# Porous flap trailing edges for the reduction of jet-flap interaction noise

Christian Jente

DJINN – Decrease Jet Installation Noise




DLR

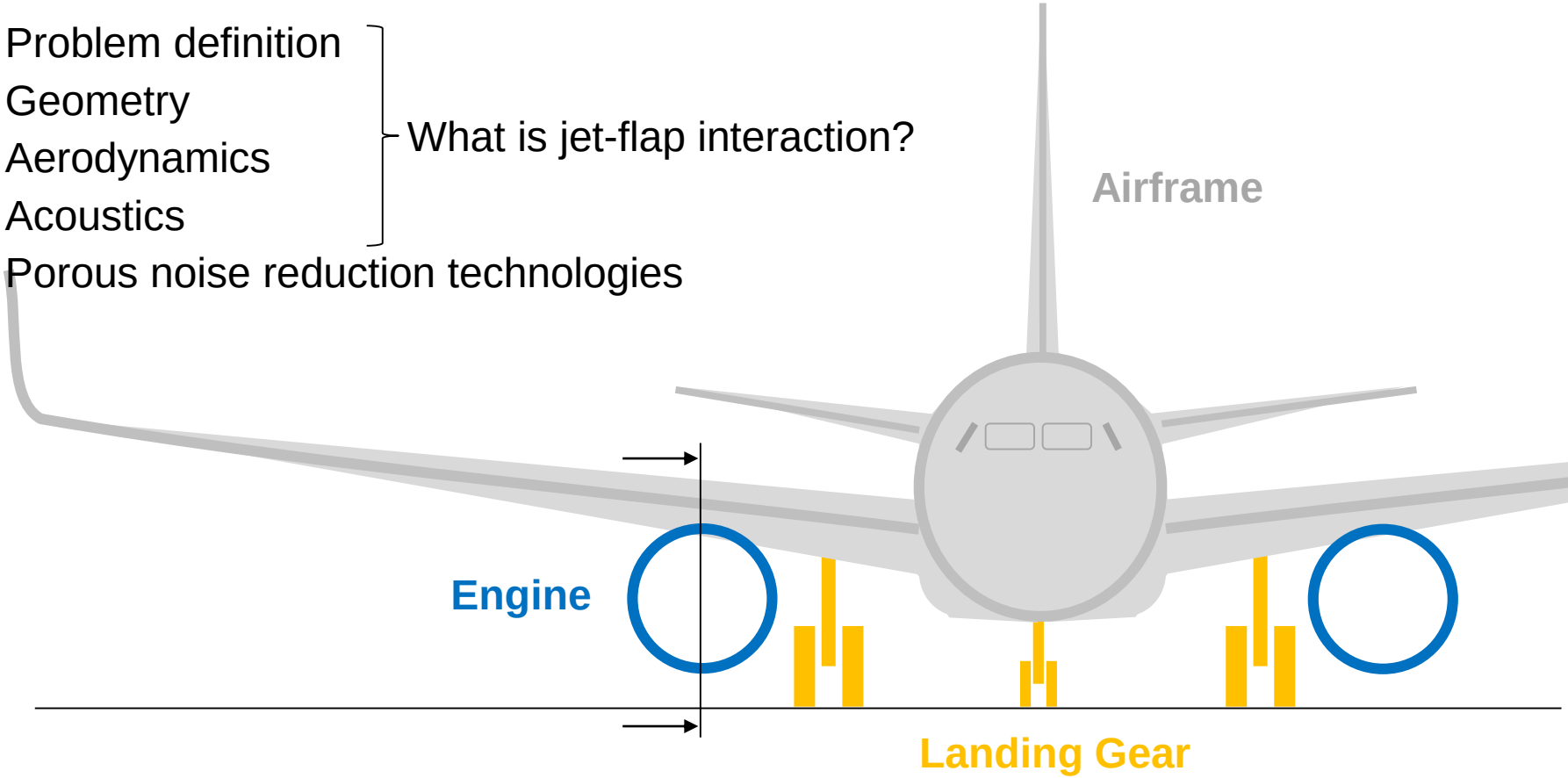
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# Porous flap trailing edges for the reduction of jet-flap interaction noise

- Problem definition
- Geometry
- Aerodynamics
- Acoustics

What is jet-flap interaction?

- Porous noise reduction technologies

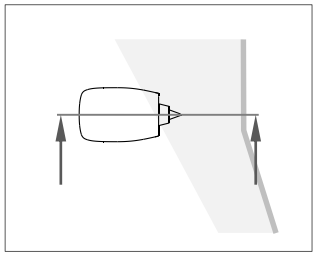


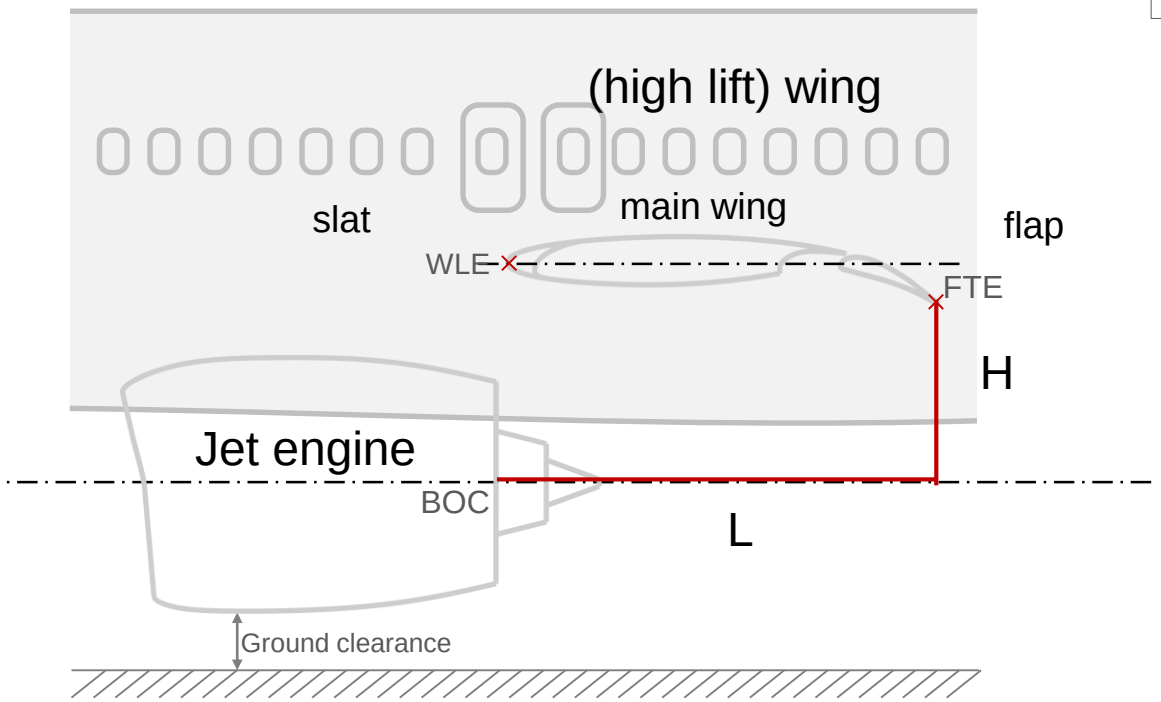

Warren East (CEO Rolls Royce, 01/2021): "We [will] fully test our [Ultra-Fan] demonstrator. At that point we will put the thing on ice. I can't force airframe manufacturers to invent new aeroplanes and if there is no demand for them then there is no demand for engines."
https://www.ft.com/content/6fcf500c-4089-45d5-92c3-5743d96984d9

