TEENI
Turboshaft Engine Exhaust Noise Identification

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Introduction

The TEENI project is an FP7 level 1 (Theme 7 – Transport) 1st Call EU-funded project. It focuses on Helicopter Engine Exhaust Broadband Noise, and tries to identify the origin of this noise from external measurements only. The project was launched on 1 April 2008 and will last 3 years. TEENI, a collaborative project, has EU funding of 3.3M€ with 11 partners:

Partner	Country	Type
Anotec	Spain	SME
Avio	Italy	IND
Bruel & Kjaër	Denmark	IND
COMOTI	Romania	REC
DLR	Germany	REC
EPFL	Switzerland	HES
INASCO	Greece	SME
Microflown	The Netherlands	SME
ONERA	France	REC
TCD	Ireland	HES
Turbomeca - Coordinator	France	IND

Unlike Turbojet engines, Turboshaft engine gases are ejected at low speeds, leading to almost no jet noise. Although the turbines generate high amplitude tonal nose, their high RPM and blade count result in the frequencies being above the audible threshold. However, a previous European project: Friendcopter has demonstrated through flight tests the significance of medium-frequency exhaust engine noise for the Take-Off flight certification condition.

The origin and generation mechanisms of this exhaust broadband noise "Corenoise" – figure 1, have not yet been fully defined: low frequency content is generally related to combustion phenomena in the literature, but the sources above 1kHz are not understood.

Understanding the origin (location and physical mechanisms) of this broadband noise range is the main objective of the TEENI project, with the final industrial goal being to better attenuate this exhaust noise.

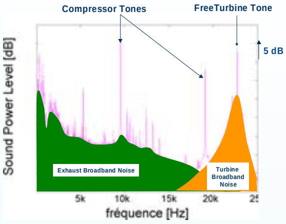

Figure 1. Turboshaft "Corenoise"

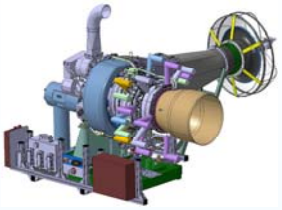

Figure 2. Ardiden-1H Turboshaft engine.

Objectives

In order to achieve the project goals, the main project workpackages address the following objectives:

1. Develop innovative sensors to allow pressure, flow velocity, temperature and acoustic intensity measurements to be made in extremely harsh pressure and temperature environments.

2. Develop novel noise source identification techniques to gain a thorough understanding of the engine broadband noise contribution. Specifically: the location of origin within the engine of any contributing sources and also the physical mechanisms of their generation.

3. Full scale tests on an Ardiden-1H Turboshaft engine (figure 2) with the novel sensors and techniques which will provide for the first time a broadband noise source decomposition per engine module.

Results to Date

Work Package 1

• DLR has developed pressure probes, based on standard G.R.A.S. ¼" microphones of type 40BH (up to 192dB) or type 40BP (up to 172dB SPL) with a G.R.A.S. amplifier type 26AC directly connected to the microphone (see Figure 3 -a).

• DLR also developed temperature probes, based on a twin thermocouple design -also called fast thermocouple- which has proven to be able to detect variations up to 700 Hz.

• INASCO has developed an innovative dielectric unsteady flow velocity sensor (see Figure 3 -b)

• Microflown has developed an acoustic intensity sensor, based on their proprietary technology, and adapted to engine environment (up to 650°C) (see Figure 3 -c).

A realistic engine environment has been taken into consideration in sensor design by reinforcing the sensitive part, improving the casing or remotely using the sensor where possible.

Figure 3a. DLR Pressure probe tested in COMOTI's combustion chamber

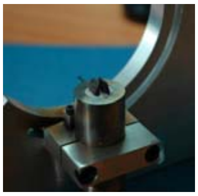

Figure 3b. INASCO unsteady Flow Sensor

Figure 3c. Microflown High temperature Acoustic Intensity Sensor

Work Package 2

• Trinity College Dublin has developed several noise source identification techniques, with a special focus on non-linear phenomena and modal decomposition [1] to [4]

• ONERA will apply the 3-microphone technique

• Bruel & Kjaër has developed a statistical method, the Blind Source Separation Technique

• DLR develops further their multiple sensor modal analysis technique applied to broadband noise

• EPFL develops the acoustic goniometer, which is a microphone network

• Turbomeca implements a Tone-Cutting Method, which can be applied to all test results in the spectral domain, and should prove useful to extract the engine broadband noise signature

• Anotec integrates individual engine noise sources into the Helena software

• Avio numerical study of noise propagation through the turbine stages

Conclusions

The project is currently at the 24 month stage with WP1 and WP2 on time and having achieved their objectives, validated on dedicated test rigs. WP3 is due to start using the developed techniques and sensors.

References

[1] Bennett G. J., Davis, I., Tapken, U., 'Broadband Noise Source Location in Turbomachinery using a Conditioned Spectral Analysis Technique Coupled with Modal Decomposition' - InterNoise 2010 (Lisbon, Portugal 2010) [2] Bennett, G.J., O'Reilly, C., Tapken, U., and Liu, H.: 'Modelling multi-modal sound transmission from point sources in ducts with flow using a wave-based method'. Proc. 16th International Congress on Sound and Vibration (ICSV16), Kraków, Poland, 5-9 July 2009 [3] Bennett, G.J., O'Reilly, C., Tapken, U., and Fitzpatrick, J.: 'Noise Source Location in Turbomachinery Using Coherence Based Modal Decomposition'. Proc. 15th AIAA /CEAS Aeroacoustics Conference, Miami, Florida, 11–13 May 2009, AIAA-2009-3367 [4] Bennett, G.J., Mahon, J., and Fitzpatrick, J.: 'Non-linear Identification Applied to Broadband Turbomachinery Noise'. Proc. 12th CEAS-ASC Workshop on Turbomachinery Broadband Noise, Bilbao, Spain, 23-24 October, 2008

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