ANCORA
A NoteC-Comoti Rotorcraft Acoustics initiative for preliminary acoustic flight tests for the tuning of simplified rotorcraft noise models

State of the art – Background
One of the objectives of GRC5 is to implement a tool for the minimisation of noise impact on the ground, capable of being executed on-board “on-the-fly”, providing flight directives to the FMS of the helicopter. To this end reliable and fast noise predictions will have to be made, based on actual flight conditions. The envisaged semi-empirical model to be used for this purpose requires information to be derived from experimental data. For this purpose noise measurements have to be made simultaneously on the exterior of the helicopter (i.e. close to the noise source) and on the ground.

Until now microphones on the exterior of helicopters have mainly been used to measure the influence of airborne noise (in particular boundary layer noise) on interior cabin noise or as error signal sensors in active rotor noise control systems. In these applications, there are quite relaxed requirements for the microphone type and its location. In the application in the ANCORA project, however, the transfer function between on-board and ground noise will have to be determined in order to provide accurate information for the validation of prediction models. This requires a correct measurement of the absolute noise levels on-board over a wide frequency range. This implies a much more strict selection of the microphone type to be used and its location on the helicopter exterior, avoiding areas where important influence of rotor flow or forward speed is encountered. In ANCORA the use of surface microphones was envisaged for this purpose, together with a boom microphone with nose cone.

Objectives

The main objective of ANCORA was to develop and validate the measurement systems and methodologies required to derive the transfer functions between on-board and ground-based microphones. Somewhat more concrete, the principal objectives for ANCORA were:

- To deliver a robust and reliable mobile noise measurement system, easily scalable and optimised for minimum deployment time and cost.
- To develop an advanced method for the determination of the transfer functions between on-board and ground microphones.
- Validate the system and the methodology by means of a flight test campaign.

Description of work

The work performed in ANCORA was divided into several tasks, each one addressing one of the objectives of the project.

- Development and validation of the on-board noise measurement system

As a first step a selection was made between various available surface microphones and nose cone designs, by means of tests in a wind tunnel and on a car. After this, specific flight tests were performed on the AW139 P1 to determine the best position for the surface microphones on the helicopter and to validate their use for the purpose of the project. Since the remaining part of the project was to be performed with a small turboprop aircraft these tests were repeated on such a vehicle, with microphones placed on the lower wing surface and a boom microphone below the fuselage.

Based on the research performed in ANCORA it can be concluded that the use of an on-board microphone system, consisting of surface microphones and a boom microphone, is feasible. Appropriate locations for the microphones may be selected by means of a semi-empirical approach. A proper position is required to guarantee adequate tonal information up to sufficiently high speeds. Repeatable results may be obtained under a range of operating conditions.

- To demonstrate the feasibility of the application of surface microphones on the helicopter fuselage and on a small turboprop aircraft to subsequently use this knowledge for a flight test campaign with the same helicopter at a later stage.
Development of a robust and reliable mobile noise measurement system

The main challenge for the development of the ground-based measurement system was to provide a robust and reliable noise measuring system, comprising of 31 microphones, quickly deployable in the field.

After investigating a variety of options to optimise the system and minimise the risk, a solution was found based on the latest generation of sound level meters. Based on its SV979 model, Svantek developed a station that contains in a single unit all major system elements (microphone, real time analyser, digital recorder, GPS, modem Wi-Fi). Integration in a single unit practically eliminates the need for any connections to be made in the field, thus significantly reducing any problems in this respect.

Each NMS is equipped with a zigbee modem which provides bi-directional data communication with the central ground station (CGS). The modems are configured in mesh mode, which allows for deployment in large arrays. An internal battery provides an autonomy of at least 8 hours. During each measurement noise levels are sent to CGS for quick look purposes and simultaneously stored locally for post-processing. All stations and the aircraft are synchronised with GPS time.

A flight test campaign was performed in Trebujena (Spain) with a small turboprop aircraft to validate the complete measurement system.

Based on the research performed in ANCORA it can be concluded that the mobile noise measuring system developed for the flight tests is a robust and reliable solution that can easily be deployed in the field. Its architecture makes a very flexible microphone layout in the field possible, thus facilitating the use of complex flight test procedures.

As a by-product, the zigbee communication developed by Svantek for ANCORA has now been implemented in their product range.

Development of an advanced method to determine transfer functions

A main objective of ANCORA is to validate algorithms to determine the transfer function between the noise measured on-board the helicopter and the noise measured on the ground. The sensor time series recorded during the measurements, by both the on-board and ground systems, are processed, Doppler effects are compensated and cross-correlations are performed to obtain the transfer functions.

During a flight test campaign in Trebujena (Spain) simultaneous noise measurements were made on-board and on the ground with the earlier developed systems to obtain a comprehensive database for a variety of operating conditions and flight procedures. The data obtained was used to test and validate the algorithms developed.

Based on the research performed in ANCORA it can be concluded that it is feasible to derive Transfer Functions between the noise measured on-board the helicopter and the noise measured on the ground.

Expected results

The main objective of ANCORA was to validate algorithms to determine the transfer function between the noise measured on-board the helicopter and the noise measured on the ground. This transfer function can then be used in the tuning of a semi-empirical rotorcraft noise prediction model, being developed for the implementation in an on-board system of an AgustaWestland helicopter for the minimisation of the noise impact “on-the-fly”.

Successful completion of ANCORA is thus decisive for enabling future application of the above described development.

An important condition for the accomplishment of the abovementioned objective was the availability of validated noise measurement systems for both on-board and ground applications.

The development and validation of an on-board microphone system for the measurement of noise signals close to the source was therefore an important enabler for the main objective of ANCORA.

Another result of ANCORA is the availability to the EU aircraft industry of a robust and reliable mobile noise measurement system, easily scalable and optimised for minimum deployment time, at a cost substantially lower than that of systems currently used. Having such a system readily available for flight tests anywhere, greatly enhances the possibility of its use in research projects with relatively limited budget, thus allowing for a significantly increased knowledge of rotorcraft (and also fixed wing aircraft) noise, one of the main objectives of the Clean Sky JTI.
Figure: Positions of surface microphones on helicopter

Figure: Noise signal for various flight speeds
Figure: Positions of surface microphones on turboprop aircraft

Figure: Noise measurement station

Figure: Spectrogram of signal measured on-board

Figure: Spectrogram of signal measured on ground
Project Summary

Acronym: ANCORA

Name of proposal: ANotec-COMoti Rotorcraft Acoustics initiative for preliminary acoustic flight tests for the tuning of simplified rotorcraft noise models

Technical domain: Helicopter noise

Involved ITD: Green Rotorcraft

Environment friendly flight path

Grant Agreement: 287094

Instrument: Clean Sky

Total Cost: 284 200 €

Clean Sky contribution: 213 150 €

Call: JTI-CS-2010-5

Starting date: July 2011

Ending date: December 2013

Duration: 30 months

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