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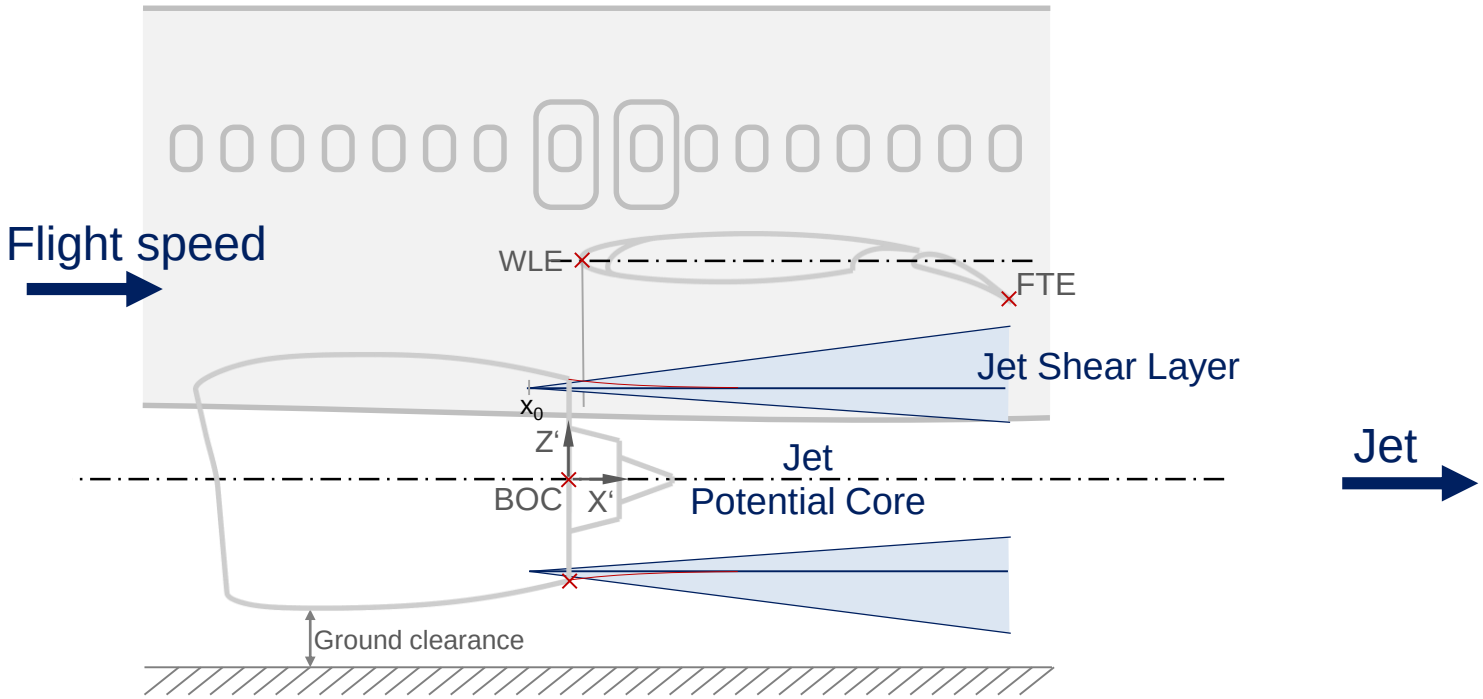


