ALIAS

Acoustic LIners for Air conditioning Systems

State of the art – Background

On modern aircraft, passengers and crew breathe a mixture of fresh and recirculated air. This combination rather than fresh only allows the regulation of temperature, pressure and humidity. The air is bled from the engines and supplied to air conditioning units. It is then ducted into the cabin, circulated and eventually drawn into the lower fuselage where is sucked out by the pressurization outflow valve for the cycle to begin again. Besides creating a safe and comfortable environment, the aircraft air conditioning systems generate noise. The noise radiated from the aircrafts' air conditioning systems is reduced thanks to acoustic liners. These liners present a major design challenge because of the need to address a wide range of conflicting requirements. Acoustic liners must provide high levels of noise reduction over a wide range of operating conditions. They should also be light and flexible to meet strict weight and tight space restrictions.

Objectives

Until now, acoustic liners for air conditioning systems are made of porous materials, very efficient for sound absorption in the high-frequency range. However, the air conditioning systems manufacturer who is the Topic Manager of the JTI-CS-2012-2-SGO-02-036 CFP, is developing an electrically driven air system composed of an air pump which generates low- and mid-frequency noise. New kind of acoustic liners are therefore required to mitigate this noise source.

The ALIAS project (Acoustic Liners for Air conditioning Systems) consists in designing optimized locally reacting treatments for mid-frequency acoustic attenuation in air conditioning systems. The French Aerospace Lab (ONERA) and the SME ATECA, specialized in Aeronautics, Advanced Materials & Manufacturing, combined their research and technological capabilities to propose a solution of TRL5 that meets the industrial requirements. This was achieved by implementing a simulation-based design process, during a two-year long project between 01/01/2013 and 31/05/2015.

Description of work

First, technical specifications were defined with the Topic Manager. Then, ONERA in-house simulation tools (a fast modal analysis code as well as a more complex solver of the linearized Euler equations) were used to estimate the acoustic liner impedance that maximizes noise damping of the set of cut-on modes in the target range of frequency. A sheared flow profile in a cylindrical duct was considered. The next step was to design locally reacting acoustic liners that best fit the target impedance. For this purpose, semi-empirical models were reproduced from literature to link geometrical properties to the acoustic impedance attained. This allowed the selection of five concepts of acoustic treatments.
Laboratory samples of these concepts were then manufactured by ATECA and tested in ONERA facilities, both in an impedance tube and in the B2A flow duct with a grazing flow up to M=0.3. In the flow duct, the acoustic impedance was measured in-situ, except for a specific advanced concept, the impedance of which was educed from pressure measurements at the wall opposite the liner. The accuracy of theoretical predictions has been confirmed by comparing them with the acoustic impedance measurements. Then, the latter were used as an input for the ONERA acoustic propagation code, which predicted the expected attenuation in the industrial configuration. These numerical predictions allowed the selection of the best two concepts. The selection criteria were not only the reached acoustic attenuation, but also manufacturing, costs and weight considerations. These issues were indeed specifically studied by ATECA, who performed an analysis for integration of proposals solutions in an industrial context.
Finally, large-scale prototypes of the two selected designs were manufactured by ATECA and tested in industrial settings in the Topic Manager's acoustic facility. The measured acoustic attenuation proved to be as high as expected in the target mid-frequency range.

Results

a) Timeline & main milestones

The ALIAS project was a two-year long project between 01/01/2013 and 31/05/2015. During the first nine months, numerical simulations were conducted to propose five concepts of liners, which were designed to maximize the sound absorption in the range of frequency specified by the industrial Topic Manager. Then, the next nine months were devoted to manufacturing of these concepts at a laboratory scale, followed by tests without and with grazing flow and finally numerical simulations to assess the acoustic attenuation in the industrial configuration provided by the measured impedance of the proposed liners. Mid-2014, the best two concepts were therefore selected. They were then manufactured as large-scale prototypes, and at beginning of 2015 they were delivered to the Topic Manager. Finally, acoustic tests were conducted during spring 2015 in the Topic Manager's acoustic facility. The industrial air conditioning system was equipped with either of the prototypes, and the measured attenuation proved to be as high as expected.

b) Environmental benefits

The simulation-based design process implemented during the ALIAS project and followed by a large-scale prototypes manufacturing phase, proved to be efficient for achieving high acoustic attenuation in an industrial configuration. This process could be applied to various in-duct noise sources, in order to develop efficient and practical lining solutions, at a controlled cost.

c) Maturity of works performed

Large-scale prototypes of the two selected designs were manufactured by ATECA and tested in industrial settings in the Topic Manager's acoustic facility, which corresponds to a TRL 5 solution.
The performance of the designed acoustic liners has been proved in the target frequency range and operating conditions. The know-how gained by ALIAS partners could now be used to expand the developed design-based process to various applications in aeronautics, or to other operating conditions of air conditioning systems. Especially, low-frequency noise attenuation under tight thickness restrictions is still an issue to be tackled. One of the innovative design studied during ALIAS project, but not yet manufactured at large-scale, could be a good candidate. Moreover, the liner design process would strongly benefit from the knowledge of the source modal content and noise level within the duct, which remains an open issue.

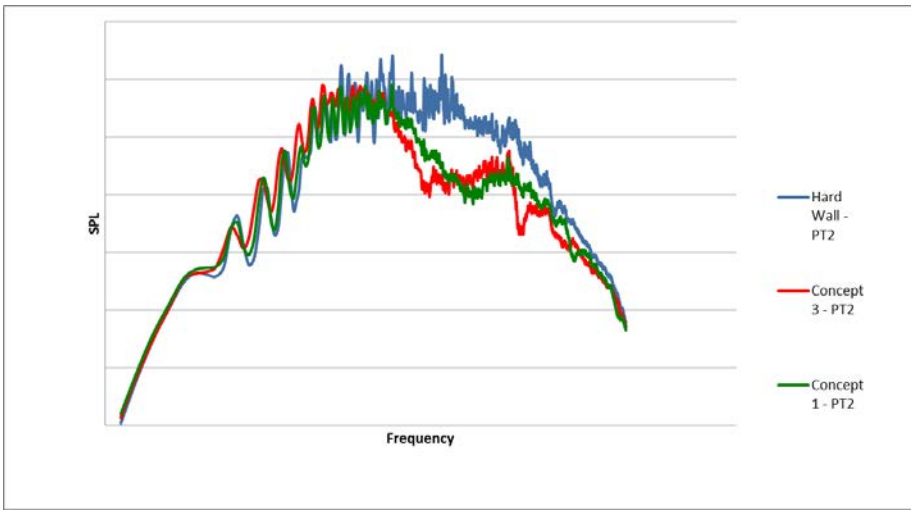

Figure 1: Noise spectrum radiated without treatment (blue line), with Prototype A (red line) and with Prototype B (green line). The target frequency range is displayed by the vertical dashed lines

Project Summary

Acronym : ALIAS

Name of proposal: Acoustic Liners for Air conditioning Systems

Technical domain:	Acoustics, Systems, Noise reduction
Involved ITD	SGO
Grant Agreement:	325976
Instrument:	Clean Sky JU
Total Cost:	294 614 €
Clean Sky contribution:	171 603 €

Call: JTI-CS-2012-2-SGO-02-036 CFP

Starting date: 01/01/2013

Ending date: 31/05/2015

Duration: 29 months

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