German Aerospace Center

Noise behind an engine – unique DLR measurements reveal noise-generating structures in engine jets

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Aircraft engine noise is a socially pressing issue with a wide range of causes. Until now, turbulent fluctuations in the exhaust gas stream have not been fully understood as one of the major sources of noise. Researchers at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) have now managed to make these turbulent flow structures in the engine exhaust gases visible using imaging laser measurement technology, and they have measured the overall flow behind the engine with unprecedented quality. Future generations of engines will be able to benefit from this new knowledge.

On 23 September 2014, DLR presented the results of the SAMURAI (Synergy of Advanced Measurement techniques for Unsteady and high Reynolds number Aerodynamic Investigations) research project at Hamburg airport. From 23 to 28 September 2013, engine tests supported by Hamburg Airport and Lufthansa Technik (LHT) were conducted in the LHT soundproof hangar using DLR's A320-ATRA research aircraft. "For the first time, we were able to use laser measurement techniques and microphones to make highly precise, simultaneous measurements of the sources of noise in the air stream behind an engine," says project leader Andreas Schröder from the DLR Institute of Aerodynamics and Flow Technology in Göttingen. "We were able to use this experiment to identify specific flow and density structures that cause some of the noise in the engine exhaust stream. The comprehensive data obtained will help with modern simulation methods that will predict the engine flow and the noise generated in it in greater detail."

Particles show flow patterns

To visualise the turbulent speed and density fluctuations, the scientists used optical measurement systems that work with special cameras and lasers and are synchronised with an array of microphones. "In the experiment, we used the microphones as 'observers' that listened from a distance," explains Schröder. "The microphone signal acted as a filter for simultaneously identifying the measured flow structures that generate noise." Very small light-scattering particles rendered the flow patterns visible in pulsed laser light. The Particle Image Velocimetry (PIV) measurement technique developed by DLR in Göttingen is a versatile tool for flow research.

Data for quieter engines

The researchers have used the combined visual and acoustic measurement technology to build a large library of data that significantly improves the understanding of the causes and distribution of jet noise. "The critical issue is how the flow in the engine can be better influenced to reduce the noise behind it," says Lars Enghardt, who is Head of the Engine Acoustics Department at the DLR Institute of Propulsion Technology in Berlin. "Options here include slowing down the engine jet and combining hot turbine exhaust gases with the cold air outside the rear of the engine faster." Today, the first developments in this direction have already been made, such as the chevron nozzle with its serrated trailing edge. There is a wide range of options for reducing stream noise even more. "The measurement results now available could be an important basis for helping engine manufacturers develop quieter engines with less jet noise," says Enghardt.

Largest DLR research aircraft

The DLR ATRA (Advanced Technology Research Aircraft) used in Project SAMURAI is an Airbus A320 airliner that is used by DLR for a wide range of aviation research projects. The medium-haul passenger jet, which has been converted into a flying test bed, is an ideal research subject for aircraft noise research. It has V2500 range engines, which were developed in a collaboration between MTU, Pratt & Whitney, Rolls Royce and Japanese Aero Engines Corporation; thousands of them are in use all over the world. The ATRA research aircraft is operated by DLR Flight Experiments. The DLR Institutes of Aerodynamics and Flow Technology, Propulsion Technology, Aeroelasticity, and Structures and Design are participating in DLR's Project SAMURA.

Experiment in the largest soundproof hangar in Europe

Since early 2002, an enclosed soundproof hangar has been available for engine test runs for all types of aircraft; it is operated by Lufthansa Technik in Hamburg. The provision of this hangar by the Lufthansa subsidiary has been a stroke of luck for the DLR scientists. This is because the delicate measurement equipment is ideally protected in the building, which, at 95 by 92 metres and a height of 23 metres, can even house a jumbo jet. The test runs do not disturb local residents. The Hamburg soundproof hangar, which was a model for similar facilities at the airports in Leipzig, Zurich and Geneva, was built on the initiative of Flughafen Hamburg GmbH, which has been involved in carrying out DLR measurement campaigns for the past year.