# Physical Definition
# > multi body problem





# Physical Definition
# > multi phase problem



# The aerodynamic near-field of the isolated jet

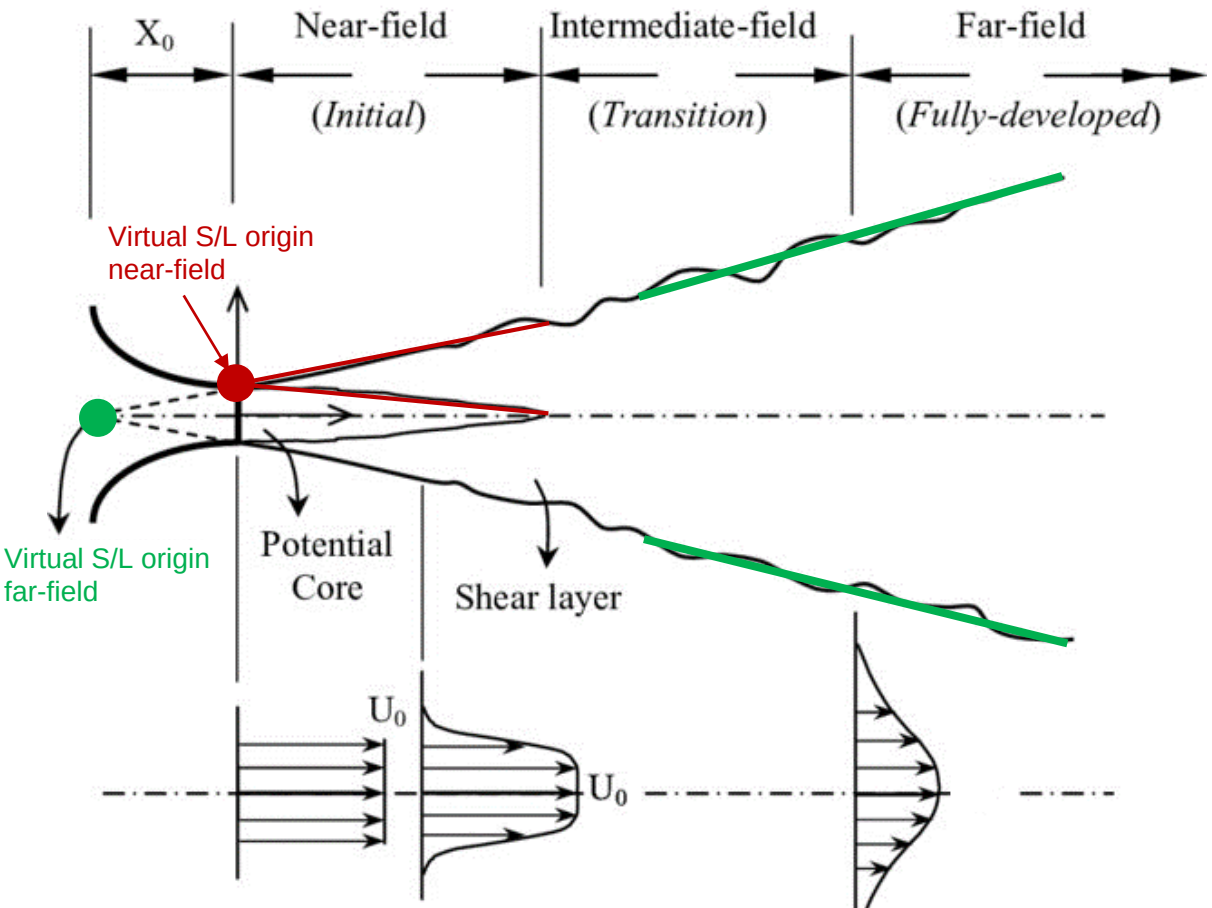
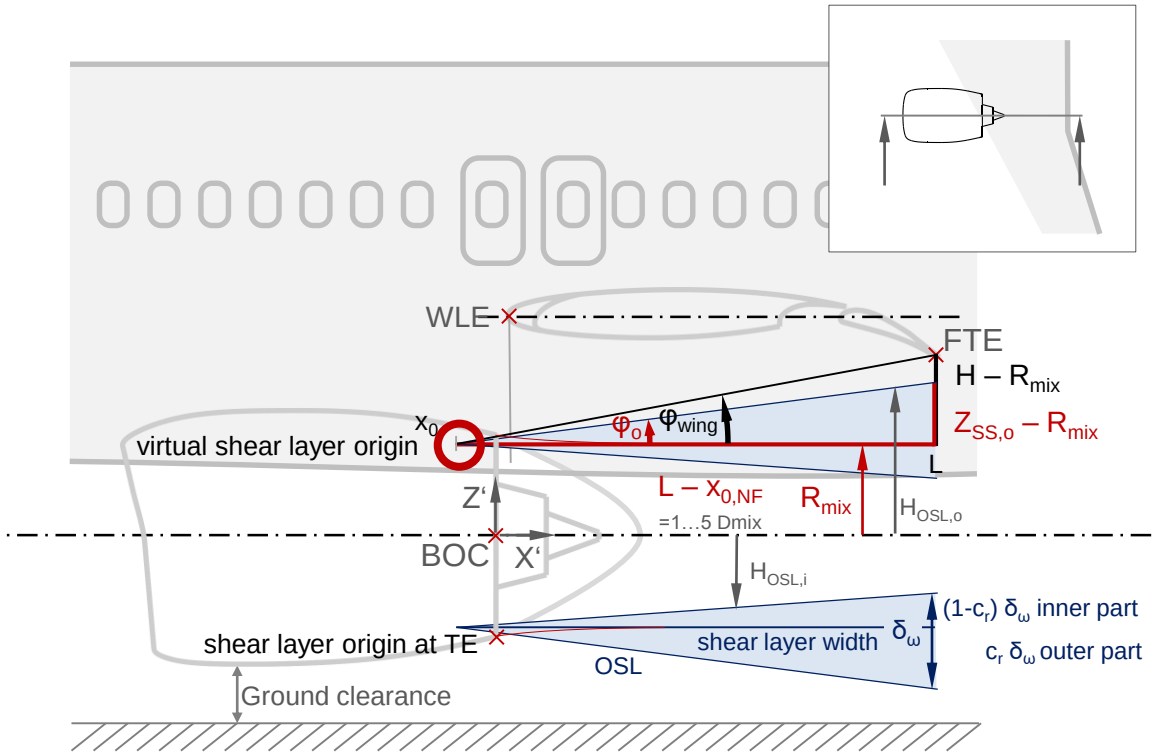



Image based on: “A Review of Effects of Initial and Boundary Conditions on Turbulent Jets” Abdel-Rahman 2010

# Geometrical specification

## space requirement of the isolated jet S/L vs installed wing

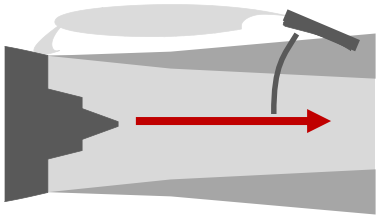



Jente, C: "Jet-Flap Interference Noise of Highly Integrated UHBR Turbofans", Dissertation, TU Braunschweig, 2023

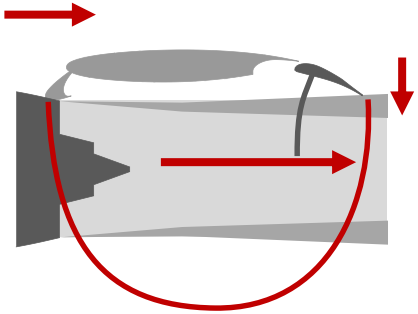
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# Jet-Flap-Interaction Aerodynamics

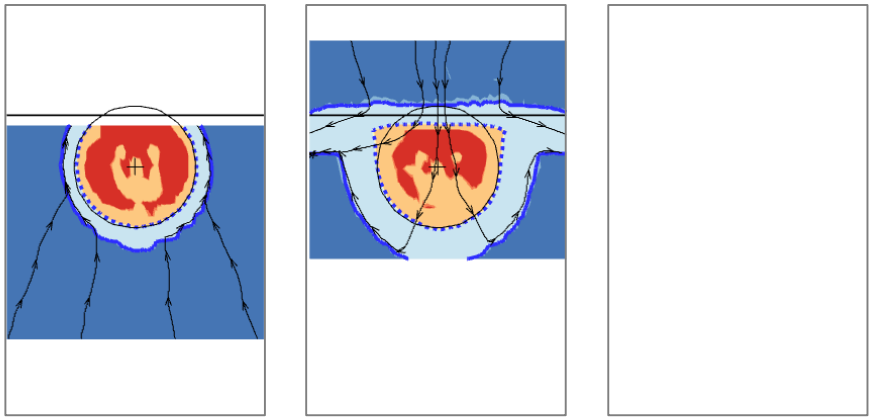
**JFI (static ops)**
Jet vs inclined plate
(of fixed length)

