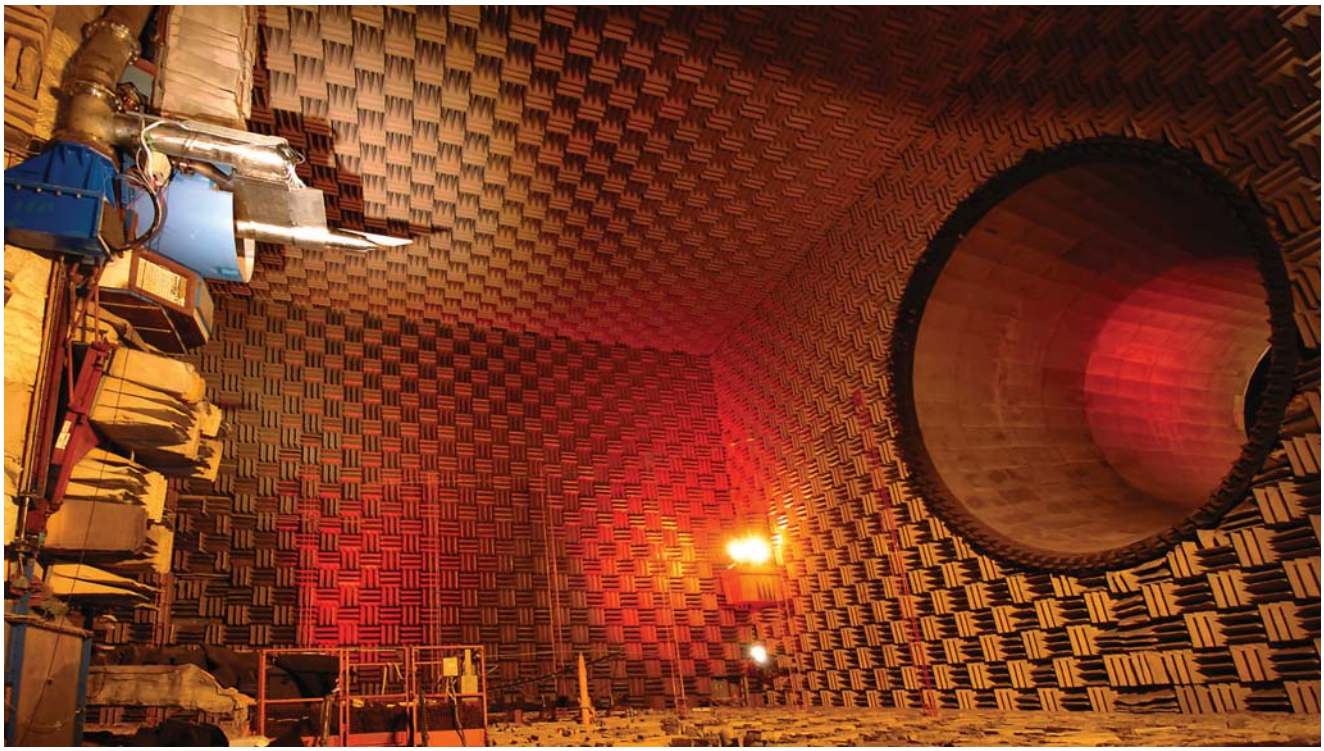
QinetiQ

Noise Test Facility

The Noise Test Facility (NTF) at QinetiQ Farnborough (UK), incorporates one of the largest anechoic chambers in the world.



