National Research Council Canada
Conseil national de recherches Canada

Corporate Services
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NRC·CNRC

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7 January 2000

Mr. Grote Reber
Michael Street
Bothwell, Tasmania
Australia 7030

Dear Mr. Reber:

This is in reply to your letter of 14 December 1999. NRC actually has three wind tunnels, which are being operated by our Institute for Aerospace Research, in Ottawa. You will find enclosed some information on these facilities, including the names of addresses of NRC scientists and engineers that you might wish to contact directly for more details.

Thank you for your continuing interest in the activities of the National Research Council and my best wishes for a happy new year.

Yours sincerely,

Serge Hamel

Serge Hamel
Executive Offices Secretariat

Attachments

Canada

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INFORMATION

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Fact Sheet

9 Metre Low Speed Wind Tunnel

NRC's 9 metre low speed wind tunnel facility is used for aerodynamic testing in collaboration with industry, universities, government agencies or other research institutes. This document describes our facility and areas of expertise, which are available on a contractual basis.

General Specifications

The 9 metre low speed wind tunnel is a horizontal, single closed-circuit, atmospheric facility. The test section is 9.1m (30 ft.) wide, 9.1m (30 ft) high and 22.9m (75 ft) long. It is powered by a 6.7 MW (9000 hp) DC electric motor driving an 8-bladed fan. Speeds can be varied from very low to 55m/second (120 mph).

Test Programme Support

- Wind tunnel testing techniques
- Wind tunnel instrumentation
- Model design
- Model manufacture
- Data processing
- Computational fluid dynamics

Aerospace Testing

Aircraft models up to 6 metre wing span, or half-models of 5 metre semi-span, can be mounted on the underfloor external six-component balance. Provision can be made for surface pressure measurements on the models.

Industrial Testing

The large size of the test section and the speed range provide an attractive test environment for non-aeronautical subjects such as:

- surface vehicles
- buildings
- bridges
- oil rig platforms
- wind turbines

The floor boundary layer can be manipulated to simulate the Earth's surface winds' mean velocity distribution and turbulence profile.

A new groundboard allows observation and and measurement of underbody flows for full-size automobiles, vans and light trucks, and half-scale models of heavy trucks. This facility is described in greater detail in a separate document.

The reverse side of this sheet provides more detailed technical specifications.

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Technical Specifications

Type of Wind Tunnel	Continuous flow, closed throat, atmospheric pressure test section
Test Section Size:	9.1m x 9.1m (30 ft x 30 ft)
Special Configuration:	Automotive groundboard
Maximum Velocity:	55m/second (180 ft/second)
Drive Motor:	6.7 MW DC Electric (9000 hp)
Force Balance:	6-component, pyramidal, external mechanical
Model Support:	Strut, sting, floor mounting
Balance Capabilities:	± 22,250 N (± 5000 lb) Lift & side force ± 8900 N (± 2000 lb) Drag ± 8100 Nm (± 6000 lbft) Pitching & yawing moment ± 4050 Nm (± 3000 lbft) Rolling moment
Auxiliary Electric Power:	4 – 150 kW (200 hp) variable frequency power supplies
Compressed Air:	6 in. diameter supply line of 1700 kPa (250 psi) at 4.5 kg/second (10 lb/second)
Data System:	82 channel Neff A/D with networked DEC MicroVax 3400/PDP 11-44
Pressure Measurement:	Electronically Scanned Pressure (ESP) system HYSCAN

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1.5 Metre Trisonic Blowdown Wind Tunnel

This major facility is a pressurized, intermittent flow wind tunnel capable of running in the subsonic, transonic and supersonic flow regimes. The speed range is from 1/10 to more than 4 times sonic speed.

Stream stagnation pressure is closely controlled during the blowdown, and, by varying the diffuser throat area or controlling the outflow from the plenum chamber, the test Mach number may be held within very close limits as a model pitches.

Testing configurations
The basic test section is 1.5 m square with solid walls for measurements in subsonic and supersonic flow. For subsonic-transonic flow regimes, a separate test section with perforated walls provides the necessary flow adjustment and is contained within a pressure-tight plenum chamber.

A special test section (0.38 m wide and 1.5 m high) is widely used to produce aerodynamic data on aerofoil section characteristics. Chord Reynolds numbers approaching full scale values on transport aircraft for Mach numbers up to 0.9 can be achieved. This test section has attracted world-wide attention.

While the run time of this tunnel in its various modes depends on the run conditions required, a typical time is 20 seconds.

