

High-Speed Tunnel (HST)

DNW's Largest Transonic
Wind Tunnel for Aerospace
Applications



German-Dutch Wind Tunnels

www.dnw.aero

High-Speed Tunnel (HST)

Key Aspects at a Glance

Type of wind tunnel	Continuous, pressurised, transonic
Mach number	0 – 1.32
Test section size(s)	2.0 m x 1.8 m 2.0 m x 1.6 m Top and bottom walls perforated, slotted or optionally closed
Total pressure	25 – 390 kPa
Reynolds number (max, $l_{ref}=0.1 \sqrt{A}$)	7.6×10^6
Temperature range	288 – 323 K
Contraction	25:1
Drive power	~19 MW
Auxiliaries	Air supply: ~4 kg/s at 17 bar Power supply up to 1000 VDC

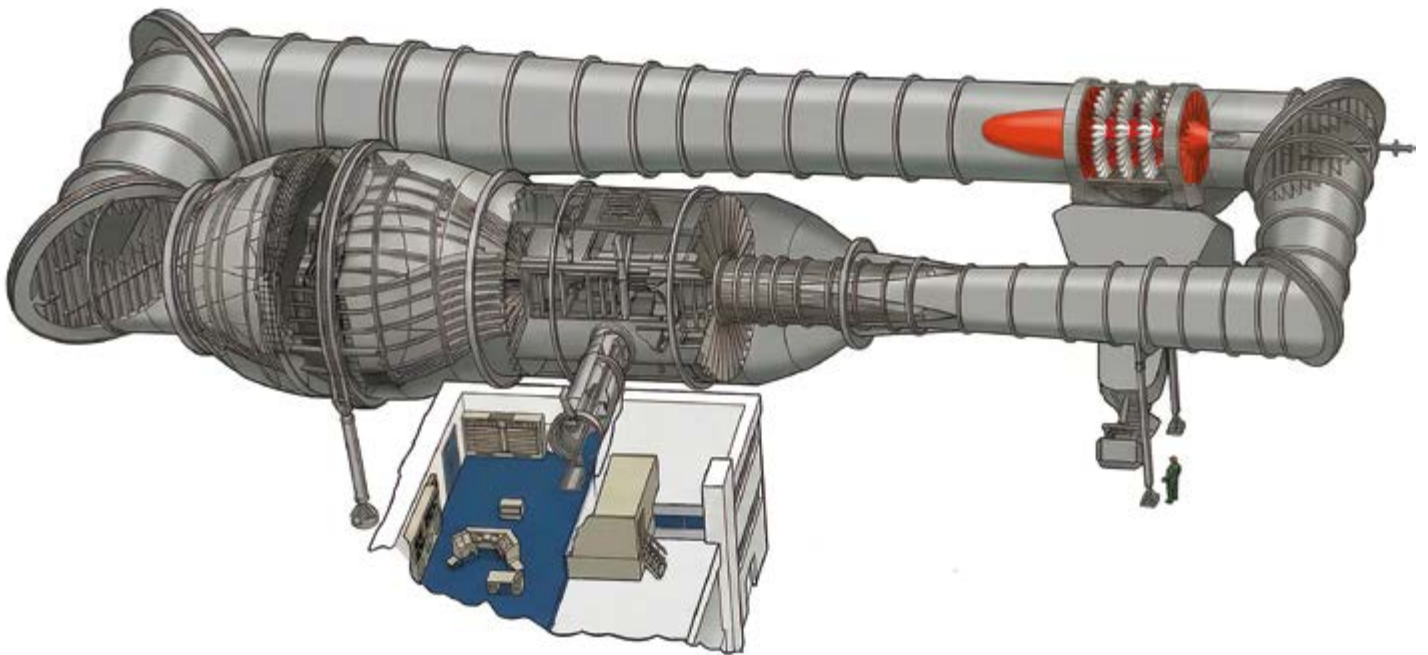


Illustration of DNW-HST wind tunnel

The High-Speed Tunnel (HST) is DNW's primary facility for high-subsonic and transonic aerodynamic testing.

It allows independent variation of Reynolds number and Mach number, a capability that is particularly valuable for assessing Reynolds number effects on aerodynamic performance, shock behaviour, boundary-layer development, and separation phenomena under well-controlled conditions.

