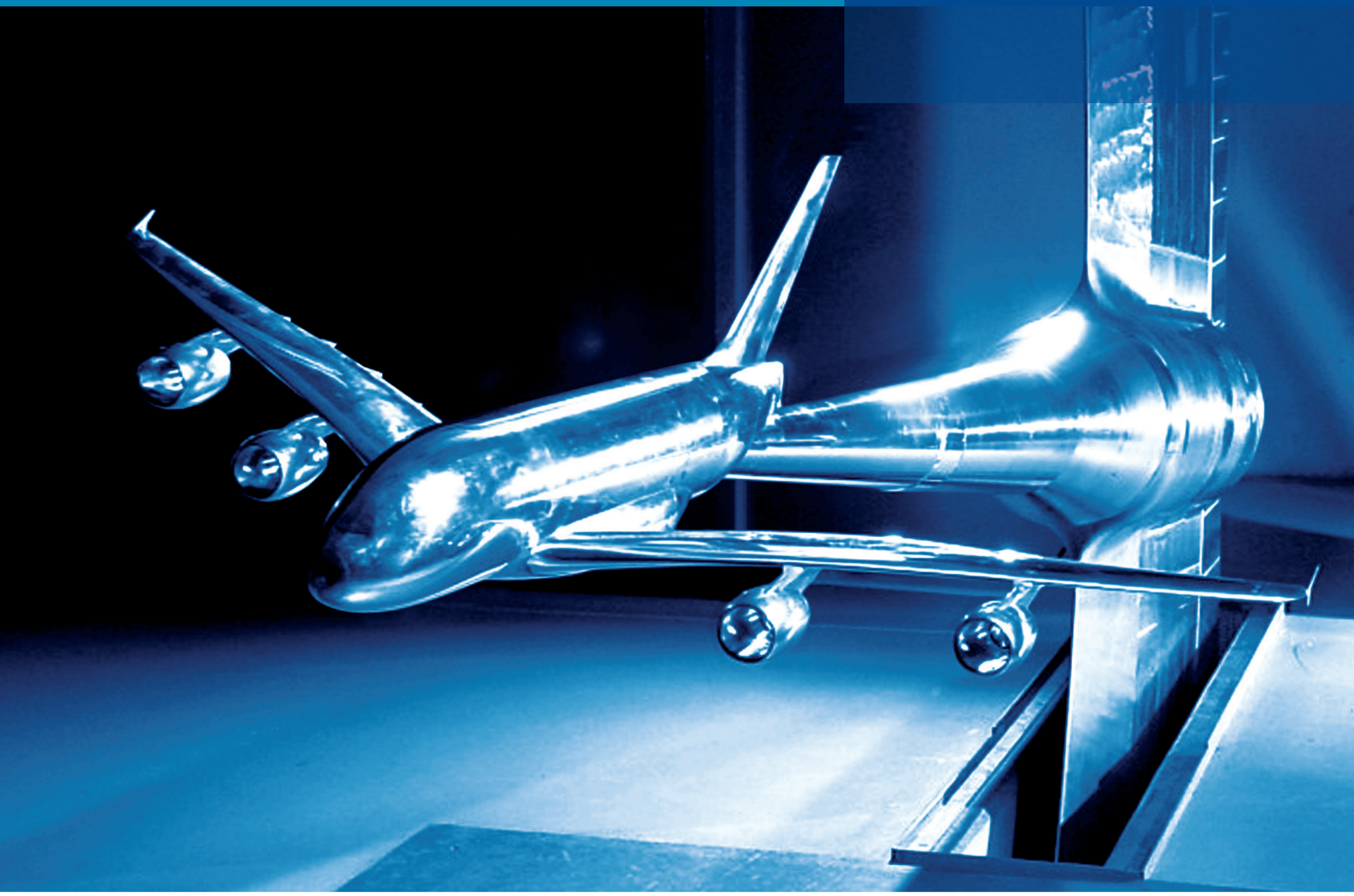
EUROPEAN TRANSONIC WINDTUNNEL

PUSHES THE LIMITS



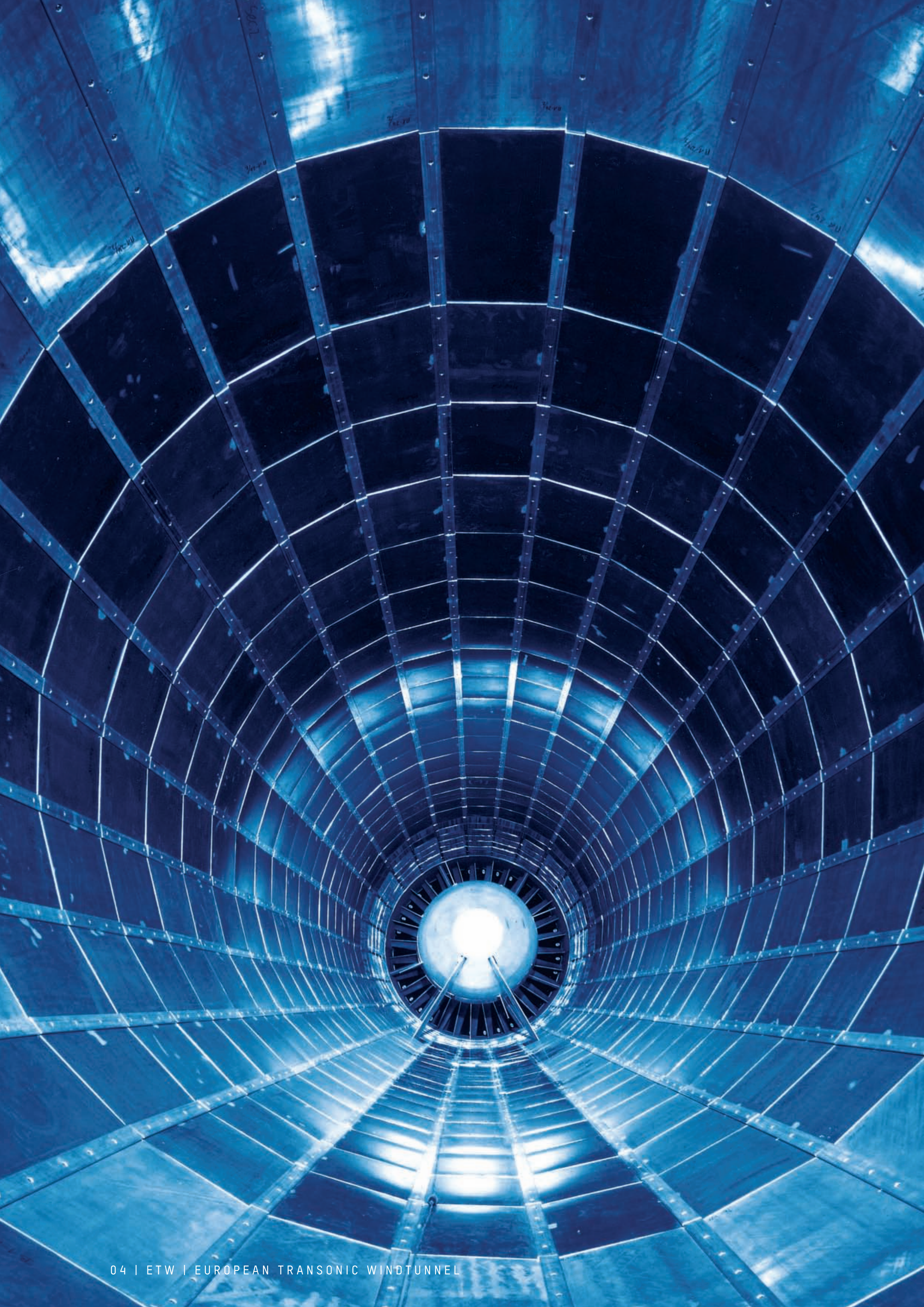
ETW – PUSHES THE LIMITS

Wind tunnels, using scaled down aircraft models, are the major source of aerodynamic design data for new aircraft projects. Wind tunnels are indispensable tools for aerodynamic research and aircraft development and complement the most powerful computers.

ETW, the European Transonic Wind Tunnel, was designed, constructed and is operated by the four European countries France, Germany, Great Britain and The Netherlands based on a non-profit policy. Its location in Cologne, Germany, is right in the middle of Europe.

European researchers and engineers harness ETW's capabilities for advancing aeronautical science into aircraft innovation by accessing real-flight conditions in this cutting edge ground-test facility.

ETW is the worldwide leading wind tunnel for testing aircraft at real-flight conditions. Aircraft performance and their flight envelope limits can be accurately determined with unique quality at ETW long before flight testing of a first prototype. This enables significant reduction in the technical and economic risks associated with the development of new aircraft. Manufacturers from all over the world take advantage of the exceptional features of this high-tech facility enhancing the performance, economic viability, and environmental friendliness of their future aircraft.

