Turning Jet Engine Noise Down to 2020

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1. Motivation

This project investigates non-traditional acoustic liners for civil jet engine fan inlets.

**Industrial:**
- The engine is the largest contributor to aircraft noise; at approach it accounts for ~68% and at take-off ~98% [1].
- The Advisory Council for Aircraft Research and Innovation targeted a 50% reduction in perceived noise for new civil aircraft entering into service in 2020, but as of 2017 only a 32% reduction was secured and 37.5% reduction foreseen [2].

**Social:**
- Residential areas around airports experience unacceptable noise levels as part of daily life and research demonstrates that prolonged exposure to ≥55 dB day-evening-night level is linked to conditions including tinnitus, hypertension, coronary heart disease and myocardial infarctions [3].

2. Project Aims

**Industrial Aims:**
- Propose a prototype acoustic metamaterial panel for a jet engine inlet.
- Model and predict noise attenuating capabilities in the presence of high-speed grazing flow.
- Undertake experimental and computational testing of metamaterial panels.

**Academic Aims:**
- Understand and apply metamaterial theory to aeroacoustics.
- Competent use of the CFD software OpenFOAM for computational modelling.

3. Process

**Understanding the problem and identify opportunities:**
- Identify the key engineering problems (Fig 1).
- Research and compare current liners (Table 1).
- Classify the opportunities of metamaterials.

**Computer modelling:**
- Generate a suitable model in OpenFoam CFD software (Fig 2).
- Determine acoustic solver and meshing method for liner prototyping.

**Experimental testing:**
- Validate the OpenFoam model.
- Use 4 microphone impedance tube method (Fig 3).
- Measure the pressure and particle velocity and determine the sound transmission loss.

**Liner prototyping:**
- Design metamaterials acoustic liner prototypes.
- Determine attenuation properties including transmission loss and frequency range using OpenFoam Model.

**Final selection and validation:**
- Evaluate the preferred liner designs.
- Validate the final design for operating, commercial and manufacturing criteria.

4. Research Direction

**Metamaterial panels alone will not meet reduction targets of 10EPNdB per operation (effective perceived noise). Currently the Clean Sky 2’s acoustic liner only gave a 0.5dB overall engine noise reduction [2]**
- The direction is to prototype metamaterial absorbers within the traditional Honeycomb acoustic liner (Fig 4).

5. Future Work

**In situ engine testing.**
- Investigate applications in other modules of jet engines.
- Investigate other industrial applications such as factory environment noise cancellation.

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Table 1 - Summary of Traditional and metamaterial liner comparison

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<td><strong>Theory</strong></td>
<td><strong>Advantages</strong></td>
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| Helmholtz Resonators comprises of a rigid cavity and neck which connects the resonator to the wider system. The action of the volume of air in the cavity is comparable to a mass spring system. | • Simplicity of construction.  
• Widely used e.g honeycomb. |
| Metamaterials introduce a new structure into the basic material usually an array of structures smaller than the wavelength of interest providing acoustic attenuation properties. | • Lightweight, thin liners.  
• Increased attenuation for low frequency.  
• Can be combined with existing liners technology. |
| **Drawbacks** | **Absorption coefficient** |
| Poor at low frequency.  
Causes detrimental back pressure upstream of the system from the attenuated sound. | • Typical Honeycomb 0.3 for 10-2000Hz [6]  
• Thin-film elastic acoustic metamaterial 0.4 for 10-1000Hz [7]  
• Metamaterial perforated honeycomb-corrugation hybrid 0.5 for 10-2000Hz [6] |

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REFERENCES

Available on request.