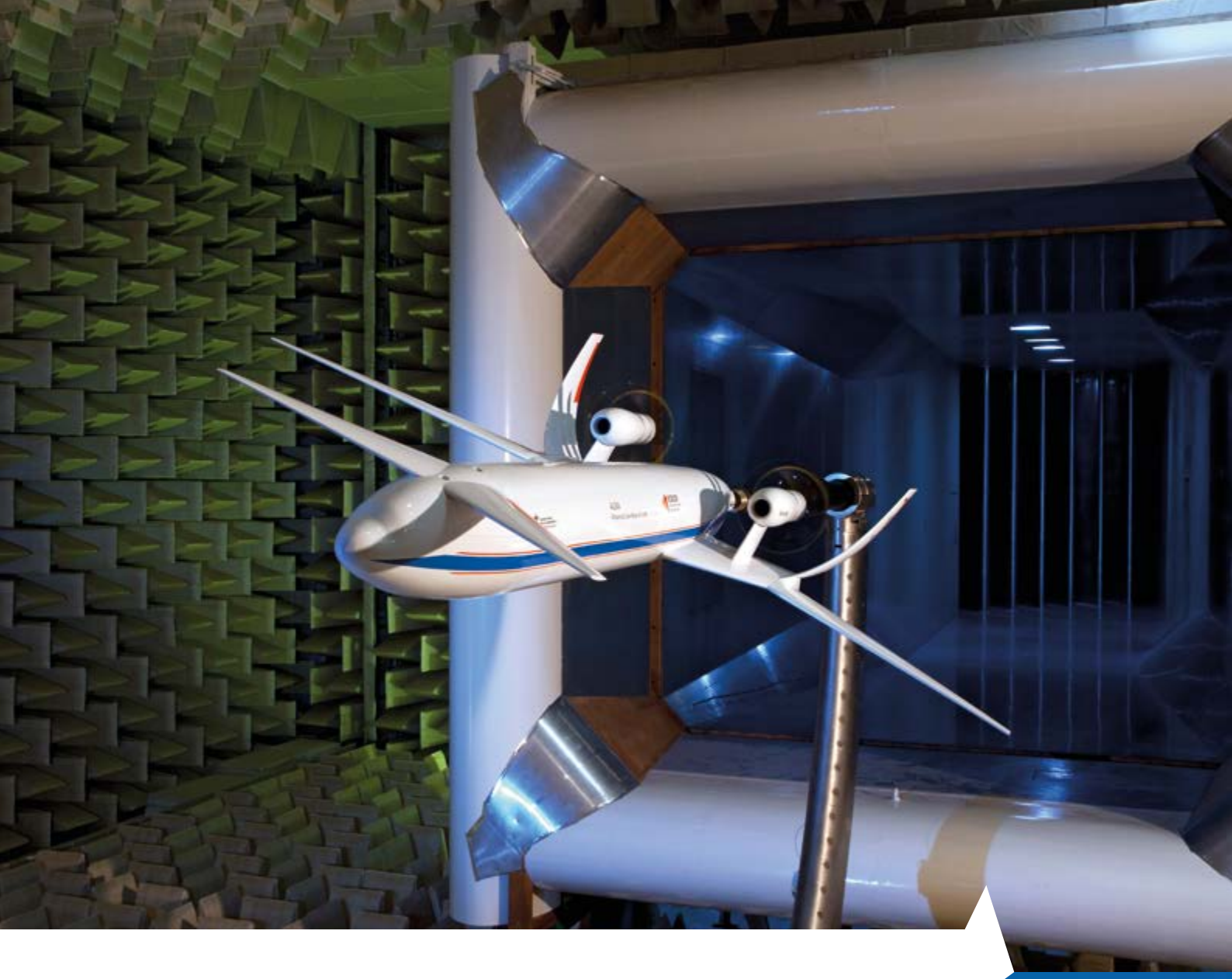


Niedergeschwindigkeits-Windkanal Braunschweig (NWB)