Within DNW's portfolio, the HST forms the high-speed counterpart to large-scale low-speed testing. The facility is optimised for large and complex three-dimensional aircraft configurations, including high-lift systems, control surfaces and propulsion installation effects. By operating at elevated pressures, the HST enables high-Reynolds number testing. Sub-atmospheric testing allows reduction of loads on model parts and measuring devices.

Another strength lies in the strong complementarity between the HST and the SST; both facilities employ a common model interface, balance systems, sting concepts and data-acquisition philosophy, allowing the same model hardware to be used efficiently across speed regimes. This enables a seamless transition from transonic testing in the HST to supersonic testing in the SST.

While HST focuses on large-scale, high-Reynolds-number testing with emphasis on aerodynamic fidelity, load accuracy and industrial relevance, it is complemented by the TWG for small- and medium-scale, more development oriented testing.

Why High-Subsonic & Transonic Testing

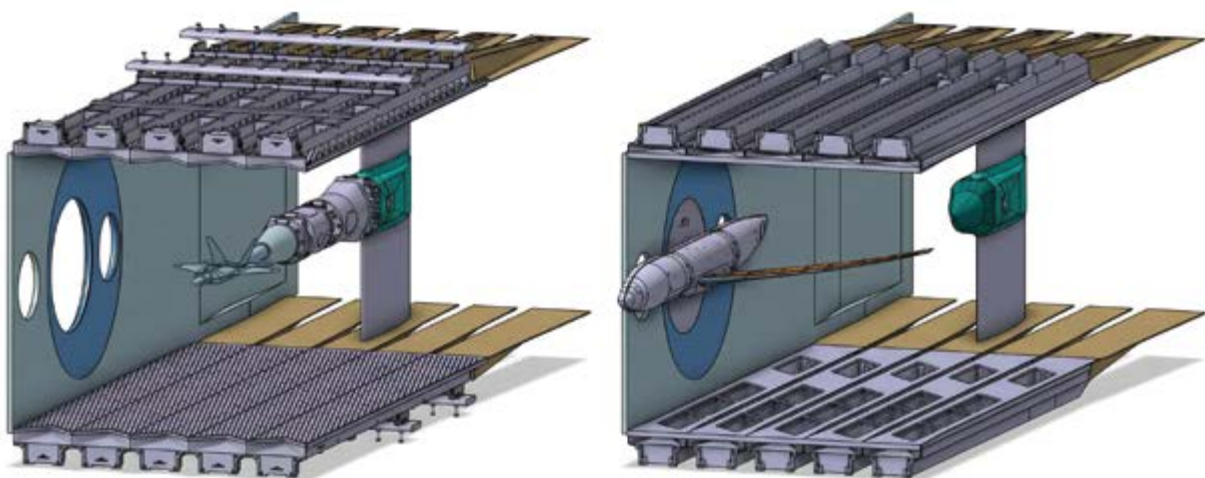
In the high-subsonic and transonic regime, compressibility effects, shock formation and shock-boundary-layer interactions introduce strong non-linearities in aerodynamic behaviour. Small changes in Mach number, Reynolds number or configuration can result in significant variations in lift, drag, stability, control effectiveness and structural loading.

Despite continued advances in numerical simulation, experimental testing remains indispensable in this flow regime to:

- Capture shock-dominated flow phenomena and non-linear aerodynamic effects
- Quantify buffet onset, unsteady loads and stability margins
- Assess inlet and exhaust flow behaviour
- Validate and calibrate numerical simulation for certification-relevant conditions
- Enable rapid generation of extensive aerodynamic datasets compared to state-of-the-art computational methods.

Scale effects become particularly critical at transonic conditions, where Reynolds number strongly affects boundary-layer development, separation onset, and shock-boundary-layer coupling. HST is specifically designed to operate at high Reynolds numbers, allowing customers to capture these effects with a level of realism not achievable in smaller facilities.