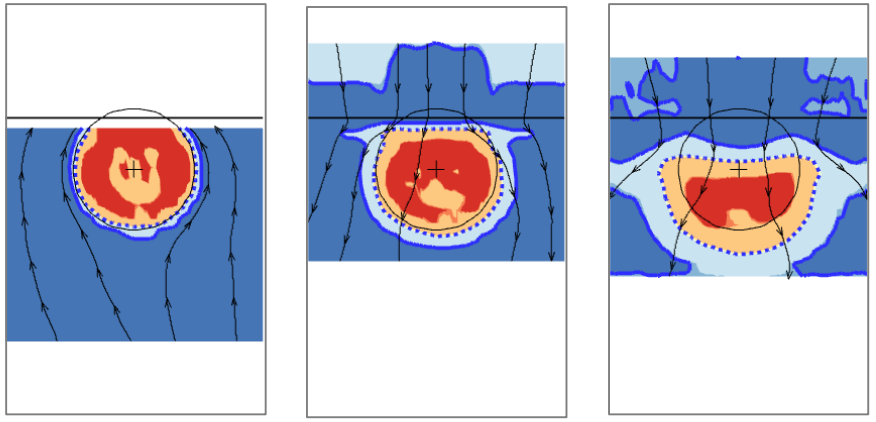


**JFI (flight ops)**
Jet vs high lift wing
(of fixed length)



| X=1D below wing | X=FTE at flap T.E. | X=4D far downstream | X=1D below wing | X=FTE at flap T.E. | X=4D far downstream |
|---|---|---|---|---|---|

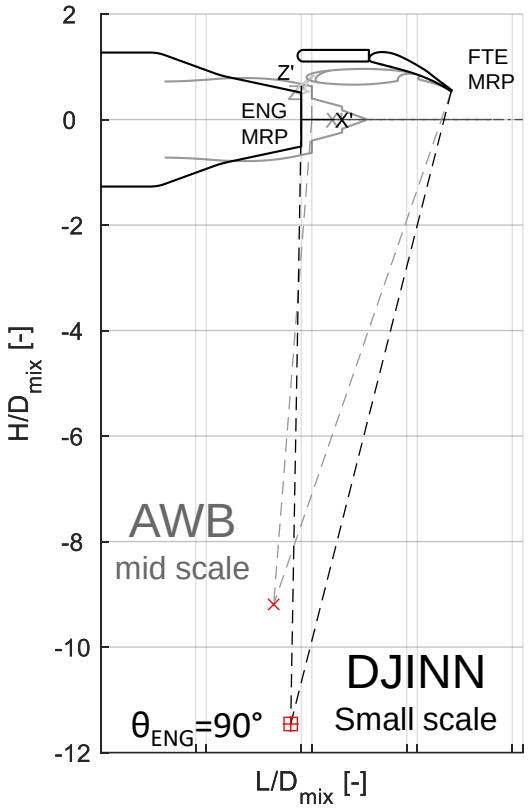


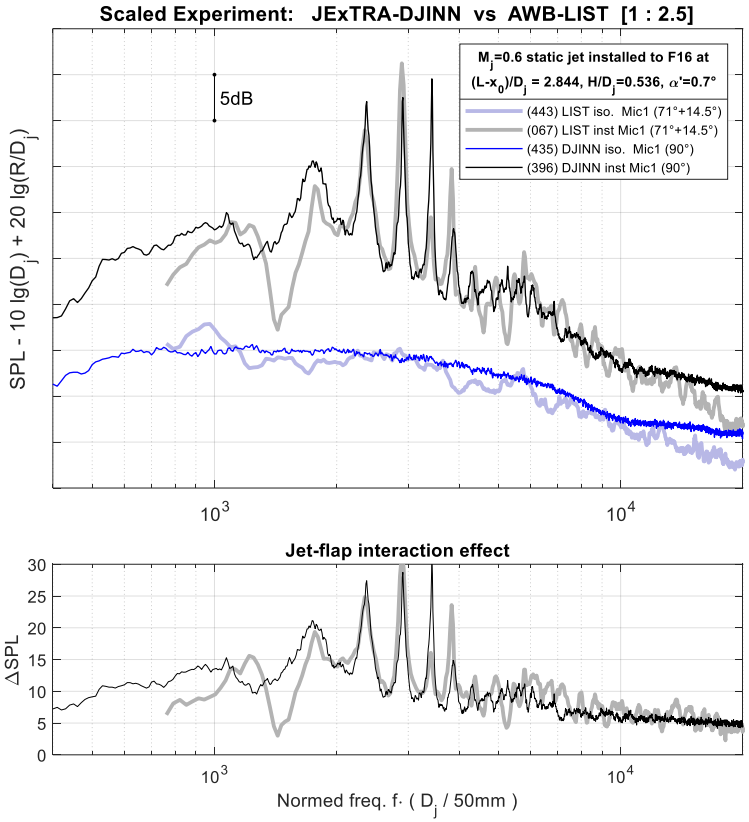


Jente, Christian (2022) *Strahl-Klappen-Interferenz – wie bedeutsam ist die Interaktionsschallquelle am Flugzeug.* In: Fortschritte der Akustik - DAGA 2022, Seiten 1278-1281. DAGA 2022 - 48. Jahrestagung für Akustik, 21. - 24. März 2022, Stuttgart, Deutschland. ISBN 978-3-939296-20-1

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# Acoustics: A typical JFI spectrum
## - mid scale 2.5 : 1 small scale