Reference Facility for Low-Speed Aerodynamic and Aeroacoustic component Testing

German-Dutch Wind Tunnels

www.dnw.aero

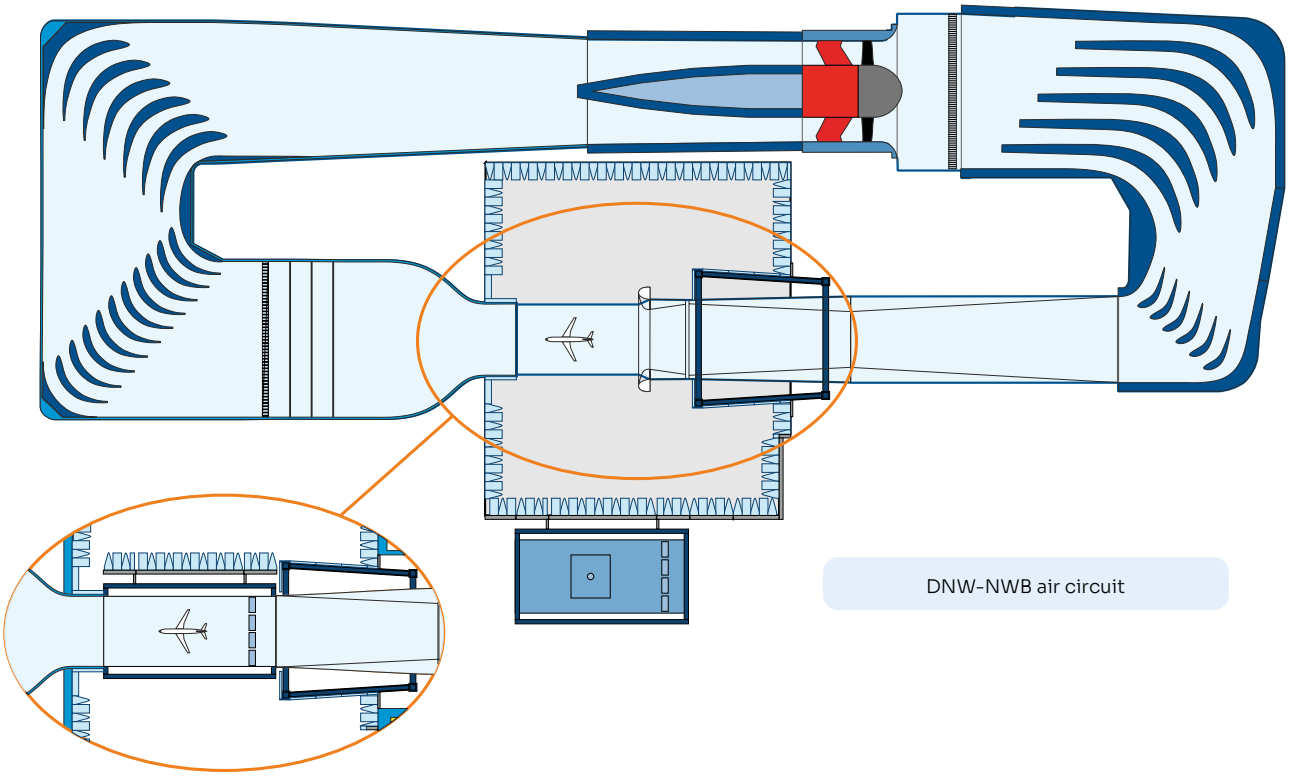
Niedergeschwindigkeits-Windkanal Braunschweig (NWB)

Key Aspects at a Glance

Type of wind tunnel	Continuous, atmospheric, subsonic
Mach number	0 – 0.26
Test section size(s)	3.25 m × 2.8 m closed test section
	3.25 m × 2.8 m open-jet
	3.25 m × 2.8 m ¾-open-jet
Total pressure	Ambient
Reynolds number (max, l_{ref}=0.1 √A)	5.5×10^6
Temperature range	Ambient
Contraction	5.6:1
Drive power	3.5 MW
Auxiliaries	Air supply: ~3.4 kg/s at ~10.0 bar
	Vacuum supply: ~3.0 kg/s at ~0.5 bar
	Power supply up to 1000 VDC

Cover picture - DLR LNA configuration in the open jet test section of the DNW-NWB, picture by DLR

The DNW Niedergeschwindigkeits-Windkanal Braunschweig (NWB) is DNW's reference facility for low-speed aeroacoustic testing, providing high-fidelity experimental environments for the investigation of aerodynamic noise sources and their interaction with airframes and propulsion systems.