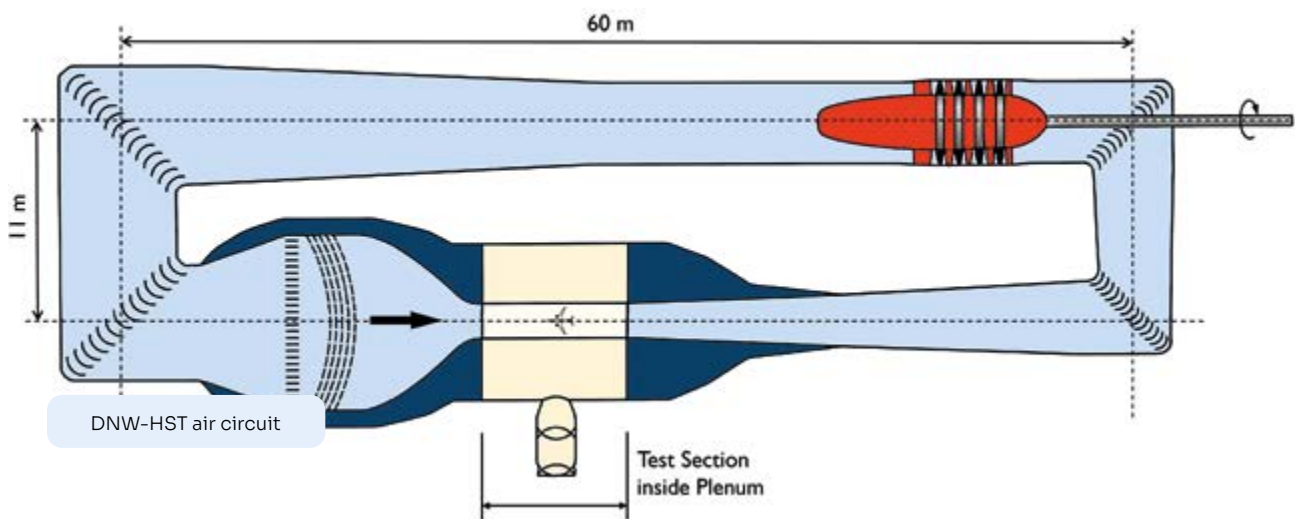
HST enables detailed, repeatable measurements of aerodynamic forces, moments, pressure distributions, and flow-field characteristics across its operating envelope.



HST test section configurations

Wind Tunnel Configuration

The HST is a continuous, closed-circuit, pressurised variable-density wind tunnel. Independent control of Mach number and Reynolds number (or dynamic pressure) allows test conditions to be tailored precisely to programme-specific requirements.



Test Section Configuration options include:

- Adjustable test section height of 1.6 m or 1.8 m
- Exchangeable slotted or perforated top and bottom walls
- Solid side walls with extensive optical access and integrated pressure instrumentation and model support provisions

The larger test section height is typically used for high incidence and supersonic testing, while the smaller height is used when maximum Reynolds number is of greater importance.

The slotted walls provide the best overall optical access and compatibility to test with floor mounted model supports, whereas the perforated walls

have the edge in terms of blockage alleviation near Mach 1 and better wave reflection cancellation performance at low supersonic speeds. Both wall sets, including side walls are equipped with pressure taps for evaluation of blockage and wall interference effects.

The test section is fully calibrated with both wall configurations which can be exchanged efficiently, allowing customers to select the optimal configuration for their test objectives.