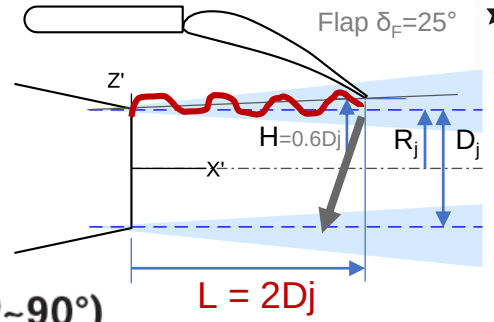

Installed engine
- Isolated engine

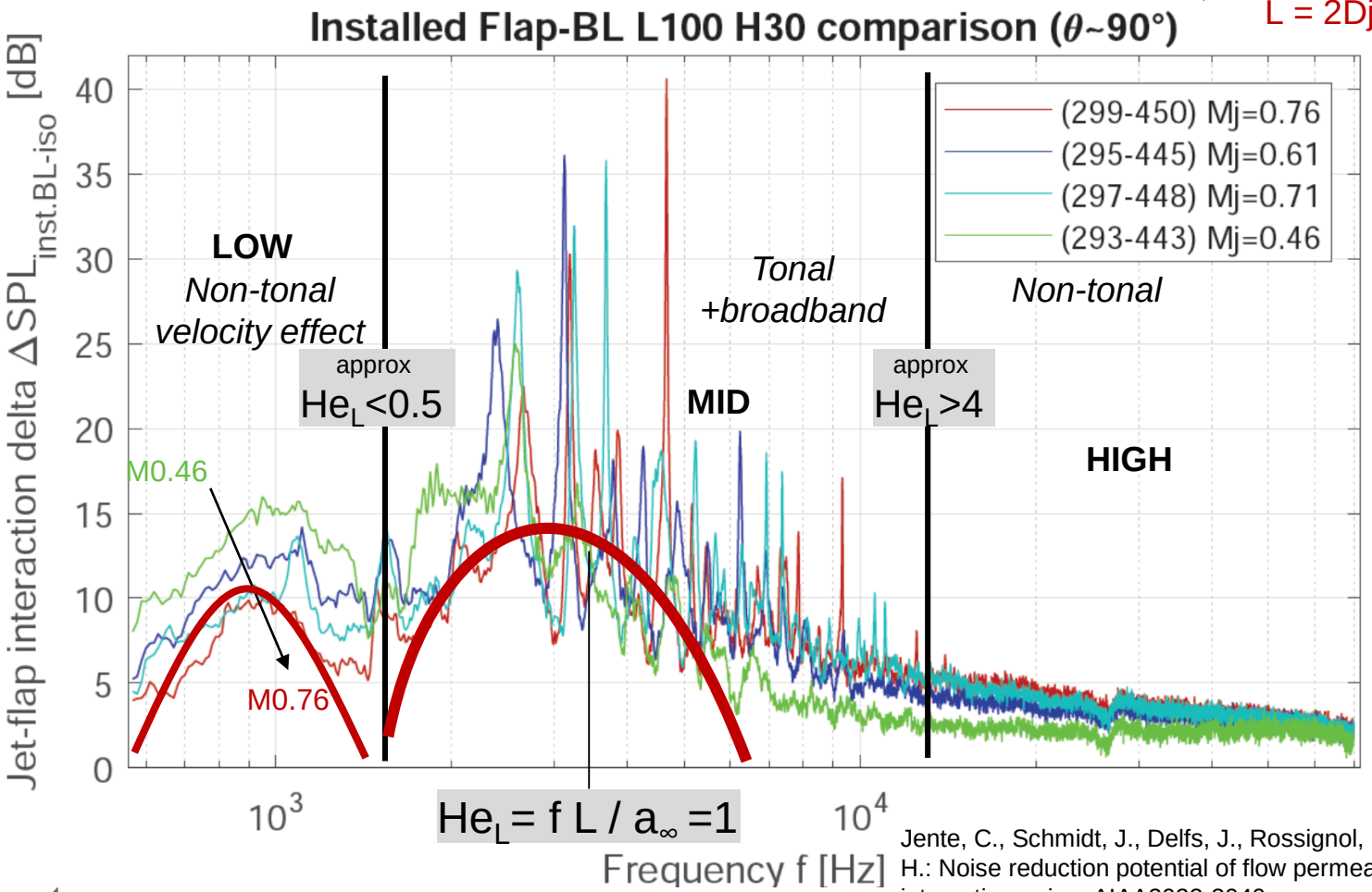
= JFI Delta

Jente, Christian (2021) Jet-flap interaction noise in model scale and full scale - and the implications for evaluating noise reduction technologies. EU H2020 1st DJINN Conference: Industrially oriented jet noise reduction technologies, 01.-03. Dez. 2021

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# Acoustics: A typical JFI spectrum



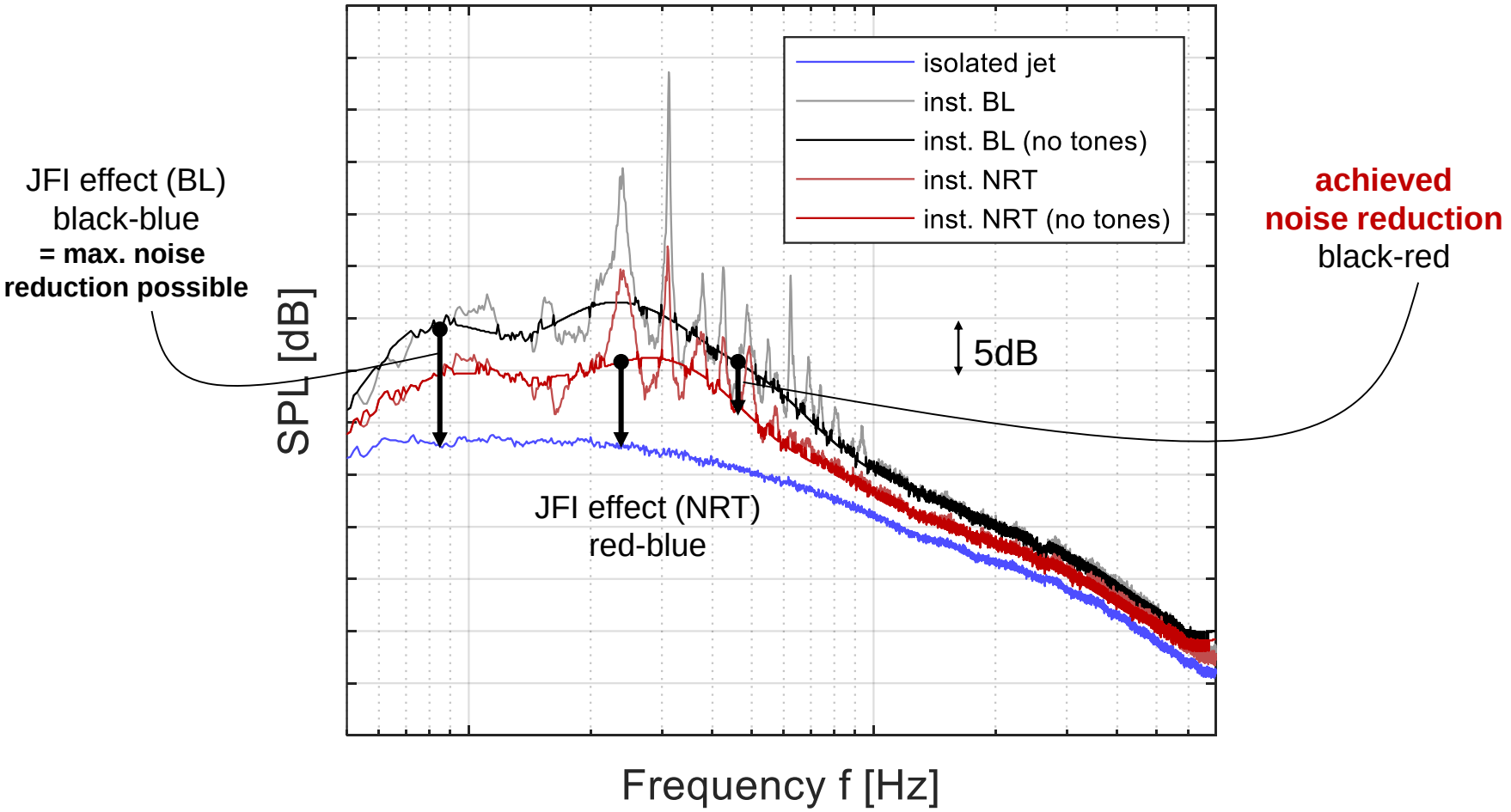




Jente, C., Schmidt, J., Delfs, J., Rossignol, K., Pott-Pollenske, M., Siller, H.: Noise reduction potential of flow permeable materials for jet-flap interaction noise. AIAA2022-3040