DNW-NWB air circuit

The facility simultaneously offers exceptional flow quality, which is essential for the further development of laminar wing technologies, and features a high degree of versatility with a wide range of wind tunnel test sections and model mounting options, enabling comprehensive and flexible experimental investigations across various aerospace applications.

Within DNW's integrated wind tunnel portfolio, the NWB complements:

- the LST, acting as the aerodynamic development and pre-testing workhorse,
- the LLF, enabling large-scale multidisciplinary and installed aeroacoustic testing, and
- the HST, providing high-Reynolds-number performance and integration testing.

Research and industrial development studies and projects focusing on detailed flow physics and noise diagnostics on component-level start at the DNW-NWB. The complementary aerodynamic and aeroacoustic validation on system-level at large scale is done at the LLF.

Why Dedicated Low-Speed aerodynamic & aeroacoustic testing on component-level?

- identify and rank dominant noise sources,
- quantify installation and component interaction effects,
- validate computational aerodynamic and aeroacoustic prediction methods, and
- support early-stage noise risk reduction and certification-oriented studies.

Component-level aerodynamic and aeroacoustic testing is essential because performance losses and noise generation originate locally — and only by isolating, understanding, and optimizing those local mechanisms can you efficiently improve the full system.

Wind Tunnel Configuration

The NWB is a closed-circuit, atmospheric low-speed wind tunnel designed for high flow quality, low background noise, and flexible test section configurations.

A defining feature of the facility is the availability of multiple test section modes, allowing it to be tailored to a wide range of aerodynamic and aeroacoustic investigations. The main configurations include:

Closed Test Section

- High flow quality and confinement
- Maximum Reynolds number capability
- Suitable for aerodynamic performance testing, force and moment measurements, and dynamic derivative investigations

Closed test section including half model setup

Open test section including rear mounted full model setup

Open-Jet Test Section

- Minimised acoustic reflections
- Optimised for aeroacoustic source localisation and beamforming
- Suitable for far-field noise measurements

Three-Quarter Open Test Section

- Best combination of aerodynamic confinement and acoustic openness
- Frequently used for noise studies of airframe and propulsion installations

These configurations allow the NWB to address both aerodynamic performance questions and noise-related investigations within the same facility.

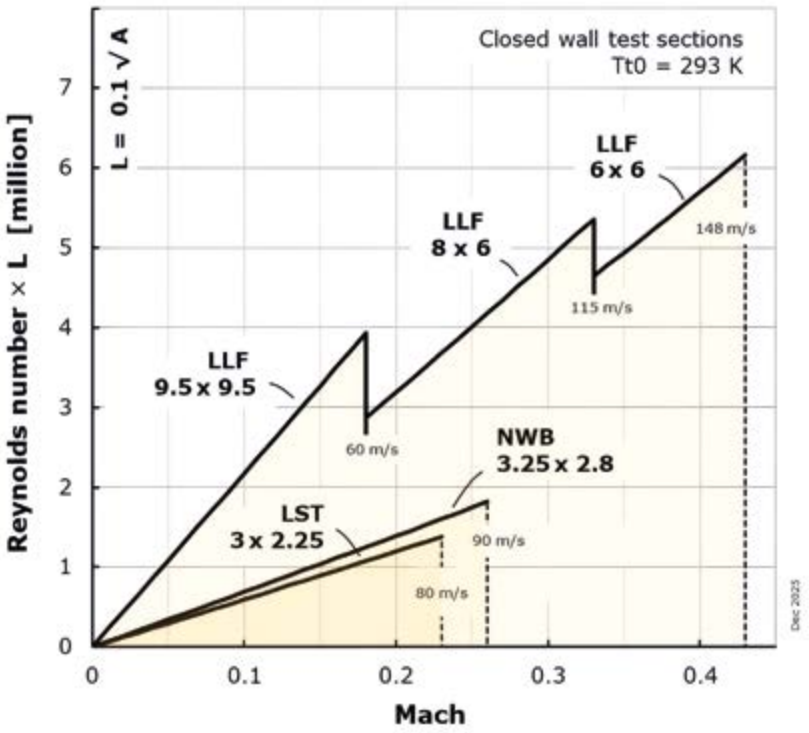
The tunnel is designed with extensive acoustic treatment, structural decoupling, and vibration isolation, ensuring low background noise and minimal mechanical interference with sensitive acoustic measurements.