Model mountings
Complete three-dimensional models are mounted using either a rear sting, or a recently commissioned "plate mount" system which permits correct modelling of the rear fuselage for transport aircraft configurations.

By installing a "reflection plane" and five-component sidewall balance, it is possible to test semi-span models of larger scale, for which higher Reynolds numbers can be achieved. This configuration also can be adapted to provide a propulsion test rig for measurement of propeller efficiency.
Two-dimensional models for airfoil development are supported between three-component balances in each sidewall.

Data acquisition and analysis
In addition to force and moment data, high-precision surface pressure measurements are routinely made on aircraft or aerofoil section models. These measurements are made using electronic pressure scanning (EPS) techniques. Force and moment measurements on external stores in the parent aircraft flowfield can also be made.

The data system used for recording nominal steady state information is built around DEC PDP and VAX computers with extensive disk storage. An upgrade to DEC's ALPHA platform has recently been implemented for use in data processing and analysis. A modern high speed data acquisition system (with 192 channel capacity and sampling rates to 40 kHz per channel) is also available for making measurements involving unsteady phenomena.

Test program support
- Wind tunnel testing techniques
- Wind tunnel instrumentation
- Model design
- Model manufacture
- Data analysis capability
- Computational fluid dynamics

Pilot wind tunnel
The Institute also operates a one-twelfth scale "pilot" version of the 1.5 m wind tunnel which offers the same performance envelope, with virtually unlimited running times. This facility is very cost-effective for testing small models, such as in calibration of flow measurement probes.

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Technical Specifications

Type of wind tunnel:	Blowdown trisonic	**Typical production:**	10 to 20 blowdowns / day 1,350 blowdowns / year
Air supply:	8.4 MW (11,250 hp) synchronous motor; 10-stage compressor	**Air storage:**	3 1,430 m^3 (50,430 $ft.^3$) @ 21 atm. & 21 °C
Useful running time:	5 to 60 seconds	**Time to charge tanks:**	40 min. from empty, 20 min. between blowdowns
Data system: **(Tunnel control, data gathering & processing)**	DEC PDP 11/55 Computer Low Speed System: • 98 analog amplifier channels 5-bit A/D conversion • 60 kHz max through-put High Speed System: • 192 channels sampled @ 38.4 kHz/channel, parallel recording @ 100 Hz of 6Hz filtered and RMS data	**Schlieren system:** **ESP capability:** **Max Reynolds number:**	Multi-source focussing type Scanivalve Z0C modules (1, 5, 15, and 50 psid ranges) Support for up to 16 modules (32 ports ea.) @ 100Hz rate, or more at lower data rate 1.5m x 1.5m: 80 x 106/m (25 x 106/ft.) 0.38m x 1.5m: 160 x 106/m (50 x 106/ft.)

	Sting/plate mount testing	**Two-dimensional testing**	**Half-model testing**
Test section size:	1.524 x 1.524 m (5 x 5 ft.) Closed solid wall subsonic and supersonic Porous walls in transonic test section, 60°inclined holes with splitter plates, porosity variable from 1% to 6% open area ratio	Test section size: 0.381 x 1.524 m (15 in. x 5 ft.) Solid sidewalls Variable porosity ceiling and floor with same geometry as transonic test section walls	1.467 x 1.524 m (4.813 x 5 ft.) Solid reflection plate in transonic test section 3 walls with variable porosity in range 1% to 6% open area ratio.
Typical model size:	1 m (≈40 in.) maximum span	0.3 m (≈12 in.) chord	1 m (≈40 in.) max half-span
Mach number range:	0.1 to 0.75 subsonic 0.7 to 1.4 transonic 1.1 to 4.25 supersonic	0.1 to 0.9	0.2 to 0.99
Model support:	Sting and internal balance on vertical strut (range of balances available) Plate support option available when rear fuselage geometry must be correctly represented	Pair of 3-component external sidewall balances 89 kN (20,000 lb.) maximum normal force	5-component external sidewall balance for typical model is 22 kN (5,000 1b.), but centre of load location affects capacity.
Pitch motion:	Sting mount: -11° to +23° @ max 23°/sec. Plate mount: 30° range @ max. 15°/sec.	±50° @ max 15°/sec. Dual-sided synchronous balance drives	±50° @ max 15°/sec.External balance drive
Roll motion:	±354° @ max 37°/sec.	N/A	N/A
Special features:	Model air supply of 0.9 Kg/sec (2 lb./sec.) or more @ 17 atm. Air extraction to 1 atm. from model Combined pitch/yaw motion Captive store load measuring rig (articulated sting) Schlieren windows in transonic and supersonic test sections	Dual-sided model air supply of 4.1 Kg/sec (9 lb./sec.) @ 17 atm. 2-D Test Standards • 192 orifice max model surface pressure instrumentation (96/side) • 4-tube vertically traversing wake rake • Ejector augmented sidewall suction for boundary layer removal	Model air supply of 2.3 Kg/sec (5 lb./sec.) @ 17 atm. Air extraction to 1 atm. from model