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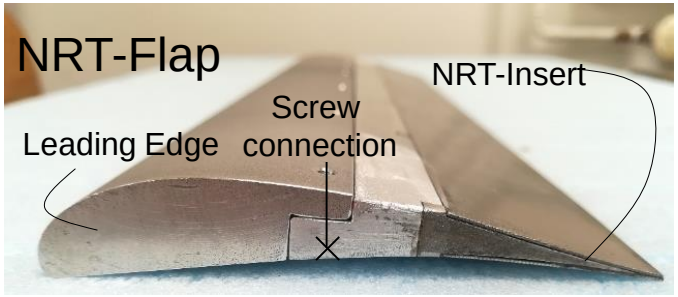


# Installed and isolated jet noise, with and without tone removal tool (median filter)



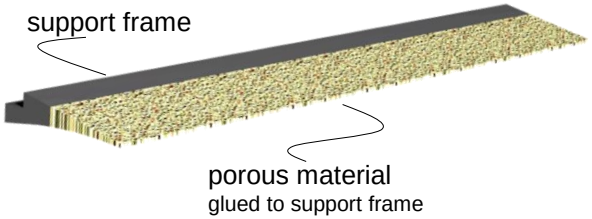

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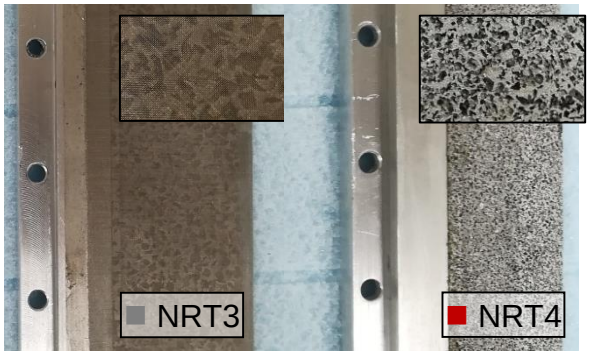
# How to reduce JFI noise: Porous flap design ideas




## Porous flap TE concept

full volume of TE insert is porous




**Porous Aluminium PA**

| **coarse** | **fine** |
|---|---|
| Ø200µm – 250µm | Ø80µm – 110µm |
| **+ cover mesh B** | |

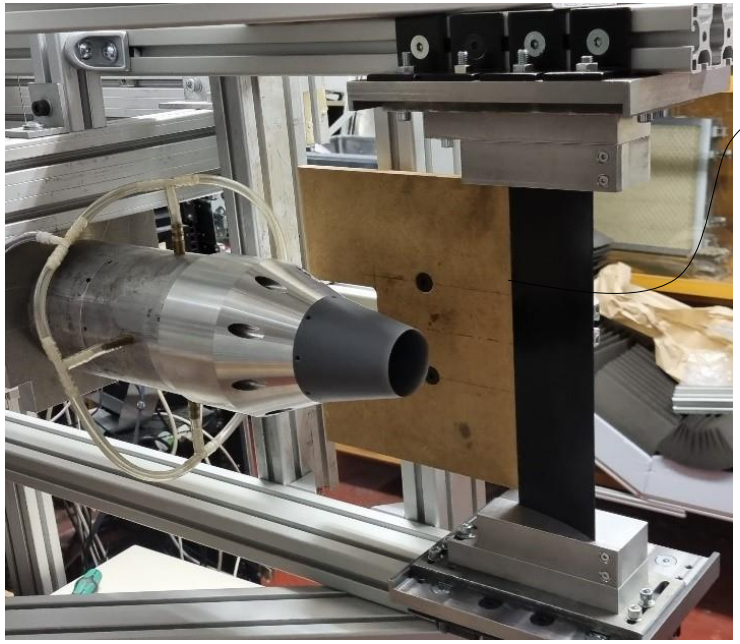
*Materials:* Collaborative research center SFB880 - Fundamentals of High-Lift for Future Civil Aircraft

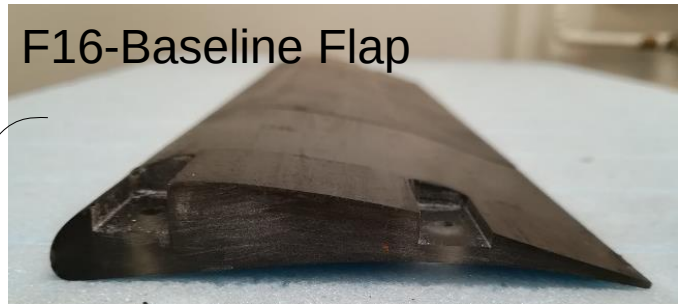
- Lippitz, N.: Poröse Materialien zur Reduzierung von Hinterkantenschall an Flugzeugflügeln, PhD thesis, Technische Universität Braunschweig
- Herr, M., Rossignol, K.-S., Delfs, J., Lippitz, N., and Mößner, M., Specification of Porous Materials for Low-NoiseTrailing-Edge Applications. AIAA2014-3041
- Schmidt, J., Aeroakustische Untersuchungen an porösen Hinterkanten, Master‘s thesis, Technische Universität Braunschweig, 2019:

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# Static jet experiment on flap at JExTRA/Berlin









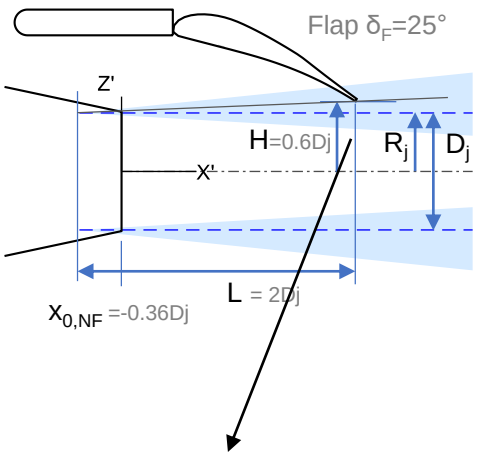
JExTRA test w/ sideways wing installation

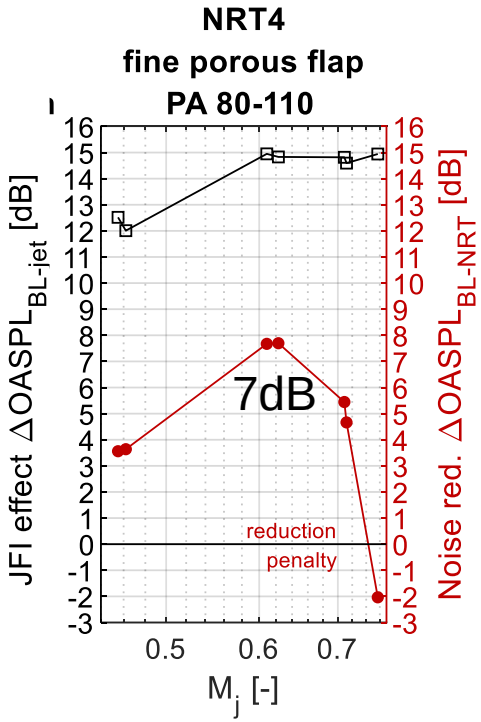
Jente, C., Schmidt, J., Delfs, J., Rossignol, K., Pott-Pollenske, M., Siller, H.: Noise reduction potential of flow permeable materials for jet-flap interaction noise. AIAA2022-3040