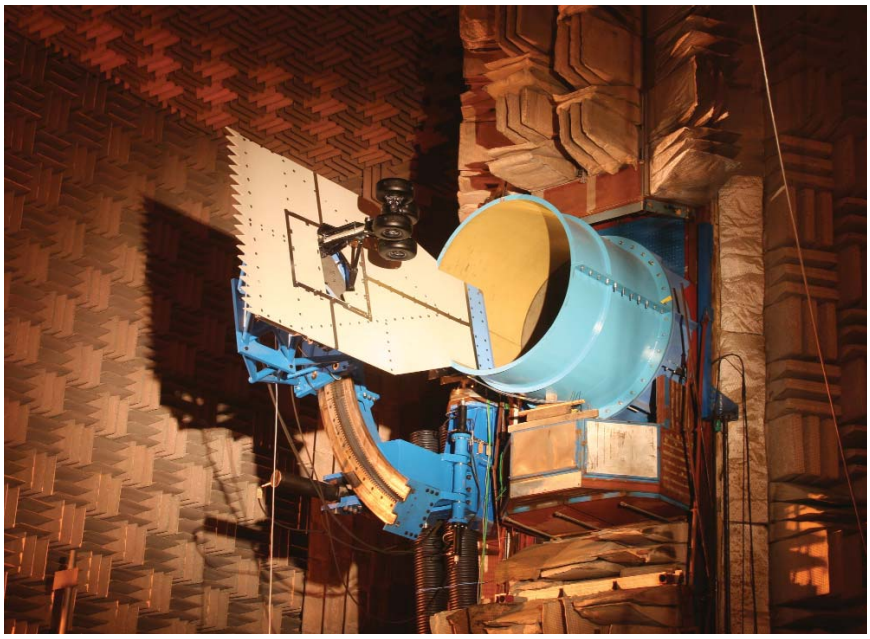
Originally designed to study the noise produced by model gas-turbine exhaust systems, the facility has been significantly upgraded in recent years and is now used for a wide variety of studies. These range from airframe and undercarriage noise investigations to installation-effects, Particle Image Velocimetry (PIV), Laser Doppler Anemometry (LDA), and shock-cell noise measurements.

External view of facility showing open-jet blower system and associated ductwork

At the heart of the facility, a large anechoic chamber occupies a floor area of 27m x 26m and is 16m in height. It is completely lined with acoustically absorbent wedges, rendering it anechoic to a lower frequency limit of 90Hz. The geometry of the chamber, complimented by this absorbent lining permits true far-field, high-fidelity jet noise measurements to be made from models under test.

The chamber is positively exhausted, using up to 10 double-stage fans, which draw air through a collector into a silenced tortuous path system before exhausting it to atmosphere.

- High quality acoustic measurements in an anechoic environment
- Identification of acoustic sources
- Test hardware design and manufacture service
- Proven ability to produce solutions to aerodynamic noise problems



Typical installation in wind tunnel for an undercarriage test

Open jet wind-tunnel
Air from a large-scale blower is ducted into the facility through a nozzle, which protrudes into the anechoic chamber at 8.7m above ground level. The blower is a dedicated 3.65MW single-stage centrifugal fan, capable of producing Mach 0.33 at the 1.8m diameter nozzle exit.

Extensive acoustic treatment and flow conditioning is installed in the supply duct-work downstream of the fan. These features ensure a uniform flow at nozzle exit, and minimal fan-noise such that measurements of the jet can be presumed to be solely due to fundamental jet mixing noise.

The tunnel can be used as a flight simulation stream for jet noise tests, or as a separate entity for undercarriage tests and similar studies.

Jet rig
A cantilevered sting assembly can be installed in the centre of the tunnel blowing nozzle, which acts as an interface to model-scale exhaust nozzles of commercial aero-engines.

Model scales as large as 10% are feasible for current high-bypass-ratio short-cowl configurations, and 20% for long-cowl designs. Two independently controlled streams of air are supplied to the sting using a 2.5MW dedicated centrifugal compressor, to form the core and bypass streams found on a full-scale engine. The compressor delivers a combined mass-flow of 12kg/s at the exhaust nozzle, with a pressure ratio of 2.2.

Core air can be heated to full-scale jet exhaust temperatures (max. 900K), using a combustion can specially modified to burn LPG.