3/4 open test section including powered half model test setup and microphone array installation

Key Flow Parameters, Operating Envelope & aeroacoustic characteristics

The NWB provides a high-quality, low-turbulence flow environment optimized for both aerodynamic and aeroacoustic testing:

- Test section cross-section (width × height): 3.25 m × 2.80 m
- Test section length:
  - 6.0 m (closed test section)
  - 8.0 m (open and three-quarter open configurations)
- Anechoic plenum size (width x height x length): 14.8 m x 6.80 m x 13.0 m
- Maximum freestream velocity:
  - 90 m/s (closed test section)
  - 80 m/s (open and three-quarter open configurations)
- Reynolds number (reference length 1 m): up to approx. 5.5×10^6 (closed test section)
- Turbulence intensity:
  - o $Tu_x \approx 0.05$ %, $Tu_y = Tu_z \approx 0.07 \ldots 0.15$ % (closed test section)
  - o $Tu \approx 0.15$ % (open test section)
- Background noise level: ≈ 60 dB(A) at 45 m/s
- Anechoic plenum absorption: ≈ 99 % from 0.1 kHz to 40 kHz in accordance with appendix A of ISO 374



Mach-Reynolds envelope of DNW low-speed facilities

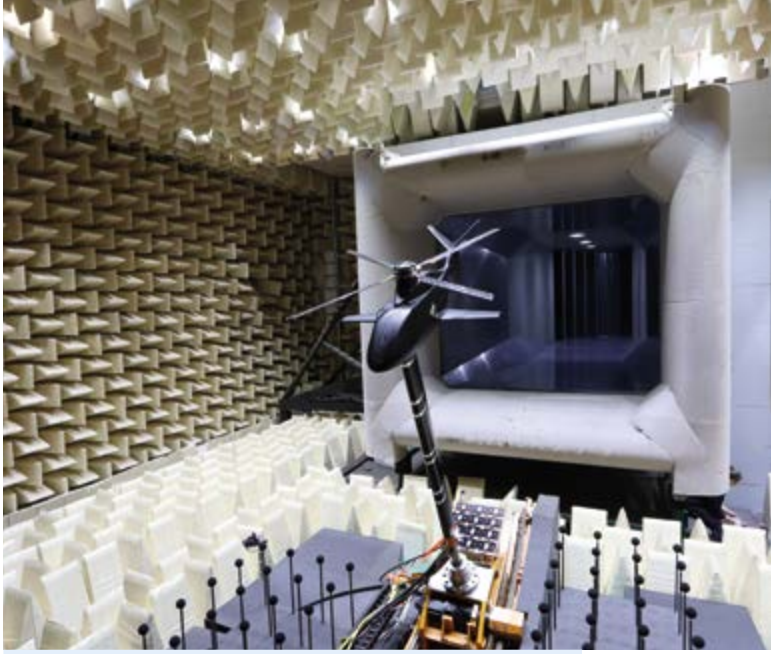
The Model Supports

The NWB is equipped with various low-interference model support systems which can be used in the different test sections:

- αβ-Support
  - used for full model testing in the closed or open test section
  - using streamlined rear, ventral or dorsal stings
  - in-the-loop-control mechanism for model attitude compensating for sting and balance deformation
  - angular range:
    - -8.0° ≤ α ≤ +52° for straight rear sting setup
    - -30.0° ≤ α ≤ +30° for straight ventral/dorsal sting setup
    - -180° ≤ α ≤ +180°

- Support for half model testing
  - Used in the closed or ¾-open test section
  - With or without external half model balance

- Support for 2D aerofoil models
  - Identical interfaces between model and wind tunnel infrastructure allow for the usage of identical models to be tested in the closed and open test section of the NWB
  - Closed test section
    - 2D aerofoil models span between floor and ceiling
    - turntables in floor and ceiling
    - angular range:
      - -180° ≤ α ≤ +180°
  - Open test section
    - C-Rig model support
    - 2D aerofoil models vertically mounted between turntables
    - Equipped with splitter plates to minimize unwanted shear layer interaction
    - angular range:
      - -180° ≤ α ≤ +180°
      - -3° ≤ φ ≤ +30° (sweep angle)



Aeroacoustic testing of powered helicopter configuration mounted on the αβ-support in NWB's acoustic open test section (DLR project UrbanRescue)