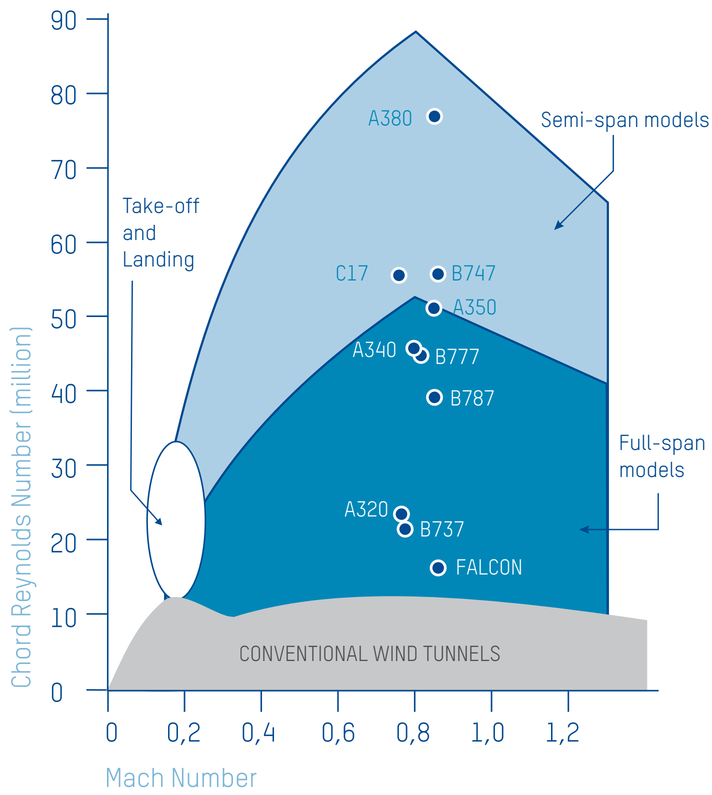


1. ETW tests aircraft models at the actual flight Reynolds numbers of the full-scale aircraft.

2. ETW delivers test data of unsurpassed quality and of the highest confidence level.

3. ETW provides outstanding test productivity resulting in excellent cost effectiveness.

4. ETW guarantees absolute client confidentiality.



Performance envelope of ETW

ONLY THE BEST IS GOOD ENOUGH

We have the best tools to get you a perfect result

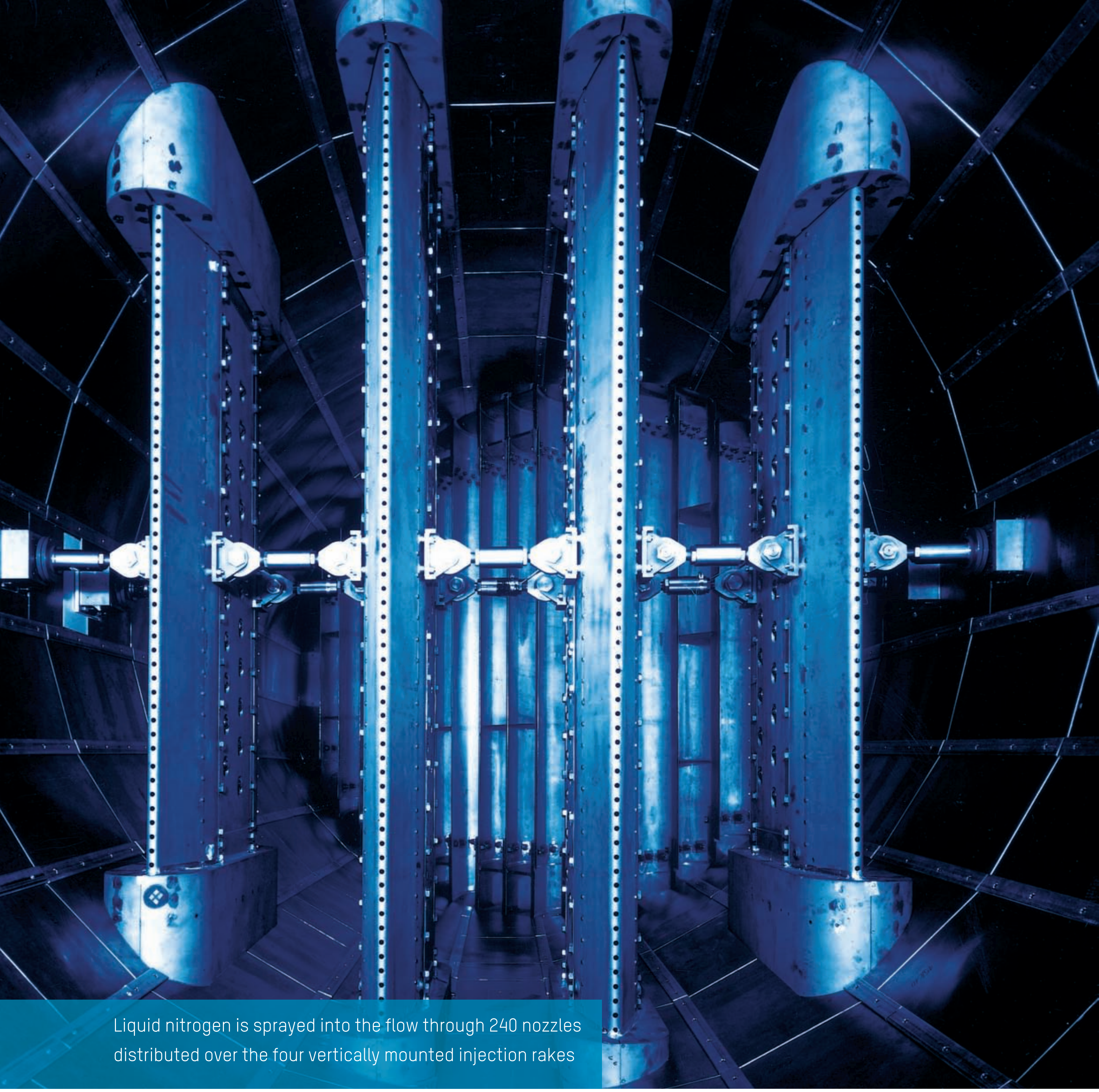
ETW uses nitrogen as its test gas thus enabling the flow temperature to be lowered down to minus 163°C (110 K). This, together with increasing the pressure up to 4.5 bar results in the physical properties of the wind tunnel flow being modified such that the similarity parameters (Mach and Reynolds numbers) are exactly fulfilled with scaled down aircraft models.