Key Flow Parameters & Operating Envelope

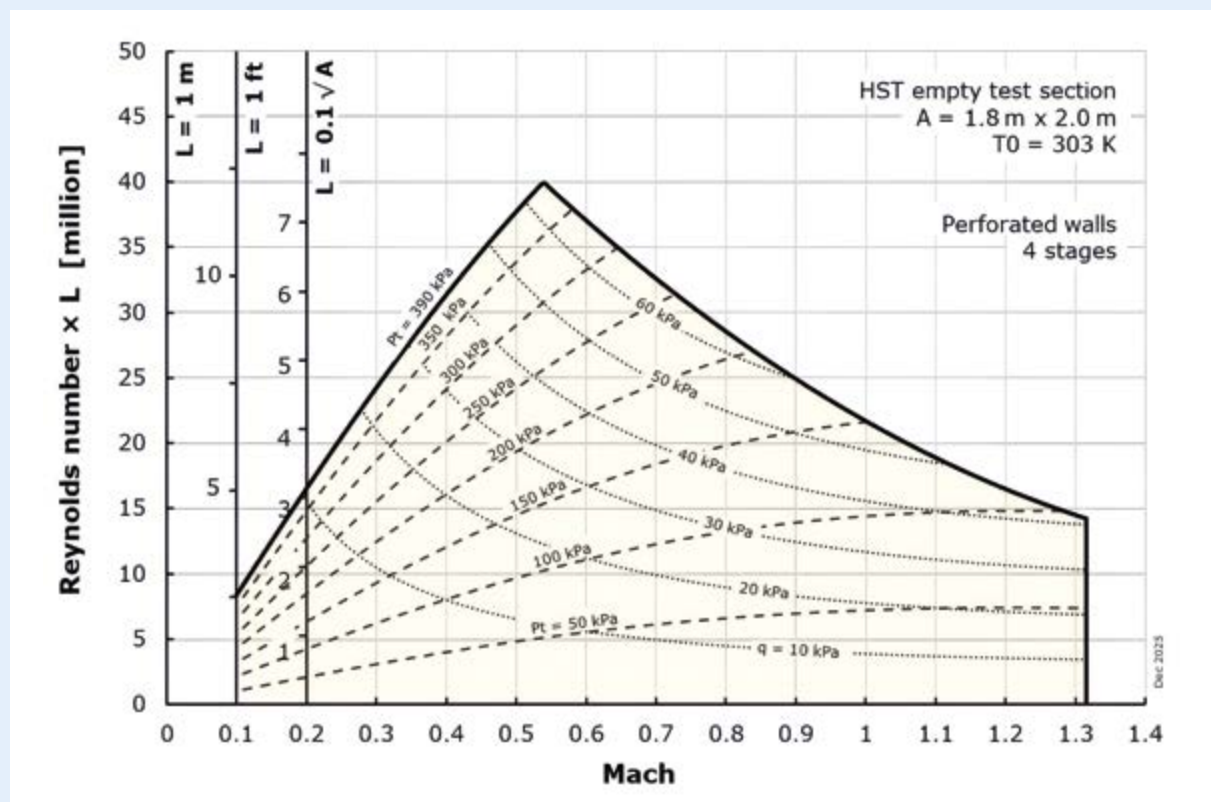
By operating at elevated pressures, the HST enables high-Reynolds-number testing, enabling independent variation of Reynolds number and Mach number.

Typical flow characteristics include:

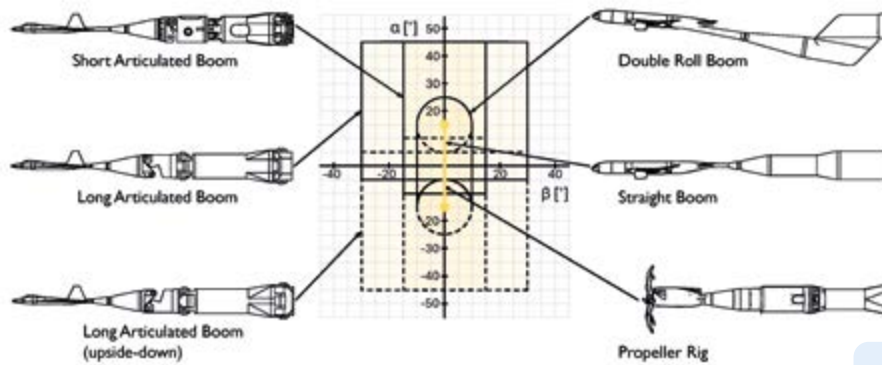
- Mach number range: 0.1 - 1.32
- Total pressure range: 25 – 390 kPa
- Reynolds number range (reference length $0.1 \sqrt{A}$): up to 7.6×10^6
- Maximum dynamic pressure: 65 kPa
- Temperature range: 288 – 323 K

These characteristics allow HST to support both detailed flow-physics investigations and certification-oriented testing, where stable, repeatable conditions are essential.

At approximately Mach 0.3 the conditions in the HST yield a Reynolds number comparable to that attainable in the LLF. This allows two datasets gathered in both facilities to be connected through Reynolds number similarity.



