THE CHALLENGE OF SLAT NOISE REDUCTION BY RETRO-FIT TECHNOLOGY

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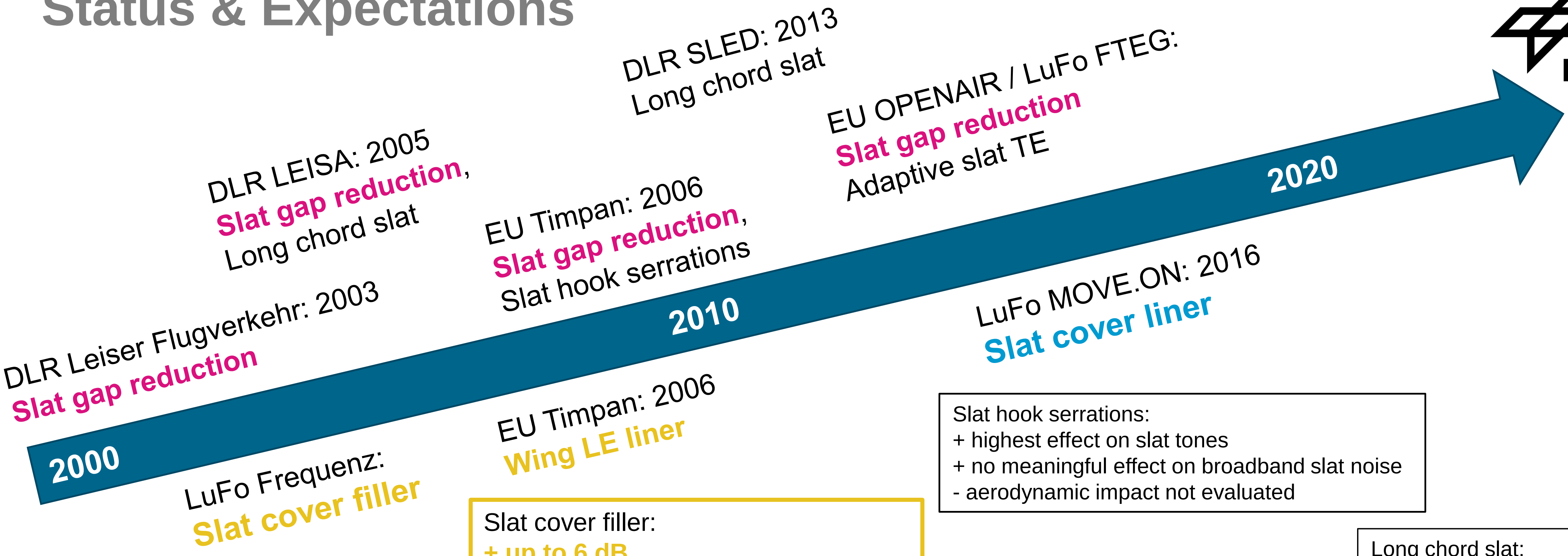
InVentor

DLR

Status & Expectations



Slat hook serrations:
+ highest effect on slat tones
+ no meaningful effect on broadband slat noise
- aerodynamic impact not evaluated

Slat cover filler:
+ up to 6 dB
+ low aerodynamic impact
- complex design
- high dependence on angle of attack

Long chord slat:
+ up to 7 dB
+ no aerodynamic penalty
- larger slat tracks
- additional weight