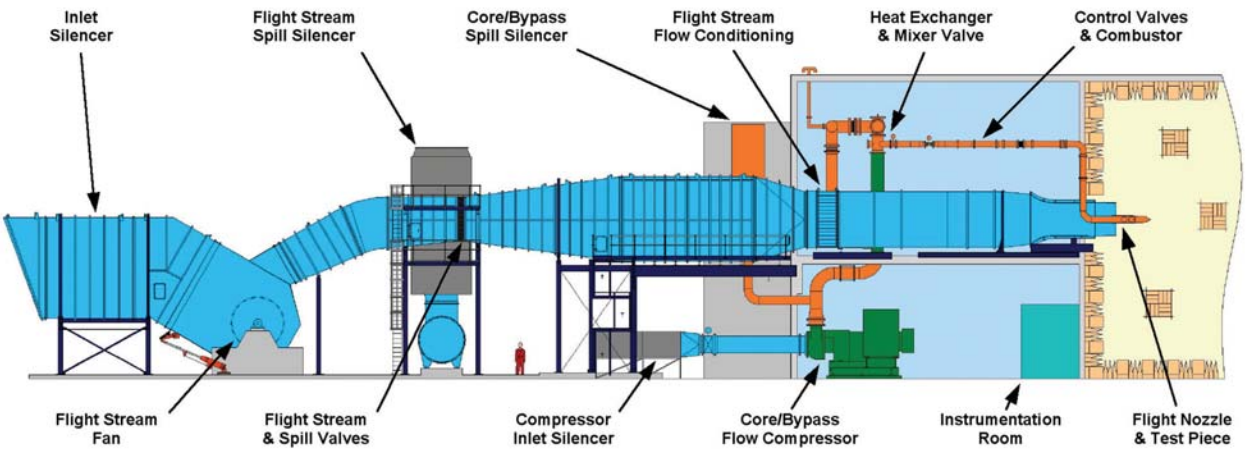
Bypass flow temperatures are controlled by mixing supply air, direct from the compressor, with cooler air channelled through a heat exchanger system (300-360K).

40 channels of instrumentation are used to monitor the pressure and temperature of the air-streams.

Measurement rakes are positioned in the sting, immediately upstream of the exhaust nozzle assembly, and are used to match the flows to full-scale engine exhaust conditions.

Internal noise has been addressed in the design of the sting, using extensive CFD, noise and manufacturing optimisation to ensure clean internal flow paths.

The resulting state-of-the-art casting, combined with in-line silencers, enables quiet flow conditions at static jet-exit velocities as low as 100m/s on 10% scale short-cowl exhaust designs.



Schematic of open-jet wind tunnel and jet rig installation

Boundary layer suction system
Combining the tunnel and jet rig capabilities for flight simulation measurements introduces additional aerodynamic complexities, common in model scale research rigs. Boundary-layer growth, and vortex effects external to the sting assembly are both actively addressed, using an optimised quiet suction system, connected to dedicated exhauster sets.

Acoustic instrumentation
32 channels of high-quality microphones are offered as standard for positioning in the anechoic chamber during a test programme. Availability of extra channels can be arranged.

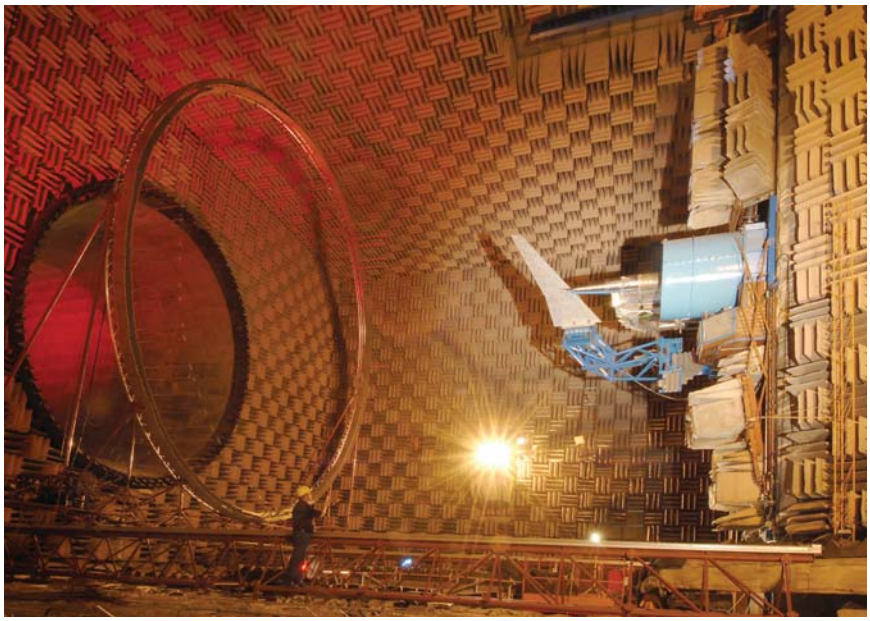
Each channel comprises a ¼" diameter free-field microphone, coupled to a remotely-controlled variable gain amplifier. Custom filters to mitigate the effects of excess atmospheric attenuation, and a flat microphone response to 100kHz mean the entire full-scale certification frequency range can be acquired from jet-exhaust models, to 10% scale. Each channel is simultaneously acquired using a 16-bit system, sampled at a rate of 200kHz per channel.

