunnel loading spectrum of a balance comprising 112 combinations of axial force (4), normal force (7) and pitching moment (4). It shows the errors in the respective loads in thousandths full scale (in black) and the applied loads (in blue) at 125 K after the signals have been processed through the balance matrix, in this case of cubic order.

Full Scale Values:

(X) =	Axial Force	1500N
(Y) =	Side Force	2600N
(Z) =	Normal Force	20000N
(Mx) =	Rolling Moment	750Nm
(My) =	Pitching Moment	1200Nm
(Mz) =	Yawing Moment	150Nm



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Test Preparation Development

"Check it out", this is the basic philosophy adopted by ETW during every stage of model preparation. This procedure ensures that once a model test assembly goes "wind on" the chances of model systems failure are significantly reduced. Once a model is in the tunnel using the very valuable commodities of time, liquid nitrogen and power, minor problems become major issues that impact the whole facility. Below are outlined some of the procedures used.

Trial Assembly

All model components are built up on a live balance and sting. The initial checks are to prove that all mechanical and electrical interfaces and space envelopes are correct, including the checking for components fouling.

Balance Check-out

The first stage of the final model build is performed on the Model Build Jig or, if available, the Model Cart. The sting and balance are fitted and connected up to a full instrumentation chain. Certified high precision weights are then applied in all balance axes (see photograph). The applied forces and moments are then compared to the calculated forces and moments from the final data processing program.

Model Build

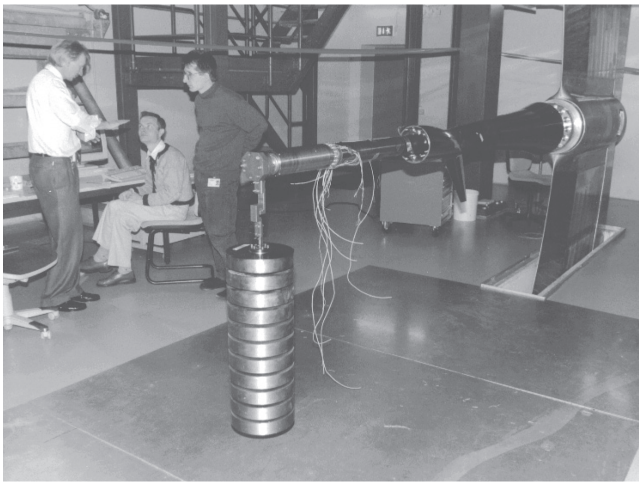
The model is now progressively built up with the instrumentation and model reference surfaces being checked at each stage. Finally the sealers, fillers and (if required) transition bands are applied. At this time a final end to end check of all model systems is performed. If the model has been assembled on the Model Building Jig it is now transferred to the Model Cart using a specially designed transporter. Prior to testing, checks are undertaken to determine the dynamic characteristics of the complete test assembly.

Environmental Check-out

The model is then transported from the Cart Rigging Bay into the Dry Air Lock to dry out the model and model cart prior to its transportation to the Variable Temperature Checkout Room. Here the assembly is cooled down over the full temperature range of the test envelope. Again all model systems are checked out during the cooldown. In the past this has proved invaluable to check the performance of balances, heated packages and moveable aerodynamic surfaces.

Wind-off traverses and model weight tare correction loads can be undertaken at cryogenic temperatures with data being computed and evaluated. This gives ETW confidence in the functionality of the model, data acquisition and data processing systems prior to testing. The model can also be loaded at cryogenic temperatures in the VCTR if required.

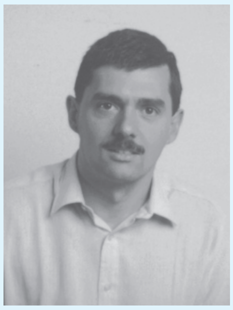
Upon satisfactory completion of all these checks the ETW test engineer along with the clients test director can release the model for test.



Check Weight Loading of Balance Prior to Model Assembly

Personnel

Senior Design Engineer



Thierry Vohy started at ETW in August this year and will be responsible for all mechanical design integration at the facility and assists both Operations and Aerodynamics and Projects with mecanical design issues. Thierry holds a diploma in Mechanical Engineering of the "Institut Polytechnique des Sciences Appliquées" in Paris. Since 1984 he was employed with ONERA/IMFL in Lille where he was responsible for aeroelastic and cryogenic models and related cryogenic instrumentation and measuring techniques.

Thierry is familiar with CATIA and CADCAM software and has a private pilot license.

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