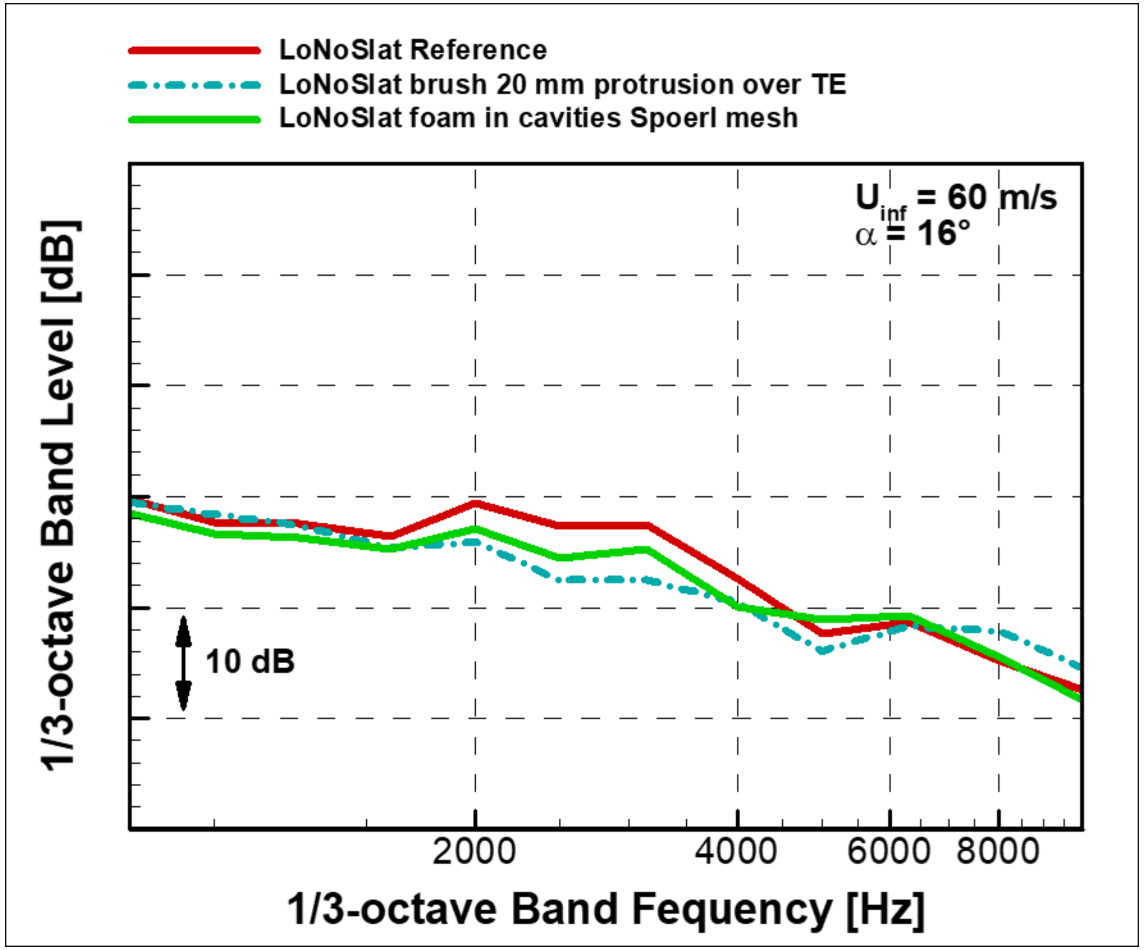
Slat gap reduction & Adaptive slat TE:
+ > 6 dB
+ up to noise cancellation for closed gap
- high aerodynamic penalty
- high system complexity
- assumed to incluce additional weight

Slat cover liner:
+ up to 3 dB (improve by InVentor)
+ no aerodynamic impact
+ good options for integration (AI)
- modest noise reduction