Mach-Reynolds envelope of DNW-HST



HST model support systems

Model Support & Load Measurement Capabilities

HST offers a comprehensive range of model support concepts and load measurement systems, enabling flexible testing of both full-aircraft models, semi-span configurations, 2D sections and propulsion test rigs.

Available support concepts include:

- Straight boom for sting-mounted full aircraft models (pitch $\pm 15^\circ$; yaw 0°)
- Double-roll boom support system for full aircraft models, enabling independent pitch and yaw motion with high stiffness and accuracy. Typical capabilities include stability, control, loads and buffet investigations (pitch $\pm 15^\circ$; yaw $\pm 15^\circ$)
- Articulated boom support enabling large angle-of-attack and yaw sweeps (pitch 50° ($-5^\circ/+45^\circ$); yaw $\pm 25^\circ$)
- Semi-span configurations for wing and control surface investigations
- Two-dimensional (2D) airfoil testing capability, supporting high-Reynolds-number aerodynamic of airfoil sections under well-controlled boundary conditions
- High-stiffness internal strain-gauge balances for full aircraft models
- External half-model balances for semi-span configurations

These systems allow accurate measurement of aerodynamic forces and moments while minimising aerodynamic interference.

The availability of both internal and external balance systems enables HST to support:

- Full-configuration testing
- Semi-span wing and empennage investigations
- Control surface effectiveness studies
- High-lift and high-incidence testing
- Detailed force breakdown analyses

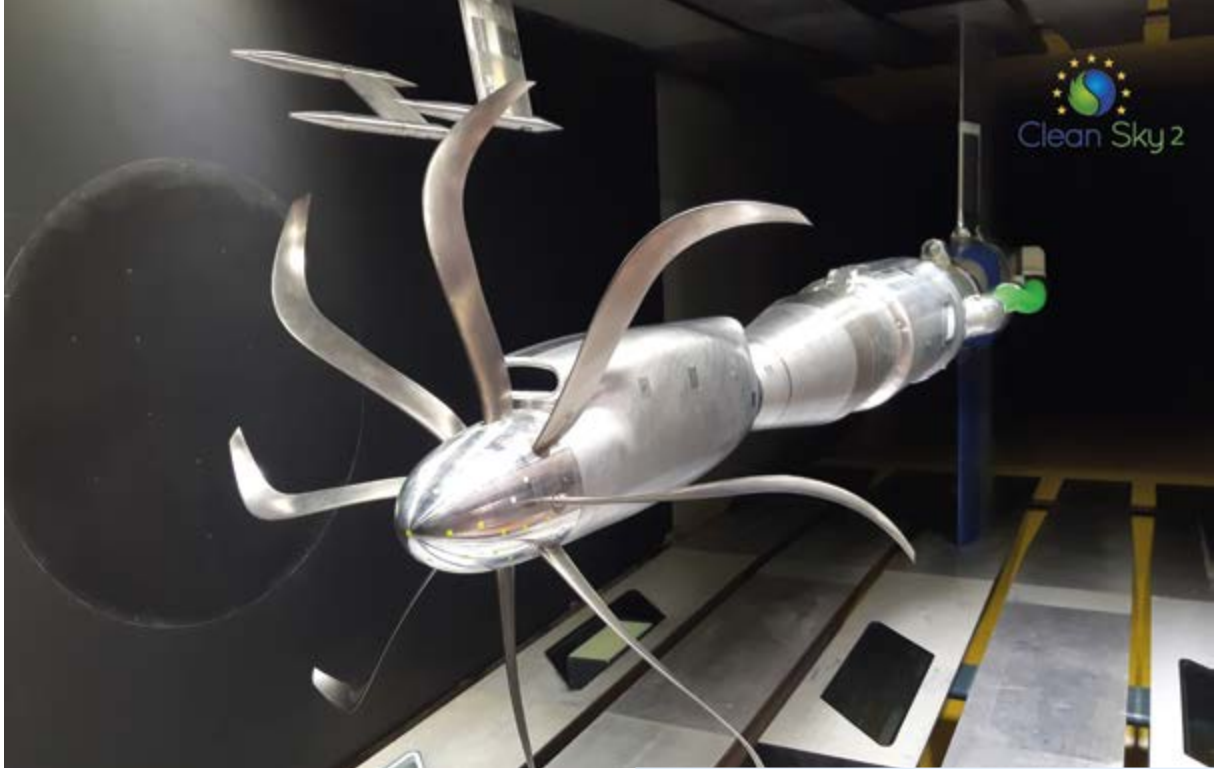
Precise model attitude and Mach number control systems enable continuous sweeps with excellent repeatability.