Client Comments:

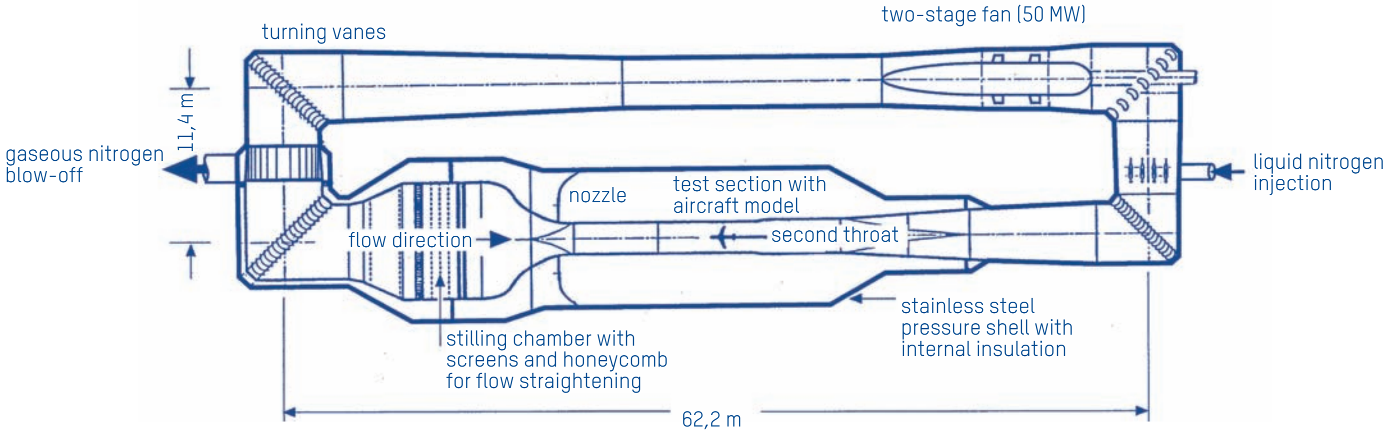
"For the first time a Reynolds number of 25 million could be reached for low-speed high-lift tests. Remarkable Reynolds number effects could be found for maximum lift."

"The tests at ETW allowed validation of the design choices for the new wing. Without this cryogenic wind tunnel, it would be impossible to know the reliability and applicability limits of the numerical models. "

"Detailed measurements in ETW including trailing edge pressures and aeroelastic model deformation in a well-balanced combination with validated CFD tools are necessary for true flight predictions."