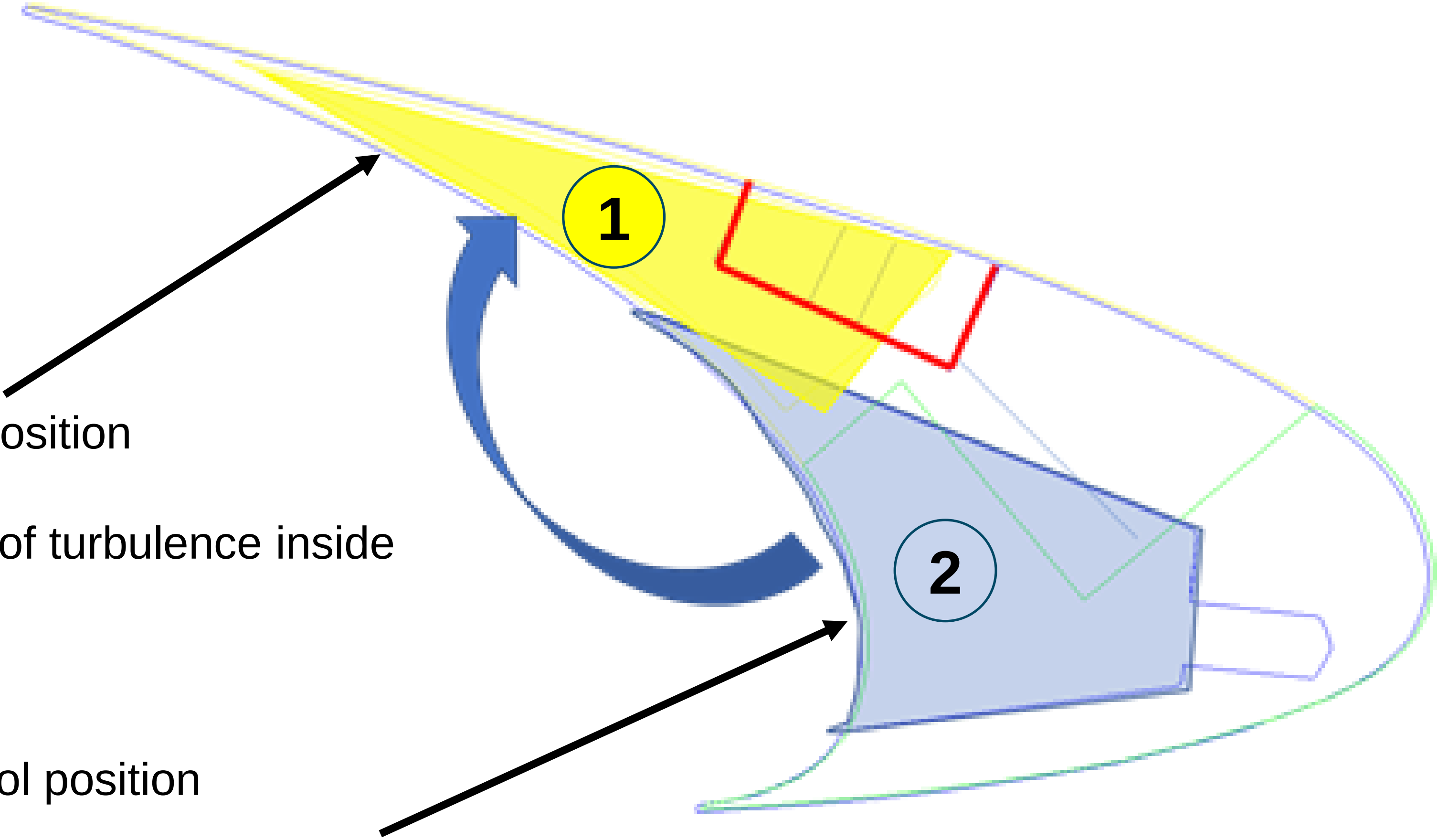
Starting Point

- German LuFo **MOVE.ON**
  - TE position
  - F16 model
  - Open cell PU foam covered with wire mesh
  - 3 – 4 dB noise reduction in frequency range 2 – 4 kHz
  - Cross check with TE brushes, know as „best solution“
  - Brushes ~1 dB quieter

➔Cove filler meets expectations



Slat Cove Filler
InVentor: Tested Configurations



Configuration: TE position

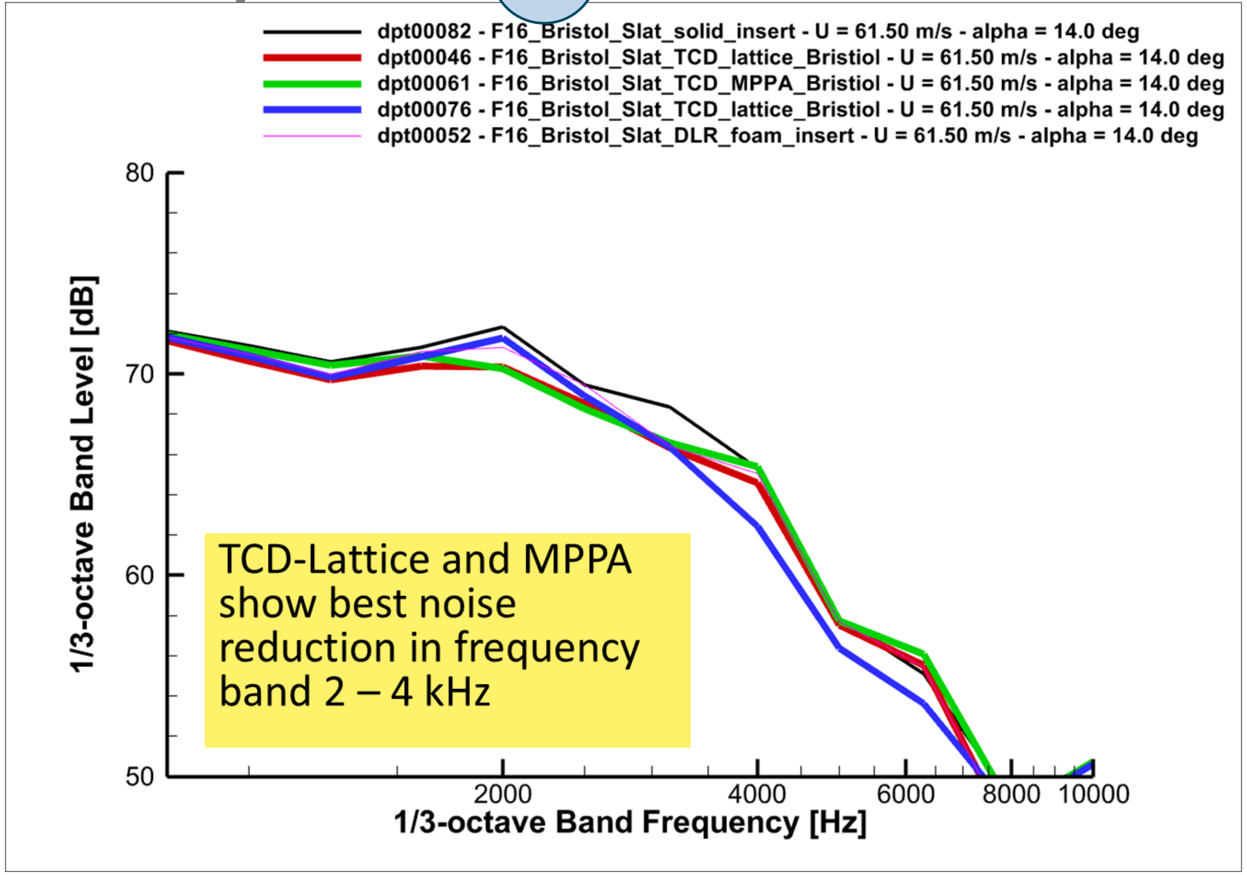
Target: attenuation of turbulence inside the boundary layer

