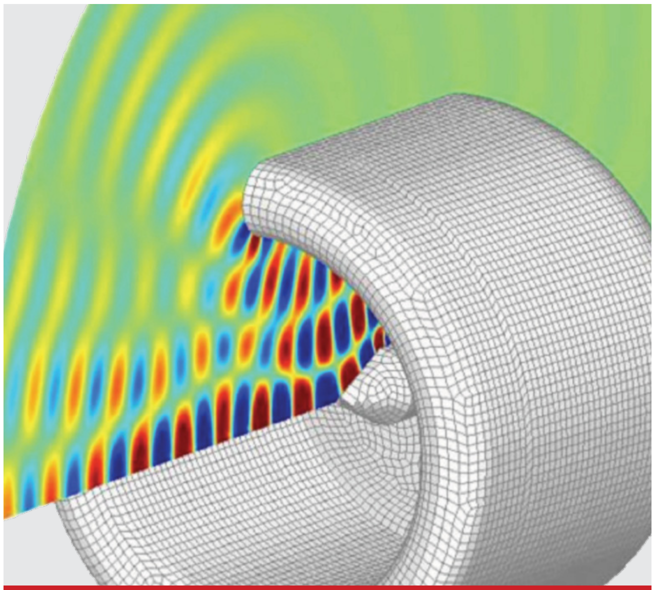
Case Study: **Airbus**

Simulation Helps Airbus Optimize Acoustic Liners and Reduce Aircraft Noise

Overview

Noise is becoming a major obstacle to growth in air transport as increasing numbers of airports place restrictions on the amount of noise that can be generated by an aircraft during various phases of flight. Airbus is working hard to reduce aircraft noise such as by improving the nacelle acoustic liners used to minimize the fan noise radiated from the engine. The company has dramatically reduced the time required to design and evaluate optimized acoustic liners by moving to a simulation-based process using Actran acoustic simulation software developed by Free Field Technologies (FFT), MSC Software Company.



Actran based simulation now plays a primary role in the design of acoustic liners for the engines integrated into the entire Airbus aircraft family.

“Airbus has confirmed the accuracy of Actran predictions by comparing them with engine static testing results. Actran is the only simulation tool able to accurately model the main physical phenomena for engine nacelle radiation.”

Jean-Yves Suratteau, Head of Numerical Methods, Acoustics & Environment Dept., Airbus

Key Highlights:

Product: Actran

Industry: Aerospace

Benefits:

- Reduce product development costs by avoiding expensive post-design changes.
- Reduce test/analysis iterations
- Improve performance predictions

Challenge

Importance of Reducing Aircraft Noise

Aviation noise is one of the most serious constraints on expansion and improvement of the air transport system throughout the world. Increases in air traffic and population growth in areas surrounding airports are increasing the impact of aircraft noise on the community. Airports around the world have taken measures to address aircraft noise including the establishment of noise budgets and noise charges to limit cumulative noise exposure and curfews, operating quotas and noise limits to reduce nighttime noise. Turbofan engine fan noise is one of the largest contributors along with jet noise to noise radiated by an aircraft at take-off. The fan pulls air into the front of the engine and generates noise at the inlet of the fan similar to the noise caused by a propeller. The air is swirling as it exits the fan which causes a loss of momentum so the air is straightened out by running it through a set of stationary vanes called the stators at the fan outlet. The impact of the air on the stator blades is another major source of noise.

The acoustic liners that are built into the engine nacelle are fundamental in controlling fan noise. Acoustic liners present a major design challenge because they must address a large number of conflicting design requirements. Liners must provide high levels of noise reduction over a wide range of engine operating conditions and frequencies. Liners must also meet tight space restrictions and need to be as light as possible in order to limit fuel consumption. The liner is typically designed at a point when aspects of the airframe and engine are not completely defined so the liner design must be flexible enough to adapt to changes. The liner must be able to survive exposure to heat, cold, water, oil, and maintenance operations. Finally, the liner must be durable enough to deliver decades of service in the highly demanding aircraft engine environment.

Solution

Improving Acoustic Liner Design

Originally, the design of acoustic liners was based on static tests performed by running the engine on a test rig and measuring the radiated noise with an array of microphones. This approach was very expensive and design evaluation could not be initiated until a prototype engine was available for testing. To address this challenge, Airbus engineers used analytical tools that predicted noise radiation but these tools were only accurate when used with very simple geometries so their usefulness in modeling noise radiation from the nacelle was limited. Airbus has long been working to more accurately simulate noise radiation from the nacelle. “When FFT created the Actran consortium in 1999, the Acoustic Department of Airbus-France decided to be part of it and to support the development of the first version of Actran software.

