PROJECT

TURNEX

Turbomachinery Noise Radiation through the Engine Exhaust

**Funding:** European (6th RTD Framework Programme)

**Duration:** Jan 2005 - Jun 2008

**Status:** Complete with results

**Total project cost:** €4,695,921

**EU contribution:** €2,899,818

**Call for proposal:** FP6-2003-AERO-1

**CORDIS RCN:** 98368

**Background & policy context:**

Research is needed to develop innovative concepts and enabling technologies to reduce aero engine noise at the source. Turbomachinery noise radiating from the bypass and core nozzles is a dominant noise source on modern aircraft, but, while recent EU research programmes have made significant progress in reducing both the generation of turbomachinery noise and the radiation of noise from the intake, little work has been conducted on reducing the radiation of turbomachinery noise from exhaust nozzles. TURNEX addressed this shortfall by delivering improved understanding and validated design methods, and by evaluating a number of low-noise exhaust nozzle configurations aimed at a source noise reduction of 2-3dB.

**Objectives:**

The goal of TURNEX was to develop concepts and enabling technologies for reduction of engine noise at the source through an improved understanding, modelling and prediction of fan and turbine noise radiation from exhaust nozzles, and through the evaluation of a number of low-noise exhaust nozzle configurations. To achieve that goal, TURNEX had four focussed, ambitious objectives:

1. To test experimentally at model scale:
   - innovative noise reduction concepts, including a scarfed exhaust nozzle, and
   - conventional engine exhaust configurations. The experiments were carried out to develop and utilise novel simulated turbomachinery noise sources and innovative measurement techniques in order to evaluate the noise reduction concepts and to provide a high quality validation database.

   - To improve models and prediction methods for turbomachinery noise radiation through the engine exhaust to a level comparable with that being achieved for intake radiation, to address specific shortcomings associated with such methods, and to validate those methods with the experimental data.
   - To conduct a parametric study of real geometry/flow effects (pylons, wings, flow-asymmetry) and noise reduction concepts (scarfed nozzles, acoustically lined after-body and wing) as applied to current and future aircraft configurations of interest, aimed at achieving a 2-3dB source noise reduction.
   - To assess technically the relative merits of different methods of estimating far-field noise levels from in-duct and near-field noise measurements, using both models and the validation data, in order to enhance the capability of European fan noise test facilities to investigate and simulate fan noise radiation through the exhaust.

**Methodology:**

The project work was organised into three Work Packages encompassing the following tasks and methods:

**Work Package 1:** Turbomachinery noise radiation experiments on an engine exhaust rig in a Jet Noise Test Facility. The main objective was to test at model scale:
- innovative noise reduction concepts, including a scarfed exhaust nozzle, and
- conventional engine exhaust configurations.

The experiments developed and utilised simulated turbomachinery noise sources and innovative measurement techniques in order to realistically evaluate the noise reduction concepts and to provide a high quality validation database. A secondary objective was to technically assess the relative merits of different methods of estimating far-field noise levels from in-duct and near-field noise measurements, using both models and the validation data, to enhance the capability of European fan noise test facilities to simulate fan noise radiation through the exhaust.

Work Package 2: Improved Models and Prediction Methods. The objective was to improve models and prediction methods for turbomachinery noise radiation through the engine exhaust, to a level comparable with that being achieved for intake radiation, and validate these with the experimental data.

Work Package 3: Assessment and Industrial Implementation of Results. The objective was to conduct a parametric study of real geometry/flow effects (pylons, flow-asymmetry) and noise reduction concepts (scarfed nozzles, acoustically lined after-body) as applied to current and future aircraft configurations of interest.

Parent Programmes:
FP6-AERO-1.2 - Improving environmental impact with regard to emissions and noise

Institute type: Public institution
Institute name: European Commission
Funding type: Public (EU)

Lead Organisation:

**University Of Southampton**

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Organisation Website: [http://www.soton.ac.uk](http://www.soton.ac.uk)
EU Contribution: €0

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Key Results:

In June 2008, the EU project TURNEX (Turbomachinery Noise Radiation through the Engine Exhaust) was completed. The goal of TURNEX was to develop concepts and enabling technologies for the reduction of engine noise at the source, through an improved understanding, modelling and prediction of fan and turbine noise radiation from exhaust nozzles, and through the evaluation of a number of low-noise exhaust nozzle configurations. At its conclusion, TURNEX has delivered validated industry-exploitable methods for predicting turbomachinery noise radiation through exhaust nozzles. It has also delivered a technical assessment on the way forward for European fan noise testing facilities and an assessment of exhaust nozzle concepts for noise reduction at source. From both the experimental and modelling work within TURNEX, some highlights are presented below:

1. Large-scale rig test

In the main experiment, two model scale exhaust nozzle configurations were tested in the QinetiQ Noise Test facility (NTF), using simulated fan and turbine noise sources and advanced measurement techniques. The rig included a rotating bypass duct section with wall-mounted microphones for radial mode analysis (RMA). A far-field azimuthal microphone array (FFA) was designed and installed, which could be moved over a range of axial positions and hence polar angles. This enabled 3D effects and the azimuthal mode content in the far-field to be studied.
2. Validation of CAA codes

A key part of TURNEX was the validation of several prediction codes with the experimental data acquired in other tasks of the project. A typical result represented measured noise levels from the two different far-field arrays ('Polar' and 'Azimuthal') compared to predictions from the Actran/DGM and FLESTURN codes, using as the source input the mode amplitudes measured with the RMA. This is validation in both far-field level and directivity shape, which is unusual in the context of aircraft noise prediction methods where normally the level is based on a semi-empirical 'calibration' and only the directivity or field shape is usually validated.

3. Tone Haystacking

The above codes address propagation through the steady component of the exhaust jet flow(s). However, industry also requires methods for predicting the effects of scattering by the turbulent components within the jet shear layer(s), which leads to broadening or 'haystacking' of high frequency turbine tones and also spatial scatteri

**Technical Implications**

TURNEX has delivered validated industry-exploitable methods for predicting turbomachinery noise radiation through exhaust nozzles, which will allow EU industry to compete effectively with NASA-funded technology developments in the US. It has also delivered a technical assessment on the way forward for European fan noise testing facilities and an assessment of exhaust nozzle concepts for noise reduction at source.

Documents:
- Final Publishable Report (Final report)

**STRIA Roadmaps:** Vehicle design and manufacturing

**Transport mode:** Air transport

**Transport sectors:** Passenger transport, Freight transport

**Transport policies:** Deployment planning/Financing/Market roll-out, Environmental/Emissions aspects

**Geo-spatial type:** Infrastructure Node