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# JFI effect vs. noise reduction (for different jet Mach number)

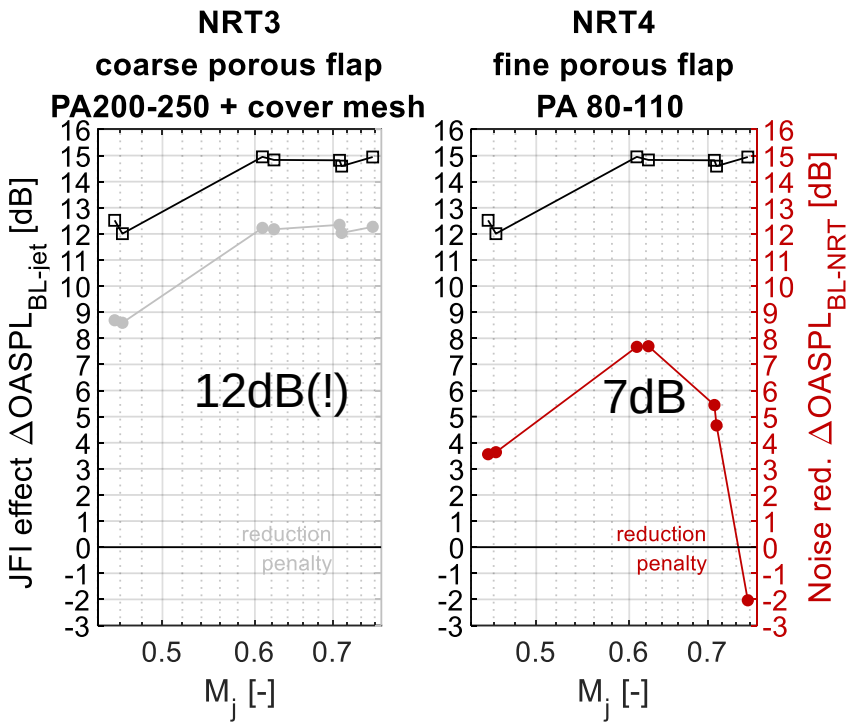



JFI effect increases with jet speed
NRT4 performs optimally upto / at $M_j$=0.62

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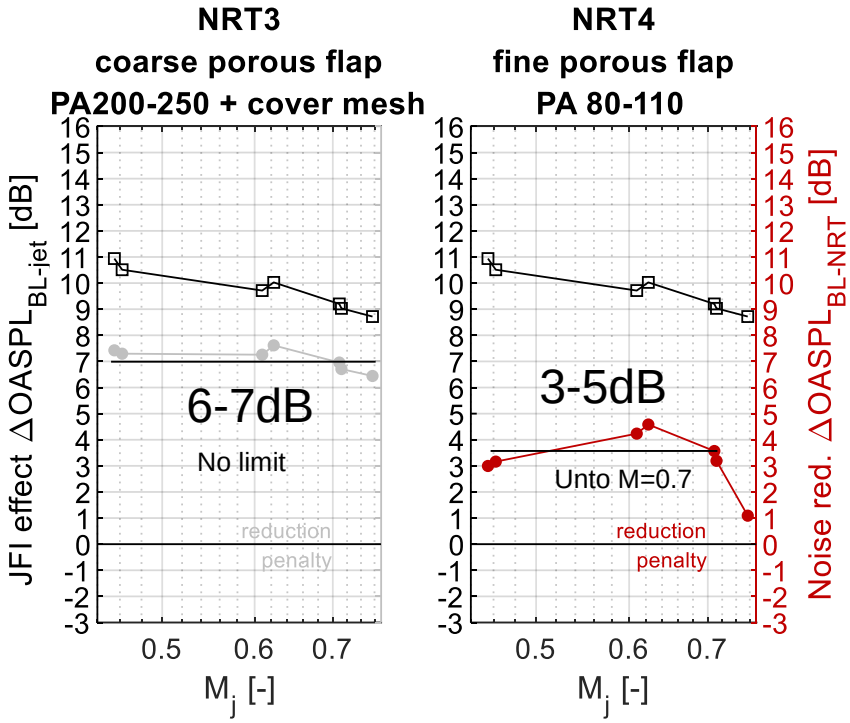
# JFI effect vs. noise reduction (for different jet Mach number)




JFI effect increases with jet speed
NRT4 performs optimally upto / at $M_j$=0.62
NRT3 performs extraordinarily well (tones reduced to zero)

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# Broadband-like JFI effect + noise reduction (tones removed)

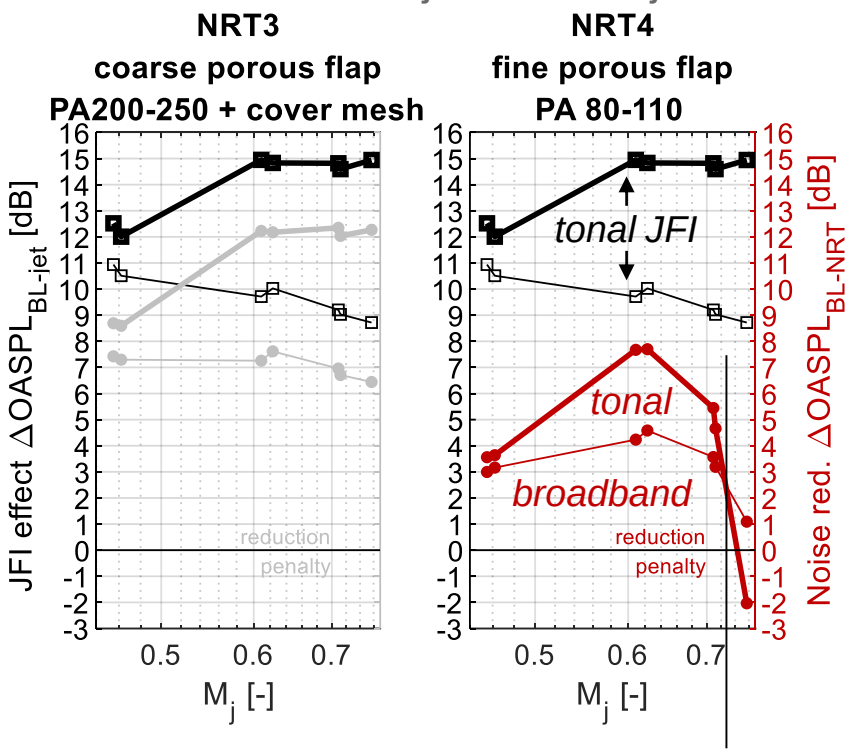



Broadband part of JFI effect decreases with jet speed (!)