We are currently using it for design of nacelle liners in engine inlets and exhaust ducts, cockpit and cabin interior noise, air systems at ground, propellers and contra-rotating propellers,” Suratteau said. “Airbus has confirmed the accuracy of Actran predictions by comparing them with engine static testing results. Actran is the only simulation tool able to accurately model the main physical phenomena for engine nacelle radiation.”

The numerical process is presented in Fig.1. The shape or wetted surface of the nacelle is defined by the aerospace engineers based on aerodynamic requirements and is provided to acoustic engineers as a CATIA V5 computer aided design (CAD) file. Engineers generate a finite element mesh of the nacelle liner geometry using hexahedral and tetrahedral elements and use a visualization tool to check the quality of the mesh. The model is based on a partitioned approach in which the inner acoustic domain is modeled with finite elements and the outer acoustic domain which extends to infinity is modeled using infinite elements. The acoustic source at the source plane is defined in terms of a modal boundary condition where the incident acoustic field is defined in terms of rigid-wall duct modes.

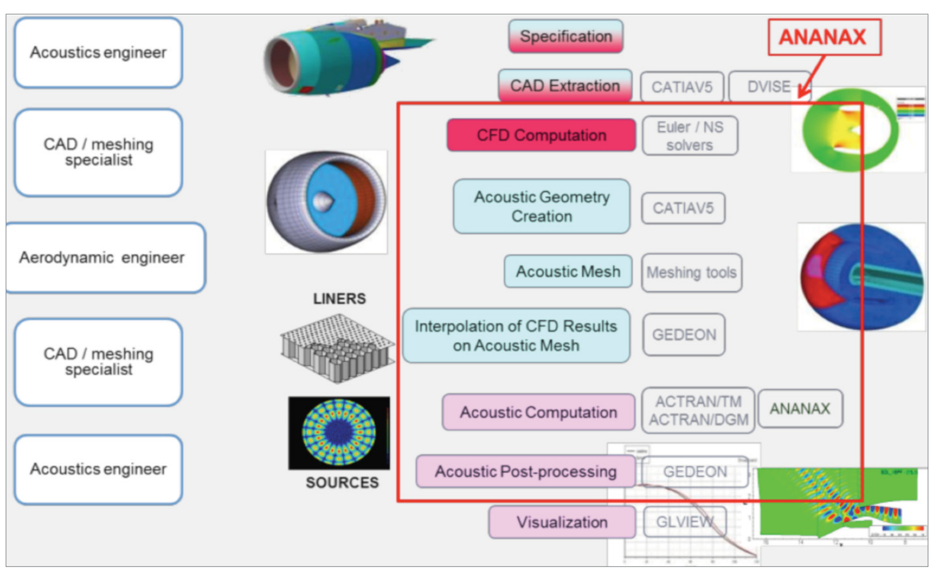


Figure 1: ANaNax streamlines acoustic simulation

The airflow inside and outside the engine has a major impact on acoustic radiation. A preliminary and important step is to get computational fluid dynamics (CFD) results from the aerodynamic engineers from Airbus. Engineers then use interpolated CFD temperature, velocity and pressure data with the acoustic simulation. Another input data for acoustic simulation is the noise at fan level which is given by the engine manufacturers in the form of a modal decomposition, obtained through engine static test results. A typical nacelle liner is composed of a sandwich constructed from a rigid backplate, honeycomb cells and a perforated facesheet (Single Degree of Freedom, SDOF). The design parameters that typically can be changed to optimize the liner design include the thickness of the liner, the spacing and diameter of holes in the face sheet, the number of blocks of material from which the liner is constructed and several others. The acoustic simulation results are provided in the form of sound pressure levels at various points around the nacelle as they would be measured by an array of microphones. The results can easily be correlated with static tests. Airbus has developed an in-house program that converts the results to effective perceived noise in decibels (EPNdB), the basic measurement for noise certification criteria.