The balance technologies used in HST are shared across the DNW facilities, enabling direct comparability of aerodynamic load measurements across facilities.

For rotating propulsion systems, HST supports the integration of rotary shaft balances, enabling full six-degree-of-freedom (6DoF) load measurements, including thrust, torque and in-plane forces and moments.

2D airfoil testing





Propeller testing (IRON Clean Sky 2 project)

Propulsion Integration

Propulsion-related testing in the HST focuses on installation effects and performance in compressible flow regimes, where aerodynamic-propulsive interactions strongly influence aircraft performance and loads.

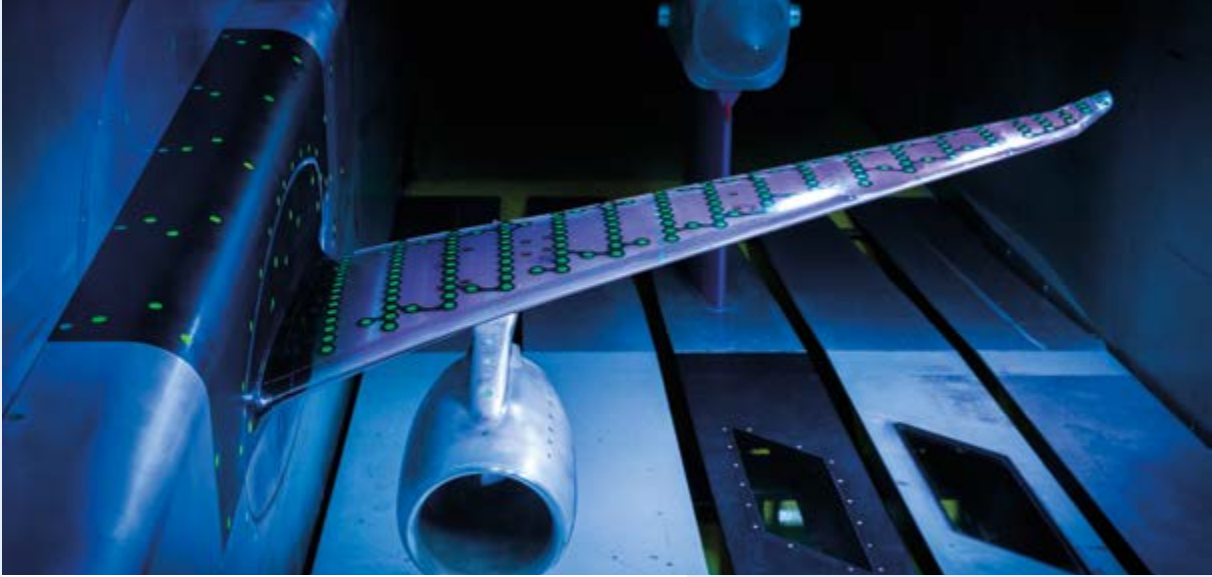
In addition to propulsion simulation, the HST supports inlet testing, including controlled mass-flow suction using ejector-based or equivalent suction systems. These capabilities enable investigation of intake aerodynamics, distortion, pressure recovery and installation effects under representative transonic conditions.

Key propulsion-related capabilities include:

- Turbofan and propeller simulation
- Electrical power supply up to 1000 VDC
- High-mass-flow compressed air supply: up to 4 kg/s at 17 bar
- Interference-free thrust measurement using airline bridge technology
- Rotary shaft balances enabling 6DoF load measurements
- In-house calibration and validation of propulsion simulators in the Engine Calibration Facility (ECF)
- Intake testing using ejector-based or active suction systems

Another capability is the isolated propeller test rig, which enables controlled propeller testing at high Reynolds number. When equipped with a dedicated rotary shaft balance, the electrically driven rig enables accurate measurement of 6DoF propeller loads, including thrust, torque and in-plane forces and moments.

