Turbomachinery Noise Radiation through the Engine Exhaust

Reporting

Project Information

TURNEX

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Final Report Summary - TURNEX (Turbomachinery noise radiation through the engine exhaust)

The goal of the TURNEX project 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:

Objective 1: To test experimentally at model scale (a) innovative noise reduction concepts, including a scarfed exhaust nozzle, and (b) conventional engine exhaust configurations in order to evaluate the noise reduction concepts and to provide a high quality validation database.

The data has provided the means to validate existing and new methods developed within TURNEX for realistic scaled geometries over a wide range of mean flow conditions, corresponding to the aircraft approach and take-off noise conditions. The mode synthesiser worked well and generated the target modes with high tone protrusion. The pylon strongly modifies the radiated modal structure of the sound field.

Objective 2: To improve models and prediction methods for turbomachinery noise radiation through the engine exhaust and to validate those methods with the experimental data.

TURNEX has made significant advances in this subject by (1) evaluating an analytic, asymptotic solution based on the Cargill 'weak' scattering method, which appears to be robust and can be rapidly computed and (2) developing and evaluating the application of a time domain CAA code, PIANO, without the limitation of weak scattering. Both methods have been initially tested against published experimental data by Candel.

Objective 3: 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 - 3 dB source noise reduction.

A parametric study on a typical full-scale engine with short cowl, called LRAS, has been conducted. Both axisymmetric and three-dimensional (3D) configurations with pylon have been addressed and two novel noise reduction noise concepts have been evaluated (afterbody liner and scarfed exhaust). Except for the scarfed exhaust concept, the computational matrix has been successfully completed.

A successful application of Actran / DGM (Axisymmetric) to real engine configurations has lead to a better understanding of the influence of shear layer refraction, through the development of an approximate model for the peak radiation angle.

Actran / DGM (Axisymmetric) has been successfully applied to the multimodal excitation situation for broadband noise and found to agree well with Actran / TM (the intake code).

Evaluation of the afterbody liner concept, including the effects of mean flow has been conducted with the Flesturn code (both broadband and tonal source). Up to 4 - 5 dB additional attenuation has been demonstrated at high angles (refraction effects) on broadband noise.

Based on the numerical results from the LRAS engine study, a specific installation effect study has been conducted in order to assess the effect of the wing on the numerical results obtained on rearward fan noise. A correction has been applied on the results in order to take the jet blockage effect into account, based on the TURNEX experimental results. LRAS results have interpolated / extrapolated in order to provide third-band octave attenuation matrix for aircraft noise predictions. The differences have been applied to the VP2-LR2 aircraft-engine (virtual platform designed in SILENCE project) which corresponds to the LRAS engine.

Objective 4: 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.

A method for estimating far-field broadband noise levels from in-duct measurements in the form of a beamformer technique has been evaluated with the aid of data acquired under objective 1. This is based on cross-spectrum measurements taken with a simple flush-mounted, in-duct axial array of microphones. In effect, an in-duct directivity is measured and a computed transfer function is used to project that directivity into the far-field, which should be insensitive to the source model assumed and this does appear to be the case, provided any influence on the directivity is taken into account, such as a change in duct area or refraction by the jet exhaust flow.

Fan models or rigs that are tested in the Anecom facility are designed to model the main bypass duct but not the final bypass nozzle. Therefore, when the Anecom in-duct beamformer data is projected to the far-field it will be necessary to take into account propagation from the axial measurement section through the bypass nozzle, which would normally involve flow acceleration and an area change.

The consortium consisted of two leading airframe manufacturers, three leading engine manufacturers, a Small and medium-sized enterprise (SME) that specialises in computational aeroacoustics software, three leading research centres and three leading universities from France, Germany, Belgium, the Netherlands, Italy, Turkey and the United Kingdom.

Related documents

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