Configuration: Bristol position

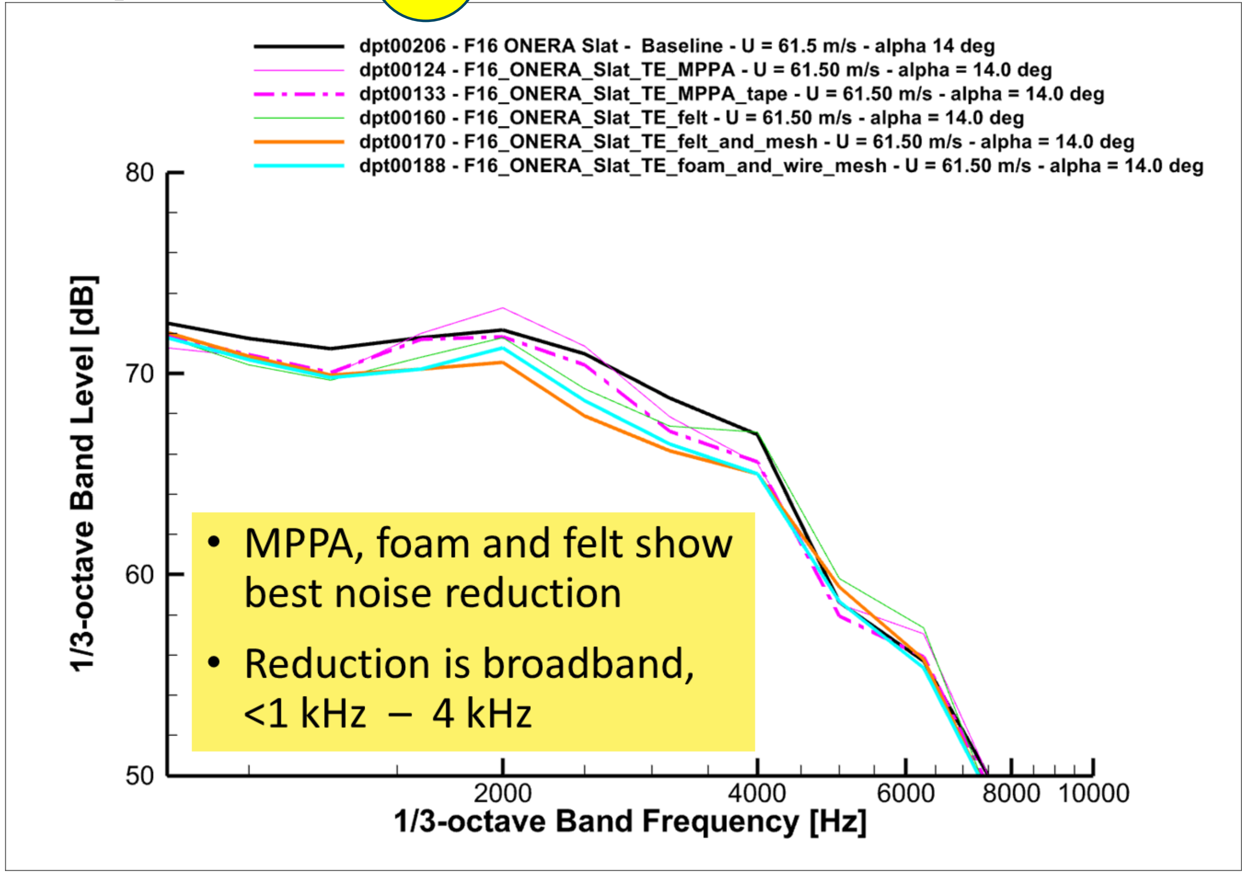
Target: near field acoustic absorption

Large Number of Configurations
Selected Results

Bristol position 2



TE position 1



- Noise reductions are achieved – well done!?