- Model Positioning Mechanism (MPM)
  - Allows for precise dynamic positioning and motion of models
  - Used for dynamic derivative measurements, forced motion testing and ground effect simulation
  - Capable of sinusoidal oscillations in all six degrees of freedom as well as transient manoeuvres about arbitrary reference points
    - Workspace (longitudinal, lateral, heave): 1100 mm, 300 mm, 500 mm
    - Pivoting angles:
      - -5° ≤ roll ≤ +5°, accuracy < 0.005°
      - -15° ≤ pitch ≤ +15°, accuracy < 0.01°
      - -10° ≤ yaw ≤ +10°, accuracy < 0.005°
    - Max. Frequency and amplitude:
      - Up to 3 Hz at 5° amplitude for roll-, pitch-, yaw-oscillations
      - Up to 3 Hz at 50 mm amplitude for heave-oscillations

- Fixed ground plane with boundary layer scoop
  - Used in the closed test section for scaled automotive testing (passenger cars, light trucks and trucks)
  - Four to eight variable support pins for different model scales or model configurations
  - Turntable to adjust side wind angle

Propulsion Integration

The NWB supports a wide range of propulsion-related aeroacoustic investigations.

Including:

- isolated propeller and fan noise testing,
- installed propulsion noise and installation effects,
- intake and exhaust noise studies,
- flow–noise interaction investigations.

The facility supports electrically powered propulsion testing, including the supply of electrical power up to 1000 VDC, enabling testing of high power-density electric propulsors in a low-noise environment.

The isolated propeller test rig, developed for high-fidelity performance testing in the HST, can also be deployed in the NWB, enabling complementary testing:

- HST for high-subsonic and transonic propeller performance and load characterisation,
- NWB for detailed low-speed aeroacoustic source identification and noise mechanism analysis.

The high-performance secondary air supply system at NWB enables specialized aerodynamic and aeroacoustic investigations of engine integration, including both engine exhaust and intake effects. Using powerful compressors, the system can deliver an air mass flow of up to 3 kg/s at a maximum pressure of 9 bar, effectively replicating the flow characteristics of real engine exhausts. Conversely, engine intakes are simulated by evacuating up to 3 kg/s of air from the test section, reproducing realistic suction effects and intake behaviour within the tunnel.

Measurements & Diagnostic Techniques

The NWB offers a comprehensive suite of aerodynamic and aeroacoustic measurement techniques, many of which are shared across DNW facilities:

- Internal and external strain-gauge balances
- Static and unsteady surface pressure measurements
- Wake and flow-field surveys using multi-hole probes and traversing rake systems
- Stereoscopic Pattern Recognition (SPR) for position and deformation measurements
- Infrared Thermography (IRT)
- Particle Image Velocimetry (PIV)
- Pressure and Temperature Sensitive Paint (PSP / TSP)
- Advanced acoustic diagnostics, including microphone arrays and beamforming systems

Aeroacoustics

The facility is specifically designed to minimise background noise and acoustic reflections, enabling sensitive detection of aerodynamic and propulsion-related noise sources.

Available systems include:

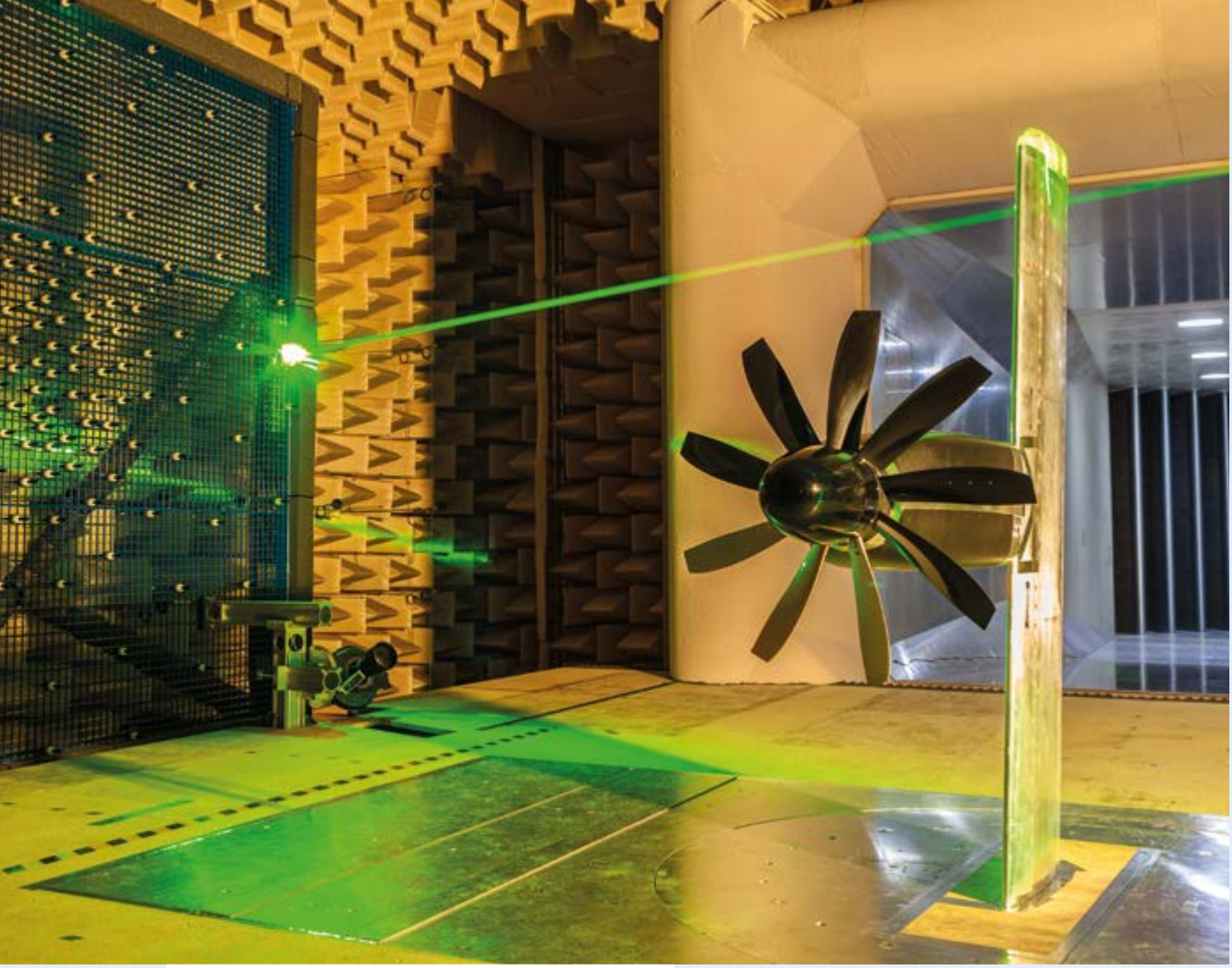
- Fixed and traversing microphone arrays
- Phased array systems
- Advanced beamforming and deconvolution methods

These systems enable:

- Source localisation
- Spectral analysis
- Directivity characterisation
- Comparative noise assessments

The NWB is particularly well suited for detailed noise mechanism studies, early-stage noise mitigation concept evaluation, and comparative design assessments.

Half model configuration in NWB's open test section using a MEMS array for noise source localization (developed by DLR, DLR project SIAM, picture by DLR)



Simultaneous application of PIV and noise source localisation technique using a micophone array (BNF project, cooporation of DLR, TU Braunschweig and Leibniz University Hannover)

Typical Applications

Typical applications of the NWB include:

- Aerodynamic performance testing of powered or unpowered models
- Aerodynamic stability and control testing
- propulsion and fan noise source identification,
- nacelle and inlet noise studies,
- aerodynamic and aeroacoustic wing–propulsion interaction investigations,
- high-lift noise testing,
- wind turbine airfoil aerodynamic and aeroacoustic testing,
- dynamic derivative testing using the MPM,
- validation of computational aerodynamic and aeroacoustic methods.

Customer Value & DNW Portfolio Synergy

The NWB provides customers with:

- a low-background-noise environment for high-fidelity aeroacoustic testing,
- flexible test section configurations tailored to specific test objectives,
- advanced diagnostic capabilities for detailed noise source analysis,
- efficient integration into staged aerodynamic and aeroacoustic development programmes.

Beyond the NWB 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
- HST delivers high-Reynolds-number transonic validation up to M = 1.3
- 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.

NWB serves as the aeroacoustic reference wind tunnel enabling customers to resolve aerodynamic and aeroacoustic questions at a high level of detail and sensitivity.

German-Dutch Wind Tunnels

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+31 527 24 8520

info@dnw.aero

www.dnw.aero