Contacts

Falk Dambowsky
German Aerospace Centre (DLR)
Media Relations, Aeronautics
Tel.: +49 2203 601-3959
falk.dambowsky@dlr.de

Dr.rer.nat. Andreas Schröder
German Aerospace Center (DLR)
DLR Institute of Aerodynamics and Flow Technology, Department Experimental Methods
Tel.: +49 551 709-2190
Fax: +49 551 709-2830
Andreas.Schroeder@dlr.de

Prof. Dr. Lars Enghardt
German Aerospace Center (DLR)
DLR Institute of Propulsion Technology, Division of Engine Acoustics
Tel.: +49 30 310006-28
Fax: +49 30 310006-39
lars.enghardt@dlr.de

Thomas Erich
Lufthansa Technik
Corporate Communications
Tel.: +49 40 5070-3895
thomas.erich@lht.dlh.de

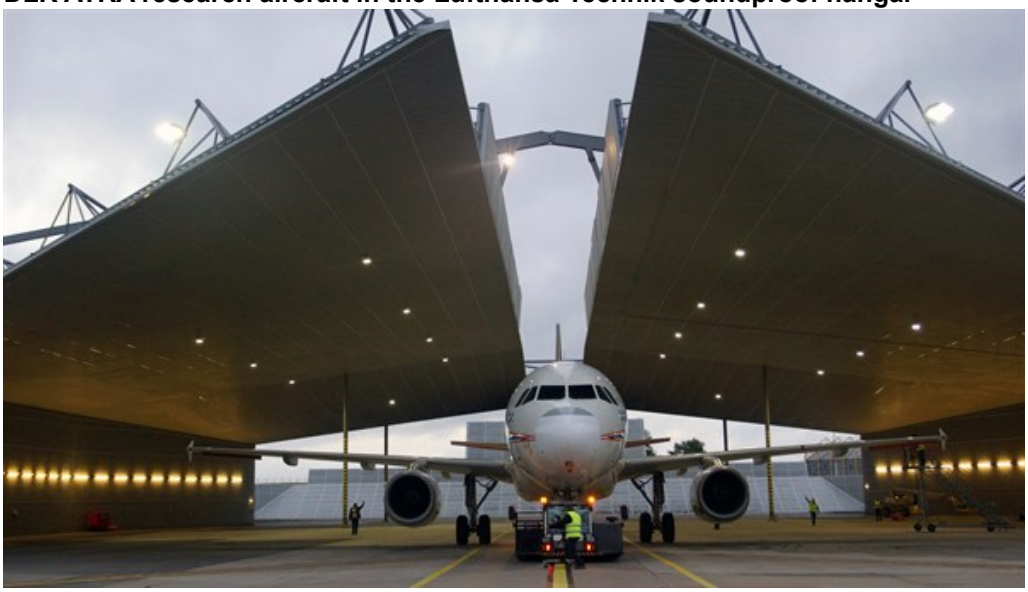
Stefanie Harder
Hamburg Airport
Press and Public Relations
Tel.: +49 40 5075-3611
presse@ham.airport.de

Laser measurements on the engine of the DLR ATRA research aircraft

To visualise the turbulent speed and density fluctuations, the scientists used optical measurement systems that work with special cameras and lasers and are synchronised with an array of microphones.

Credit: DLR (CC-BY 3.0).

DLR ATRA research aircraft in the Lufthansa Technik soundproof hangar



In the DLR SAMURAI (Synergy of Advanced Measurement techniques for Unsteady and high Reynolds number Aerodynamic Investigations) project, DLR noise researchers will use the DLR research aircraft A320-ATRA for a series of engine tests in the Lufthansa Technik soundproof hangar at Hamburg Airport.

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Presentation during the Hamburg Airport Model Show

Project Manager Andreas Schröder presenting Project SAMURAI (Synergy of Advanced Measurement techniques for Unsteady and high Reynolds number Aerodynamic Investigations) and its results. The researchers have used the combined visual and acoustic measurement technology to build a large library of data that significantly improves the understanding of the causes and distribution of jet noise.

Credit: Flughafen Hamburg / M. Penner.

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