Liquid nitrogen is sprayed into the flow through 240 nozzles distributed over the four vertically mounted injection rakes



KNOWLEDGE, EXPERIENCE: EXCELLENCE

The most advanced aeronautics wind tunnel in the world

ETW has a closed aerodynamic circuit contained inside an internally insulated pressure shell made of stainless steel.

A two-stage fan with a drive power of up to 50 Megawatt circulates the nitrogen gas around the circuit.

To achieve and maintain the desired low temperature of the flow, liquid nitrogen is continuously injected into the tunnel where it immediately vaporizes into the cold test gas.

In order to maintain the desired pressure in the test section, a corresponding mass flow of gaseous nitrogen is exhausted from the tunnel.

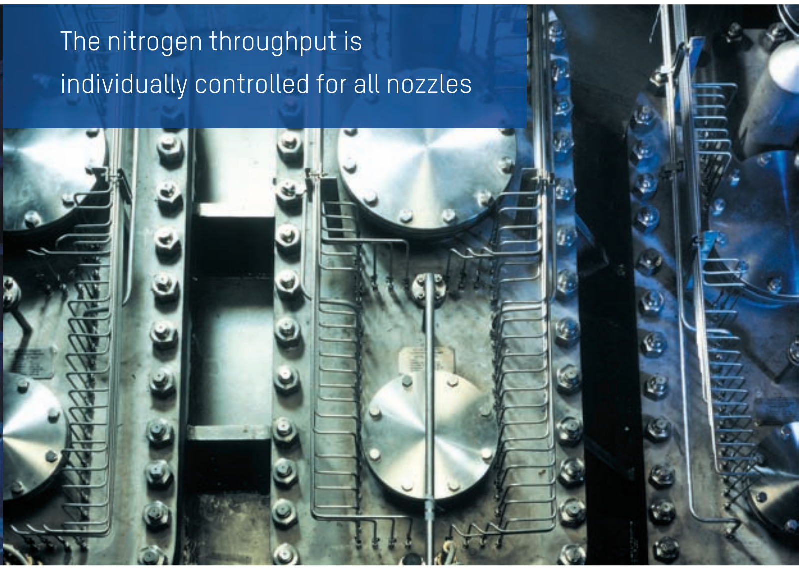
The Mach number in ETW ranges from 0.15, for low-speed high-lift testing, through the range of high subsonic speeds (0.7 – 0.9), important for the cruising flight of modern transport aircraft, up to 1.35, for supersonic aircraft or space vehicle tests in low supersonic conditions.

The test section size and the pressure and temperature ranges represent the best combination of parameters for meeting the requirement from the aerospace industry for realistic tests. The required Reynolds numbers of up to 50 million with full span models (span approximately 1.6m) and up to 85 million with half models (semi-span approximately 1.3m) are achieved in ETW.

ETW Specification

Test Section	width x height x length: 2.4m x 2.0m x 9m
Mach Number	Range: 0.15 - 1.35
Pressure	Range: 115 to 450 kPa
Temperature	Range: 313K to 110K
Reynolds Number	Range: Full Models, up to 50 million
	Half Models, up to 85 million

The wind-tunnel fan



The nitrogen throughput is individually controlled for all nozzles

TIME IS MONEY

Outstanding test productivity and cost efficiency

A key element of ETW is the efficiency in which the Clients can be accommodated in the facility, their models prepared and the speed and accuracy at which the data can be acquired.