A 12m-radius polar array is permanently available at rig height in the chamber, offering a measurement capability in the angular range 50°-150° to the aircraft axis.

Linear arrays are also available, configurable to specific azimuth and angular ranges, and individual microphone masts can be installed as required.

Full 3D noise fields can be measured using a "Large Azimuthal Traversing Array". A 12m diameter space-frame ring, centred on the rig axis, is used to mount a number of microphones.

The ring and microphone hardware can be traversed parallel to the rig axis along the length of the chamber, encompassing a polar angular range of 70°-140° to the aircraft axis.


Large azimuthal traversing array installation

Source location
Two different types of source location capabilities are available for use in research programmes.

- A coarse-fine polar array, which is more accurate for sources which are considered to lie along the jet axis (1D source location).
- A 3m diameter 2D-array.

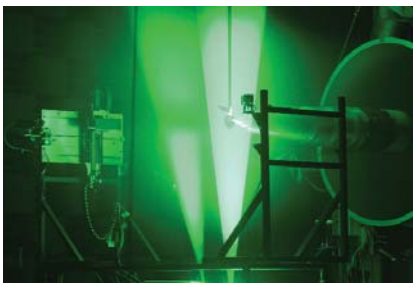
Wing support structure
Installation effects research is the investigation of the acoustic interaction of engine-exhaust jet-noise with the airframe local to the engine installation on an aircraft.

This unique capability compliments the jet-rig installation in the anechoic chamber, allowing model-scale wings (up to 1000kg) to be remotely and precisely positioned with respect to the exhaust model.

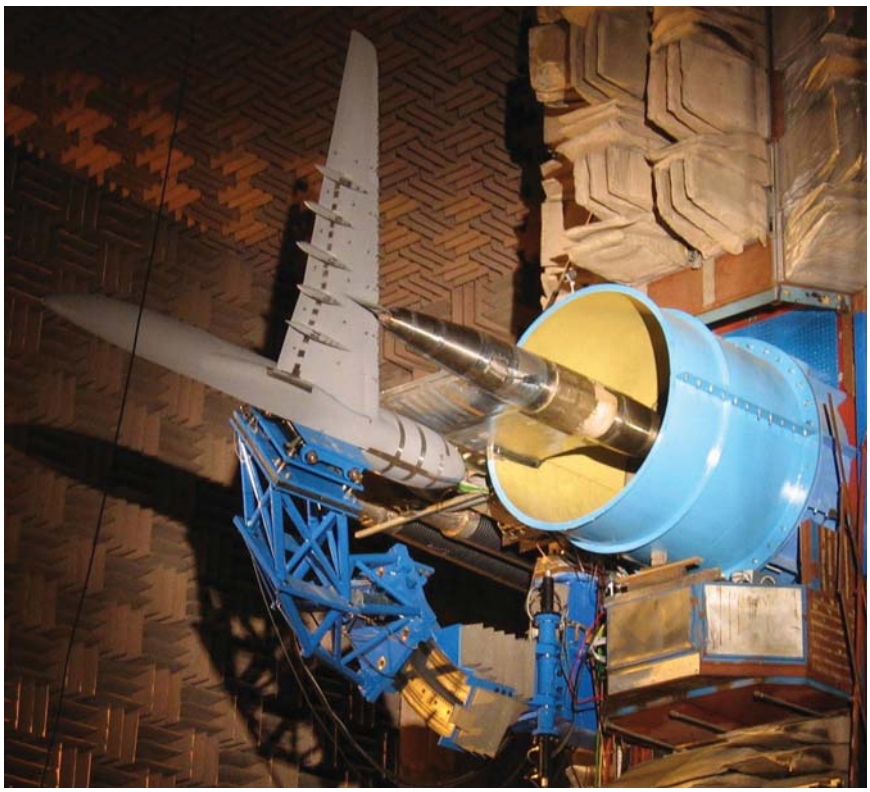
The design of the wing support structure includes the capability to retract the wing-model from its installed position in the flight simulation flow while the jet-rig flow conditions are set. This provides a back-to-back measurement capability between installed and isolated jet configurations, with minimal disruption to the test programme.