This rig can also be deployed in the LLF and NWB, enabling performance testing in HST as well as aero-acoustic investigations in LLF or NWB. This flexibility allows customers to combine performance and noise investigations across facilities using a consistent experimental setup.



Aero-elastic model deformation measurements (HMAE1 project)

Measurement & Diagnostic Techniques

HST supports a comprehensive suite of advanced measurement and flow diagnostic techniques. These techniques are largely shared across DNW facilities, enabling consistency and comparability of data.

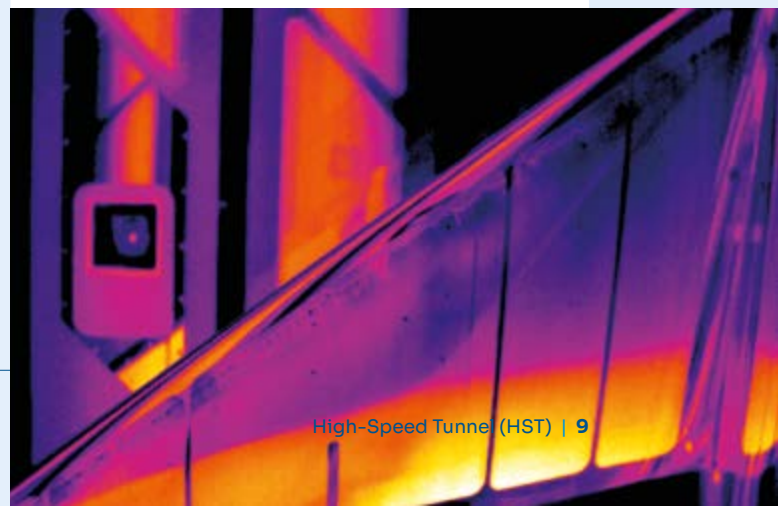
Available techniques include:

- High-accuracy force and moment balances (internal and external)
- High-density static and unsteady pressure measurement systems
- Schlieren visualisation for compressible flow phenomena
- Stereoscopic pattern recognition (SPR) for model deformation and attitude measurement
- Infrared thermography (IRT) for transition detection
- Particle Image Velocimetry (2C and 3C-PIV)
- Pressure-Sensitive Paint (PSP) and Temperature-Sensitive Paint (TSP) (by DLR)
- Laser light sheet visualisation
- Oil visualisation

The use of common or closely related measurement systems across DNW facilities allows techniques developed and validated in one facility to be efficiently applied in others. This cross-facility consistency is a key element of DNW's experimental quality and portfolio synergy.

High testing productivity is enabled by DNW's GAIUS wind tunnel control, automation and data-acquisition system, which is deployed consistently across LLF, LST, ECF, HST and SST. GAIUS supports scripted test execution, continuous sweeps and synchronised data acquisition, ensuring data quality while reducing overall test time.

Infrared thermography (IVANHOE Clean Sky 2 project)