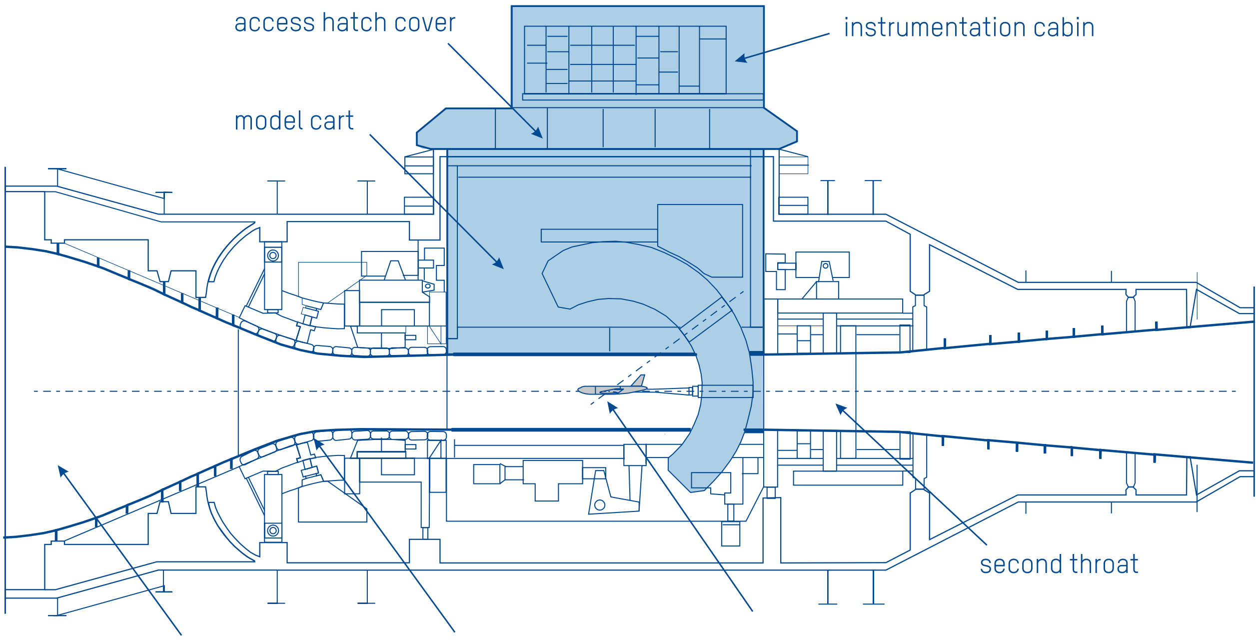
ETW uses a system of two removable and interchangeable model carts to provide both flexibility of model handling and high productivity in ambient and cold environments.

A remotely controlled transporter crane carries the model cart assembly within the large transfer hall. This enables the model cart to be lowered into the Model Preparation Rooms, the Variable Temperature Checkout Rooms as well as into the Test Section of the tunnel.

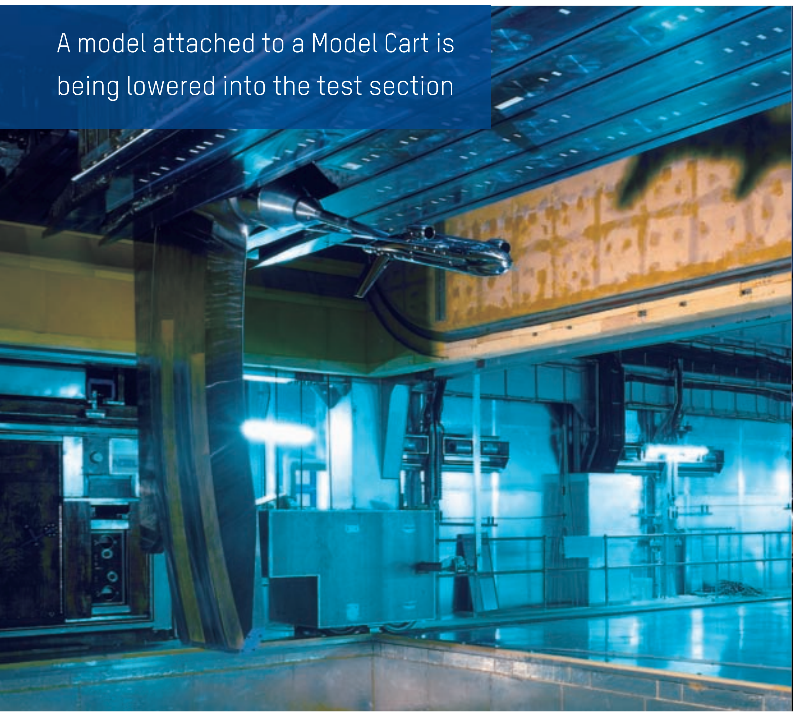
One section of this transfer hall contains extremely dry air to prevent frost and ice formation when the model cart assemblies are cold.

Computerized control systems enable the operators in the main tunnel control room to manage the different activities of the whole plant.