Designed with flexibility as a key feature, the structure is also used as a fixed mount for undercarriage installations.

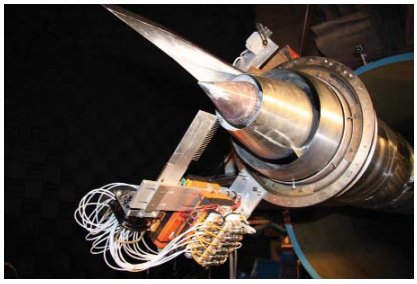
Particle Image Velocimetry
Three-component PIV techniques provide mean velocities and correlation statistics, which can be used to aid understanding and interpretation of acoustic jet data. Nozzle flows are seeded with powder, while an oil-based system is used for ambient and flight simulation flows.


PIV test configuration

Circumferential Traverse
A capability to measure total temperature and pressure profiles at the nozzle exit, and several nozzle diameters downstream, is available in the form of a circumferential traversing assembly. Custom rake design can be arranged if a specific probe spacing and type are required.



Wing-model mounted on the support structure



Circumferential nozzle traverse assembly

Cruise rig

This is a unique capability of simulating cruise requirements with hot jets. A special tunnel can be attached to the existing flight stream nozzle to simulate cruise speeds of over 0.8M in the 1.05 x 1.05 x 2m acoustically treated working section.

The test models, typically 4% scale, operate at realistic pressures and temperatures and measurements are made using flush mounted microphones.

Customers

Research in the Noise Test Facility is concerned primarily with civil applications. Recent projects have included test support to British industry, European collaborative programmes, overseas customers and the MoD.

Summary of capabilities:

- Quiet flight simulation using a 1.8m diameter open-jet tunnel at up to M0.33 at nozzle exit.
- 2.2:1@12kg/s pressure ratio available for model-supply steams.
- Typical exhaust models of 10-20% scale tested, equivalent to a maximum exit area of 0.2m diameter.
- Exhaust total temperatures of up to 900K in core stream and 360K in bypass.
- Very low internal rig-noise levels mean jet noise is uncontaminated to static jet-exit velocities as low as 100m/s.
- External boundary layer suction system to optimise external sting aerodynamics.
- Remotely operated system to support model-scale wing geometries for installation studies.
- Chamber anechoic to frequencies as low as 90Hz.
- Stable noise propagation paths.
- Jet efflux far from chamber surfaces.

Acoustic system

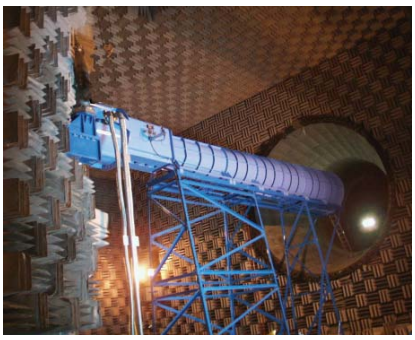
- Standard polar array at nominal 12m; 50° to 150° to aircraft axis.
- Measurements up to 100kHz frequency.
- Extra linear arrays available.
- 32 channels of data acquisition at 200 kHz, 16 bit. Extra channels can be arranged.
- 3D noise fields measured using large azimuthal traversing array.
- Noise source location.

Aerodynamic Instrumentation

- Multiple measurements of stream pressures and temperatures for rig conditions.
- Additional channels arranged if required.
- Mass flow measurements using calibrated Venturi meters.

Other instrumentation

- PIV and LDA measurements.
- Shadowgraph and surface-oil flow.
- Circumferential pressure and temperature traverses local to the nozzle exit.



Cruise Rig

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