Development Rod-Linear Cascade Model for Fan-Wake/OGV Interaction Noise Studies

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Agenda

• Introducing The Rod – Linear Cascade Test Rig

• Preliminary Computational Results using PowerFLOW

• Noise Mitigation Strategies and Outlook

• Q&A session
I. ROD – LINEAR CASCADE
A simplified test model which replicates the turbulence impingement mechanism would be advantageous for parametric studies and noise mitigation applications.

* Turbulence Impingement Noise
Mimicking Fan wake – OGV TIN

KLM Embraer 190, powered by GE CF34-10E5

Typical turbofan noise power spectra [1]

Discrete tones

Typical rod-airfoil configuration noise power spectra

Why Rod-Linear Cascade?

THE BRIDGE TOWARDS REALISM

MORE COMPLEX

MORE REALISTIC
### Why Rod-Linear Cascade?

#### A CONFIGURATION TO FILL THE GAP

<table>
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<th>Tonal and broadband excitation as source</th>
<th>Flow deflection (cascade flow field) and acoustic-blade interaction</th>
<th>Multiple blade excitation and source phase interference</th>
<th>Rotor swirl and duct mode propagation</th>
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CASCADE / HIGH-DEFLECTION WIND TUNNEL

C-1 Wind Tunnel, VKI, Belgium [1]

NGG Tunnel, DLR, Germany [2]

DEFLECT THE FLOW BEFORE OR AFTER THE CASCADE?

- Flow exiting the test section must be aligned with the collector downstream.

Parametric simulations to achieve acceptable flow uniformity within the test section.
Experimental Platform Design

Rod-linear cascade experimental rig

Test section flange
- Linear cascade deflects the flow towards the collector downstream

Test section
- 400 mm wide and 250 mm high

Rod-linear cascade model
- Inclined against the inflow axis

Wind tunnel contraction
- Ø60 mm to 400 mm x 250 mm
ONE ROD TO MAKE THE DIFFERENCE

Comparison of linear cascade acoustics response with and without rod-wake excitation
Experimental Platform Design

- Overestimated wind tunnel capability
  → Freestream velocity is readjusted from 100 m/s to 75 m/s

- Unwanted separation on the cascade blade
  → Cascade incidence is increased from 10.5° to 30° (operational condition)
FULLY-MODULAR TEST RIG
• The narrowband at the BPF dominates the OSPL in most direction.

• Very narrow directivity for the broadband components at higher frequency ranges, which may corresponds to the diffraction of turbulent eddies by the blade edges.
PWL and Pressure Distribution

- **Source PWL is reduced** due to lower freestream velocity. Better SNR at the BPF due to weaker low-frequency contents.

- **Discrepancy** in the blade pressure distribution is very likely due to stagger angle difference.
Flowfield Visualization
Flowfield Visualization
Science for Environment Policy

FUTURE BRIEF:
Noise abatement approaches

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V. OUTLOOK
Noise Mitigation Strategies

A FLEXIBLE PLATFORM FOR T/N MITIGATION STUDIES

Metal foam LE

LE serration

All metal-foam blade

Poro-serrated LE

Z-Vorticity [dimless]

-5.0  -0.0  5.0
What’s Next?

- Experimental campaign to verify the simulations.
- The inclusion of leading edge serration to the OGV as baseline noise mitigation strategy and to investigate its impacts on performance.
- Characterization of metal-foam sample with PowerFLOW porous media models.
Thank you for your attention!