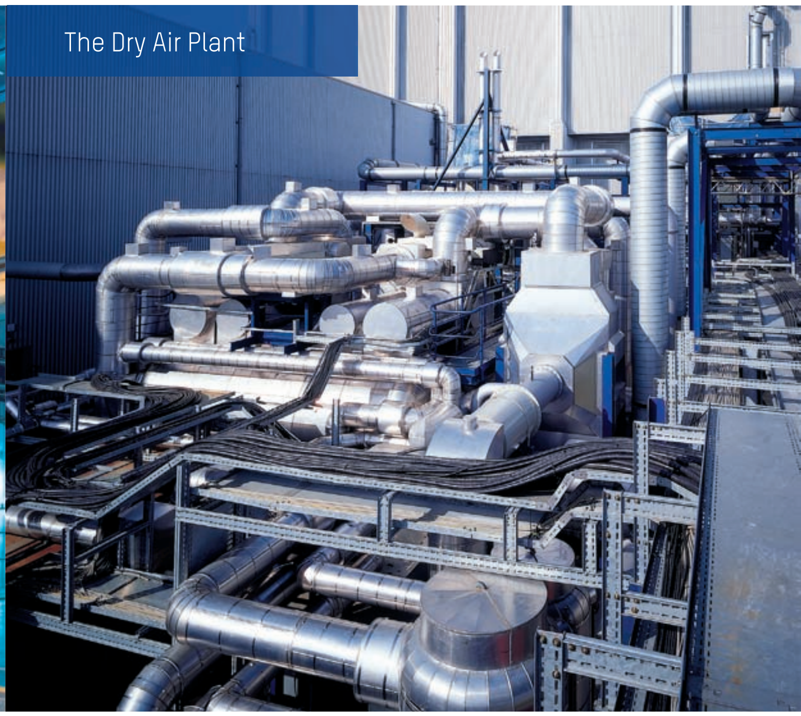
The ETW data acquisition and processing systems ensure both the strictest confidentiality of test results and the flexibility and comfort that Clients generally require from industrial wind tunnels.



Model Cart with model in the test section



A model attached to a Model Cart is being lowered into the test section



The Dry Air Plant

PRECISION AND RELIABILITY

Optimize your design – minimize your effort

The forces and moments exerted by the flow on the model are measured with high precision strain gauge balances.

Full-span models are mounted directly on a suitable balance which is internal to the model and measures six components: lift, drag, side force, pitching moment, rolling moment and yawing moment.

Semi-span or half models are mounted on a special balance which is external to the model and is situated in the top wall of the test section.

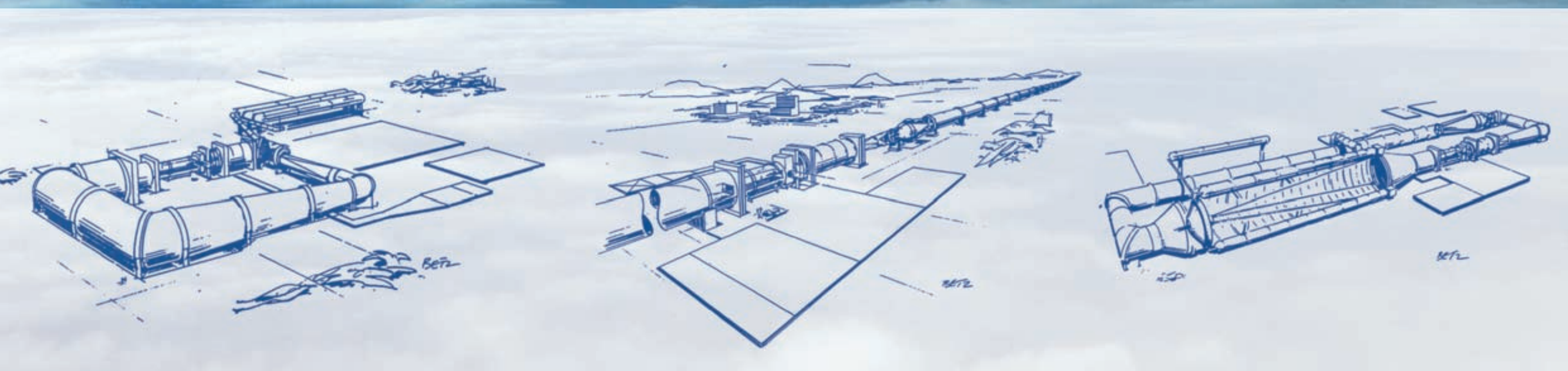
The pressure distribution on the surface of the model can be measured in various arrangements.

Vibrations of the aircraft model, which adversely affect the measurements, are suppressed by a special Anti-Vibration System. The same system can also be used for the excitation of oscillations for unsteady and aeroelastic testing.

High-precision balances for full-span models

WHERE DO WE COME FROM?

Aircraft-design risk mitigation demands flight Reynolds number testing



Inaccurate prediction of the real flight conditions based on conventional wind tunnel test data led to the development of poorly performing aircraft in the past. The shortcomings were detected late in the design process, i.e. during flight testing, and led to costly design changes.