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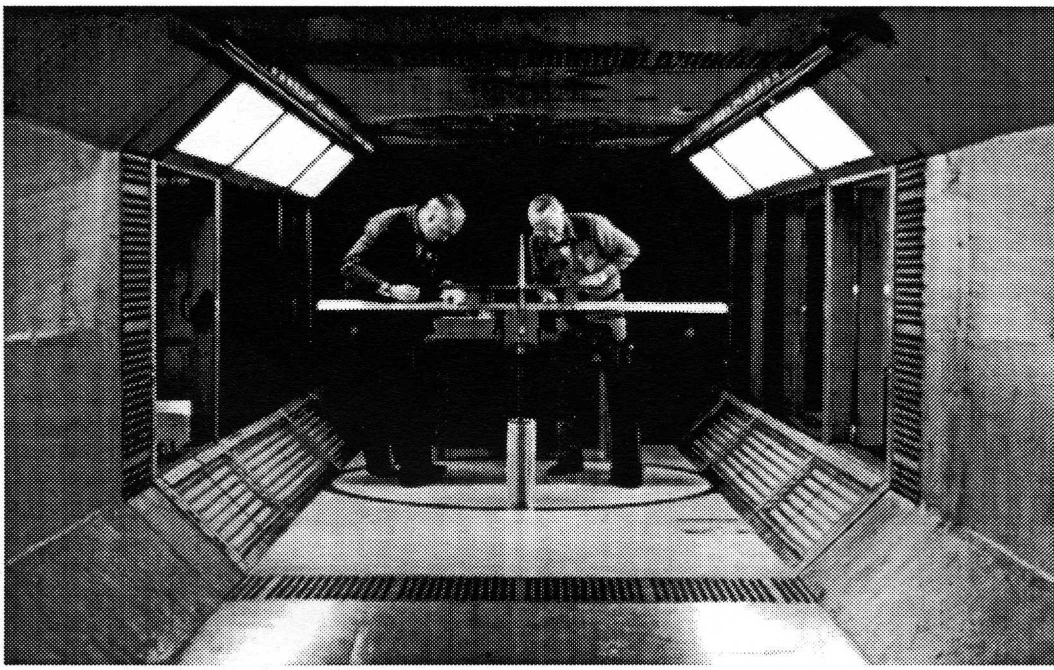
2 m x 3 m Wind Tunnel



The facility

The 2 m x 3 m wind tunnel of the National Research Council is a world-class facility for subsonic aeronautical and industrial testing. It has been used extensively for research and development by commercial companies, universities, and government in the areas of steady and unsteady aircraft aerodynamics, aeroacoustics, surface vehicle aerodynamics, marine hydrodynamics, wind engineering, and wind energy generation.

Staff at NRC's Aerodynamics Laboratory* continually pioneer specialized test rigs, flow simulations, and measurement techniques to augment the tunnel's capabilities. Integrated data acquisition and control systems complement the aerodynamic capabilities of the facility and are tailored to each customer's needs. Carefully performed wind tunnel measurements are the cornerstone of cost-effective design when subsonic and unsteady aerodynamics are important.

Technical support

The staff of the Aerodynamics Laboratory are expert in most aspects of steady and unsteady aerodynamics as applied to aircraft, surface vehicles, and ground-based structures. They also have expertise in the dynamics of vehicles and structures, in the estimation of aerodynamic stability and structural response, in the design of static and aeroelastic wind tunnel models, as well as in all aspects of wind tunnel test technology, flow visualization and instrumentation. The staff have the proven capability to design, construct, and instrument models, to select an appropriate test program, and to analyze and interpret the data obtained.

Business environment

The 2 m x 3 m wind tunnel provides a superior and secure working environment for commercial or government customers. The wind tunnel is

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available for rent for a single, all-inclusive, hourly fee. The staff provide a full range of consulting services to support any aerodynamic investigation at competitive commercial rates. The needs of the customer are always a priority.