# Static jet speed effect on JFI noise

## close engine integration ($L/D_j$=2, $H/D_j$=0.6)

Evaluation
— thick: w/ tones
thin: tones removed

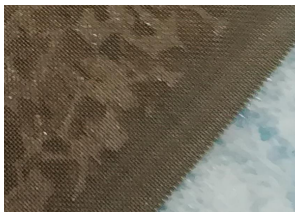


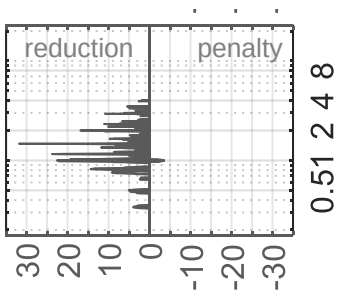

What happens here?

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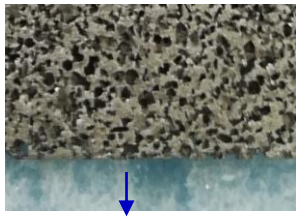
# Why performance drop near $M_j$=0.75?

NRT3 Noise red.
$\Delta SPL_{BL-NRT}$ [dB]

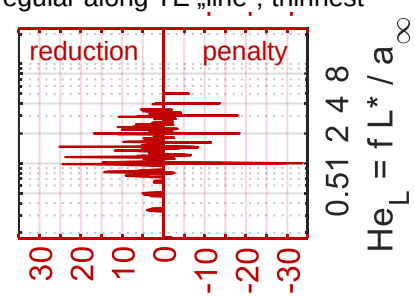





NRT4 Noise red.
$\Delta SPL_{BL-NRT}$ [dB]



Irregular along TE „line“, thinnest




n=1…5

No tones!

Trailing edge tones!





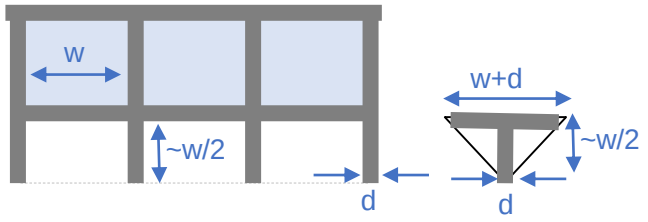
# What is so special about NRT3?

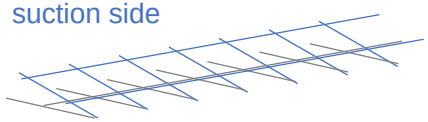







## micro-serration-like structure




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# Summary: flow permeable materials for jet-flap interaction noise

- Porous flaps help decrease broadband and tonal components of JFI noise
- Noise reduction is 6-7dB (conservative, tones removed) and can reach up to 10-12dB (tones not removed)

- influence of the cover mesh plays a significant role
  - It encloses a very permeable cavity between porous trailing edge and mesh trailing edge, and
  - forms micro-serrations-like structure at the very thin mesh trailing edge

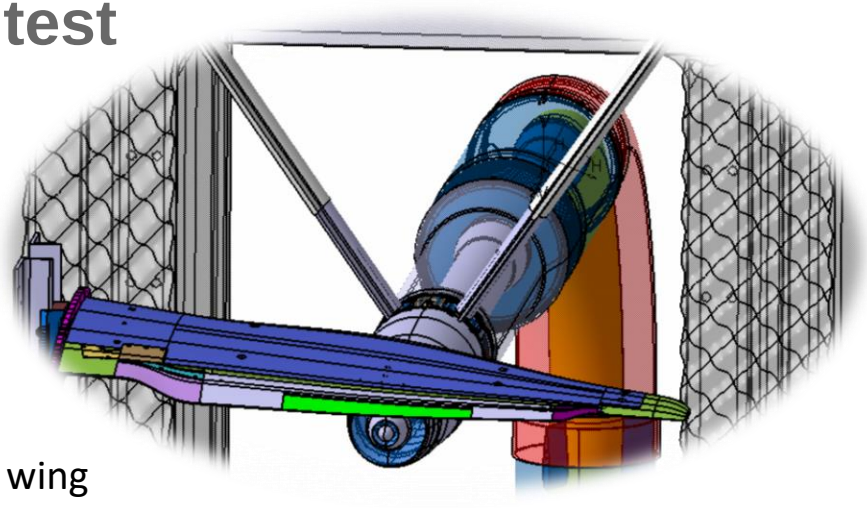
- experimenting with cover meshes (possibly even on solid surfaces) is advised

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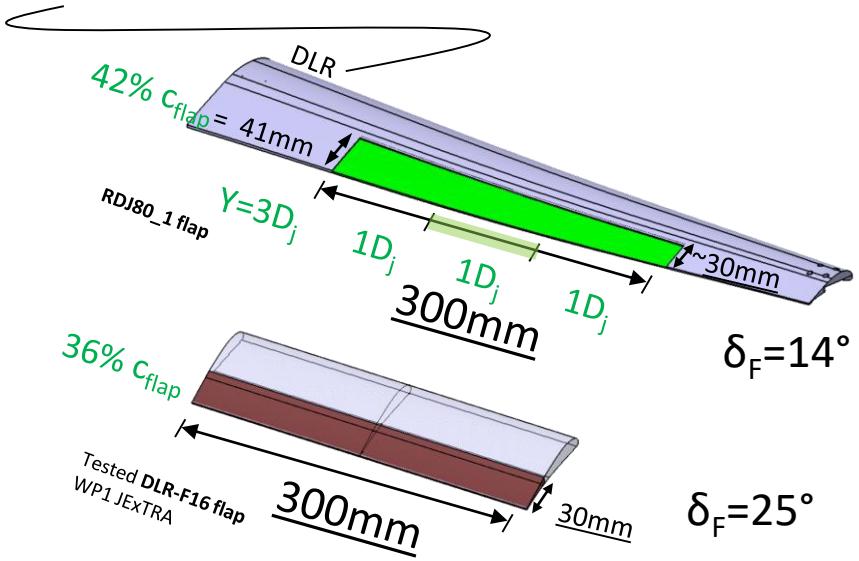
# DJINN Challenges for the WP3 test

- Show for the first time that manufacturing of complex 3D porous flap geometry is possible
- Show NRT potential at mid scale experiment (Safran engine vs. RDJ80 wing)
  - Cross compare noise reduction at static conditions (w/WP1 experiment)
  - Observe for the first time JFI noise reduction of porous materials at flight conditions



Airbus RDJ80 wing

Flap section w/porous TE




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