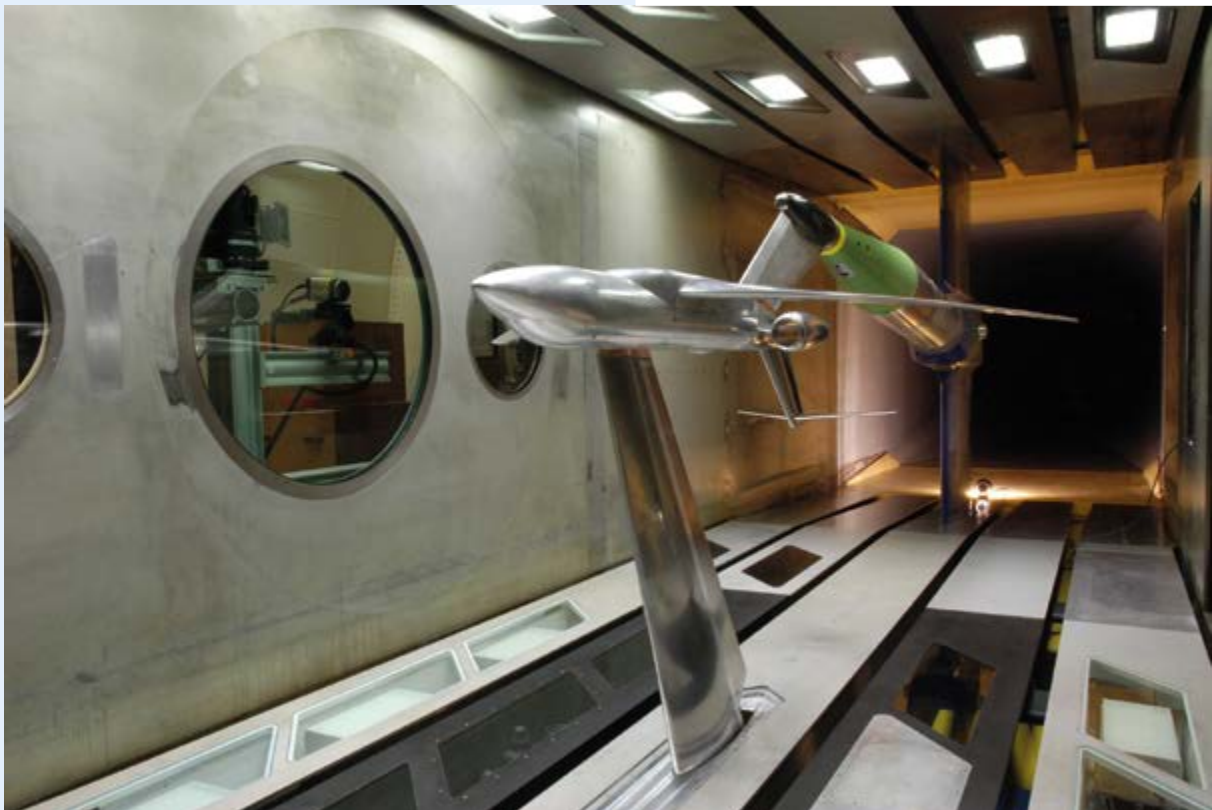
Fighter model testing
(FA5 model ©Breitsamter@TUM-AER)

Typical Applications

Typical aerospace applications include:

- Cruise drag prediction and optimisation
- Transonic buffet onset and buffet margin determination
- Shock–boundary–layer interaction studies
- Wave drag assessment and mitigation
- Stability and control derivatives
- Control surface effectiveness
- High-speed manoeuvre investigations
- Propulsion–airframe interaction studies
- Inlet and exhaust flow behaviour
- Nacelle integration and interference effects
- Propeller and fan installation effects
- Missile and projectile aerodynamics
- Aero-elastic and deformation-sensitive configurations

Business jet support interference testing
(CAE validation model)



Customer Value & DNW Portfolio Synergy

By combining large-scale, high-Reynolds-number capability with advanced measurement techniques and high testing productivity, the HST enables customers to:

- Obtain high-fidelity transonic and low-supersonic aerodynamic data
- Reduce programmes and certification risks
- Validate numerical predictions of shock-dominated flows
- Execute efficient, multi-regime experimental campaigns

Beyond the HST itself, DNW operates a complementary portfolio of wind tunnel facilities in the Netherlands and Germany, covering subsonic, transonic and supersonic regimes.

These facilities are managed as an integrated organisation. Within this portfolio:

- LLF provides large-scale, multidisciplinary low-speed testing
- LST serves as a readily accessible development and pre-testing facility for both HST and LLF
- NWB enables dedicated low-speed aero-acoustic and multidisciplinary investigations
- SST extends testing seamlessly into the supersonic regime up to $M = 4$
- TWG offers highly flexible, smaller-scale continuous transonic and supersonic testing up to $M = 2.2$

This synergy of scales and speed regimes allows customers to execute coherent experimental programmes across multiple facilities, from early concept studies at smaller scale to large-scale high-fidelity validation.

This integrated approach differentiates DNW from isolated single-tunnel providers and enables customers to move from concept-level testing to large-scale validation within a single coordinated experimental ecosystem.

The HST plays a key role within this portfolio as DNW's primary facility for high-subsonic and transonic testing, enabling large-scale, high-Reynolds-number experiments with a strong emphasis on aerodynamic fidelity, load accuracy, and industrial relevance.



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