Consequently, experts within NATO's Advisory Group for Aerospace Research and Development AGARD identified the demand for flight Reynolds number wind tunnel testing, and in 1963 started to discuss the requirements and design options for an appropriate ground-test facility. In 1973 the four European countries France, Germany, Great Britain and The Netherlands agreed to jointly proceed with the project of designing and constructing a high Reynolds number wind tunnel named the European Transonic Windtunnel ETW. They charged a group of experts with further investigations into this matter.

During the following years, they chose the so-called cryogenic, i.e. low-temperature technology as ETW's working principle, completed the various design phases, selected Cologne in Germany as the site of the facility, and in 1989 started with construction.

Mechanical completion was achieved in 1992 and on 20 October of that year, HM Queen Elizabeth II together with HRH Prince Philip visited ETW and expressed their appreciation of this outstanding facility.

First wind-on occurred in December 1992. During the following phase of commissioning, maximum pressure, highest Mach number and lowest temperature were achieved in December 1993.

On 22 September 1994, the International Council of the Aeronautical Sciences ICAS awarded ETW with the highly valued "Von Kármán Medal for International Co-operation in Aeronautics".

Since 1995 the European Transonic Windtunnel has been in full operation and has, in many test campaigns, proved to meet all demanding specifications and client requirements. New advances in wind tunnel testing, measuring and data processing technology are continuously introduced in ETW as soon as they are operationally mature and ETW has been at the forefront in the development of some of these techniques.

LOCATED IN THE MIDDLE OF EUROPE

Cologne, a Sacred Destination

At Cologne, ETW is not only situated in the middle of Europe, but is also part of a town well known for its ancient history as well as its vibrant city life of today.

Cologne is one of the oldest cities in Germany, founded in 38 BC by the Romans who called it Colonia Claudia Ara Agrippinensium out of which the name "Cologne" originated. Due to its location on the river Rhine, at the intersection of the major trade routes, in the Middle Ages Cologne became the richest and most prosperous city in the German-speaking world.

To this very day, you encounter the city's history at every turn... In the Middle Ages, twelve famous Romanesque churches were built and the construction of the large High Gothic cathedral started in 1248. It was completed only in 1880, still according to the original design and being the highest building in the world at that time. Today the Cologne Cathedral is the city's famous landmark, designated a UNESCO World Cultural Heritage site in 1996.

Cologne is a major cultural centre of Germany and has a bustling arts scene with more than 30 museums and hundreds of galleries.

The Cologne Philharmonic Concert Hall is famous for its outstanding acoustics. Cologne also offers an Opera, more than 50 theatres and a range of musicals as well as international sporting events. Other attractions include the University of Cologne, one of Europe's oldest universities, as well as the city's Trade Fair Grounds which are host to a number of important international trade shows.

Travellers longing for a rest will discover that Cologne has a special refreshing beer to offer; "Kölsch".
ETW Clients should be aware of the "fifth season of the year" in Cologne – six weeks before Easter, when in public squares and streets the "crazy days" of Carnival are greeted with great indoor and street celebrations.

Cologne and ETW would be glad to provide a memorable setting for a visit not only to its Clients, but also to their customers.

WHERE DO YOU GO FROM HERE?

Testing at ETW leads to an optimized aircraft

Additional testing techniques are available or under advanced development:

Sting interference measurement and investigation of the undisturbed tail flow using a special twin sting model support system.

Model deformation measurement to identify the actual geometric shape of the model under aerodynamic load.

Surface flow visualization to detect the transition of the boundary layer from laminar to turbulent state, and to document specific flow behaviour.

Optical measuring methods for various essential flow characteristics, e.g. Temperature Sensitive Paint, Pressure Sensitive Paint, flow-field measurement using Laser techniques.

ETW has further considerable advantages over conventional wind tunnels other than the increase in Reynolds number.

Due to the highly accurate continuous control of flow velocity, temperature and pressure in the wind tunnel, the Mach number, Reynolds number and dynamic pressure can all be varied independently. This unique capability allows for the study of the individual effects of Mach number, Reynolds number and elastic model deformation on the measured aerodynamic data.

In addition, ETW offers absolutely stable and accurately repeatable test conditions regardless of the time between tests.

Thus, ETW is world-wide established as the highest quality tool and provides its Clients and theirs customers early confidence in meeting the design requirements.

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: Georg Sötsch

Pictures: ETW, EADS Airbus, Köln Bilder © www.koelntourismus.de
Layout and Design by: www.design-union.de, Germany
Printed by: Thierbach GmbH, Mülheim an der Ruhr, Germany