Technical specifications

Areas of expertise

- Steady-state aircraft aerodynamics
- Unsteady aircraft aerodynamics
- Surface vehicle aerodynamics
- Wind engineering
- Aeroacoustics
- Flow measurement and visualization

Tunnel geometry

Contraction ratio	9:1
Test section h, w, l; m	1.9, 2.7, 5.2
Test-section area; m2	
▪ standard	5.07
▪ groundboard	3.75

Tunnel characteristics

Fan power; kW	1490
Maximum speed; m/s	140
Speed uniformity	±0.7%
Turbulence level	Š0.14%
Static pressure gradient; m-1	
▪ standard	~0
▪ groundboard	-0.0044

Auxiliary systems

Compressed air	up to 2,000 kPa
▪ dew point -40ÝC	2.7 kg/s
▪ undried	5.0 kg/s

Model supports

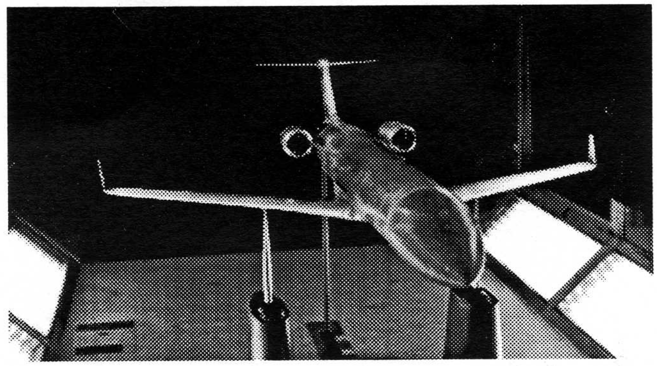
▪ 3-D steady-state	3-point support
▪ 3-D unsteady	sting
▪ 2-D steady state	upper air bearing
Flow traverse rigs	several, automated
Auxiliary power	156 kvA, variable freq.
Acoustic liner	anechoic above 400 Hz

Main balance

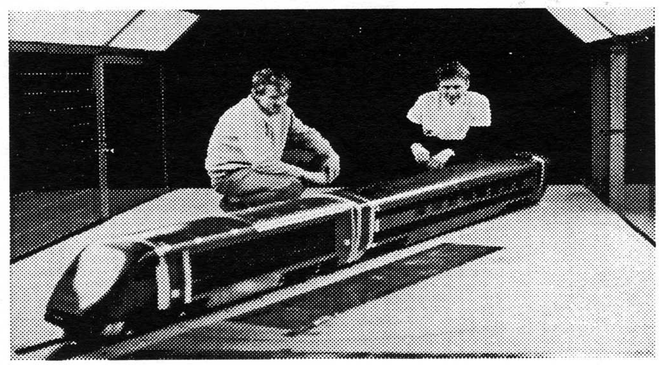
Maximum model weight; kg	450
Lift, drag, side force; kN	±6.7, ±4.4, ±4.4
Pitch, yaw, roll; kN-m	±2.7, ±2.7, ±2.7
Measurement accuracy	±0.1% full scale

Data system and instrumentation

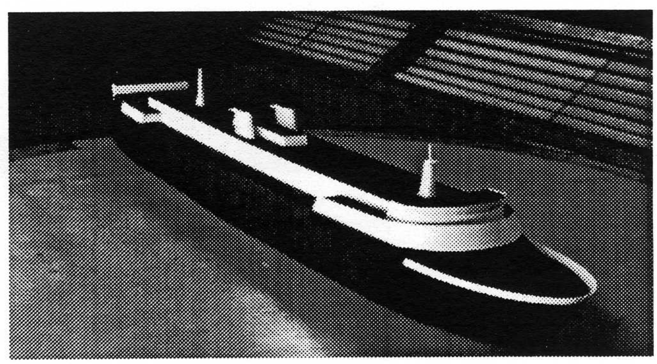
Processors	486, work station
A/D channels	32 (16 bit, 50 kHz)
Digital channels	16 (100 kHz)
Software	customer defined
Experimental control	computer-based
Pressures	Scanivalve™, ZOC™
Anemometry	hot film
Strain-gauge balances	4 platform, 1 cylindrical
Cameras	digital, VHS, 35 mm
Flow visualization	laser light sheet smoke surface oil film u-v mini-tuft



A three point mounting is commonly used for static tst, while sting mounts are used for unsteady measurements with oscillating models



An insert groundboard allows the study of surface vehicle models. In one case a train is investigated...



... while in another, the wind forces on a self-docking ferry are of interest

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* Separate fact or technical sheets available

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