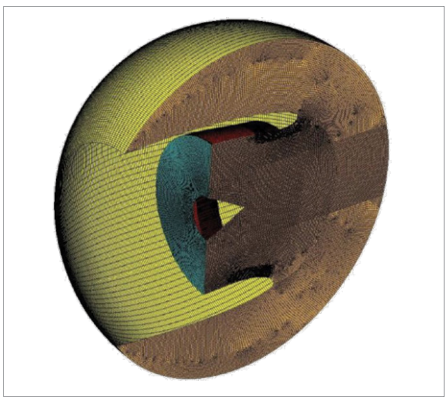


Figure 2: Actran acoustic mesh of fan intake

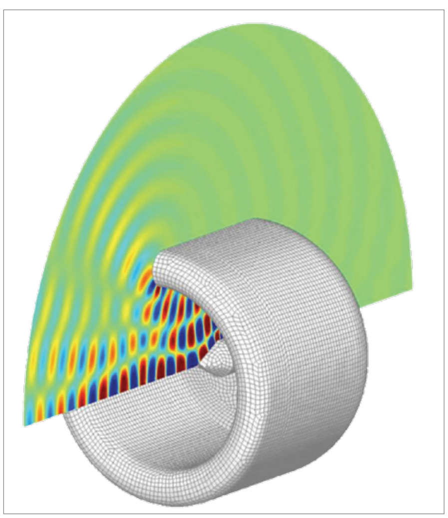


Figure 3: Actran prediction of fan inlet noise

Liners are typically manufactured in two or three curved segments that are assembled with longitudinal splices. Simulation with Actran and other numerical tools helped to reveal the substantial impact of splices on forward fan noise and these simulations were confirmed with physical testing. These simulations made it possible to compute the radiated noise fields under all relevant engine operating conditions and predict the noise reduction in certification conditions. The design of the zero-splice concept, through numerical simulation, made it possible to significantly reduce the fan noise and the acoustic discomfort.

Results/Benefits

Avoiding Expensive Post-Design Changes

Airbus developed an integrated numerical chain for Actran in order to streamline its use by acoustics engineers who are not numerical experts. The chain, called Automated Liner Optimization Chain for Nacelles Air Inlets and Exhausts (ANaNax), automates the simulation process from engine geometry to Actran results including prompting the user for all required information and performing validation checks on the data entered by users. "A typical optimization loop for the nacelle liner requires evaluation of 80 liner iterations and three flight conditions at a frequency range from 125 Hz to 5650 Hz which means we need to simulate several thousand different cases," Suratteau said. "Robustness and accuracy of the simulations is critical so realistic 3D shapes, flows and boundary conditions are a must. ANaNax greatly reduces the time required for non-analytical experts to perform simulations and to check their work to be sure inputs are realistic. Computation time has also been drastically decreased by the implementation of a high performance computing (HPC) platform based on Westmere X5670 Infiniband technology with 5312 cores combined with the high scalability of Actran."

"Since its entry into service in 2011, ANaNax has been used for 6 nacelle optimization studies in 2011 and 8 studies in 2012 and is now the standard platform for nacelle design at Airbus," Suratteau concluded.

"Actran has helped Airbus design and deliver best-in-class acoustic solutions that save aircraft weight with a huge financial impact for airlines operating Airbus aircraft. Actran also helps Airbus reduce product development costs by avoiding expensive post-design changes. Having proven the value of Actran for nacelle liner design, Airbus is now in the process of expanding its use by developing new applications such as auxiliary power units (APUs) and ground systems for ramp noise and counter-rotating open rotor (CROR) engines for community, cockpit and cabin interior noise.

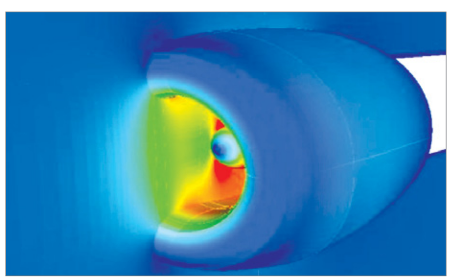


Figure 4: Flow in fan computed with CFD

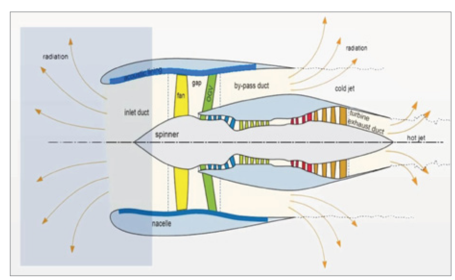


Figure 5: Diagram of noise sources in turbofan engine

For more information on Actran and for additional Case Studies, please visit **www.mscsoftware.com/actran**

Corporate
MSC Software Corporation
4675 MacArthur Court
Suite 900
Newport Beach, CA 92660
Telephone 714.540.8900
www.mscsoftware.com

Europe, Middle East, Africa
MSC Software GmbH
Am Moosfeld 13
81829 Munich, Germany
Telephone 49.89.431.98.70

Japan
MSC Software LTD.
Shinjuku First West 8F
23-7 Nishi Shinjuku
1-Chome, Shinjuku-Ku
Tokyo, Japan 160-0023
Telephone 81.3.6911.1200

Asia-Pacific
MSC Software (S) Pte. Ltd.
100 Beach Road
#16-05 Shaw Towers
Singapore 189702
Telephone 65.6272.0082

AIRBUS*2014MAY*CS