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Aircraft noise reduction : AIRBUS industrial needs in terms of new materials for nacelle liners

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Summary

• Noise & aircraft design

• Propulsion noise reduction
  ‣ Low noise configurations and flight procedures
  ‣ Engine source
  ‣ Nacelle geometry and liners

• Liner impedance requirements

• Conclusion
Aircraft noise:
A complex mix of different sources

• **Take-off: Jet & Fan**

• **Approach: Fan & airframe**
Long Range aircraft sensitivity to noise sources

Departure noise

Noise of a typical 1990s engine

Jet
Airframe
Inlet fan
Aft fan

Jet
Airframe
Inlet fan
Aft fan

Compressor
Fan
Jet
Turbine & Combustor

Turbine & combustion

$\frac{\Delta \text{EPNL}_{\text{AIRCRAFT}}}{\Delta \text{EPNL}_{\text{SOURCE}}}$
Noise: An integral part of the design process
Noise reduction results from complete aircraft optimisation

- Low speed performance
- Airframe noise
- Noise abatement procedures
- Nacelle attenuation
- Engine noise

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Low noise configurations

Masked sources
- inlet fan
- combustion
- turbine

Masked sources
- inlet & aft fan
- compressor
- combustion
- turbine
Engine noise reduction technologies

- Integrated Fan Design
- UHBR Fan
- LP Compressor
- ANTLE & High Speed LP Turbines
- Low Noise Fan Nozzle
- Low Noise Core Nozzle w/ internal/external Plug
- Different Treated Plug Technologies
- HF Treated Nozzle
- Active Stators
Nacelle noise reduction technologies

- Negatively Scarfed Intake
- Improved Impedance Liner
- 0 Splice Liner
- Intake Lip Liner
- Adaptive Liner
- Active Wall-Mounted System
- Exhaust Splitters (radial or circum.)
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Engine noise is a complex mix of broadband noise and tones
Assessment of design conditions

Radiation-Frequency Analysis of Noise emergence
(U/S fan case)
Computation of optimal impedances

**Optimal acoustic impedances**

- **APPROACH Optimal resistance**
- **APPROACH Optimal reactance**
- **SIDELINE BSN (Energy on m=n+/-2p) Opt. R**
- **SIDELINE BSN (Energy on m=n+/-2p) Opt. X**
- **SIDELINE BSN (Modal equidistribution) Opt. R**
- **SIDELINE BSN (Modal equidistribution) Opt. X**
- **SIDELINE BSN (Energy on m=n) Opt. R**
- **SIDELINE BSN (Energy on m=n) Opt. X**

**APPROACH 1, 2, 3 and 4BPF**

**SIDELINE BSN**
Possible liner candidates

Non linear SDOF liner: Reflective back skin + honeycomb + perforated face sheet

=> Features: non linear, sensitive to flow, weak efficiency bandwidth, easy to build

Linear SDOF liner: Reflective back skin + honeycomb + microporous face sheet

=> Features: linear, not sensitive to flow, better efficiency bandwidth

DDOF liner: Reflective back skin + honeycomb + micro porous septum + honeycomb + face sheet (perforate or micro porous)

=> Features: large efficiency bandwidth, difficult to build
Industrial needs

In some cases, classical liners are not able to reach all optimum impedance targets together.

Hence, there is a need to investigate new type of liners and/or new materials to improve noise reduction.

Porous materials remain good candidates!
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• Developing even quieter aircraft is necessary to ensure air transport sustainable growth

• Novel and powerful noise reduction means are needed especially to attenuate engine noise

• Limitation of current acoustic liners are well known and there is a need for improved technologies

• New materials should be investigated and porous materials are seen by AIRBUS as one of promising ways
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