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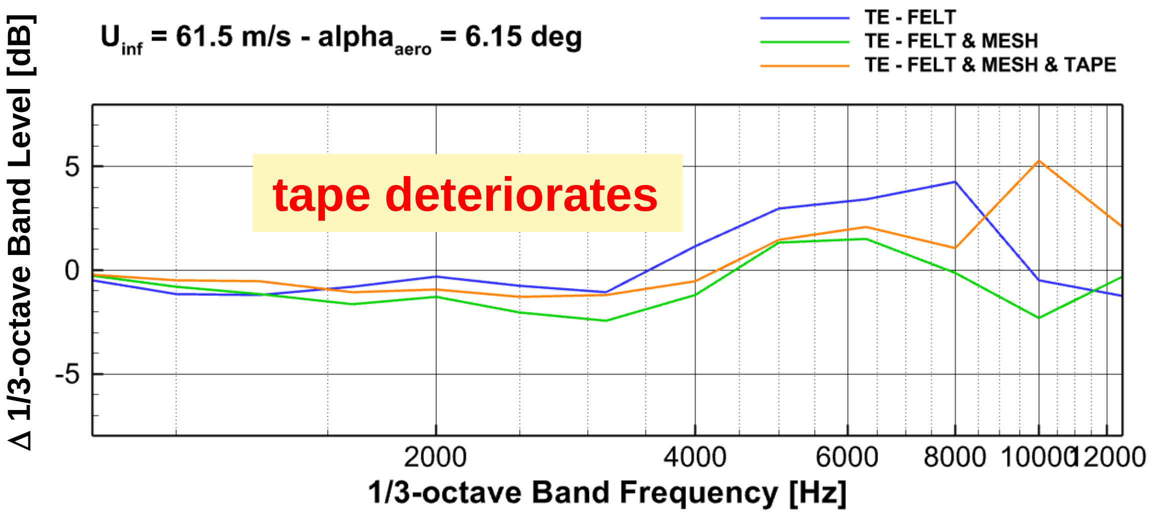
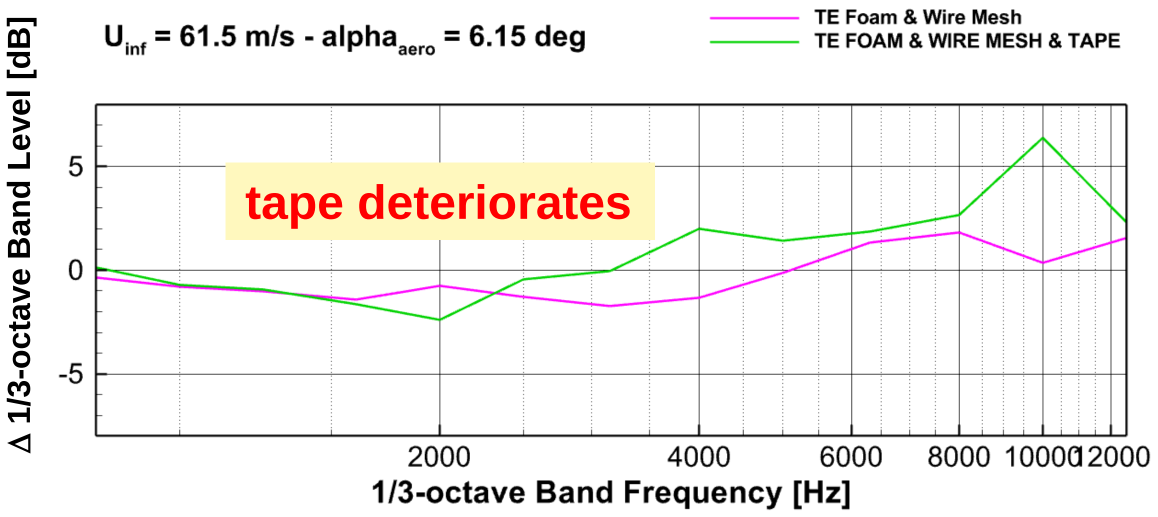
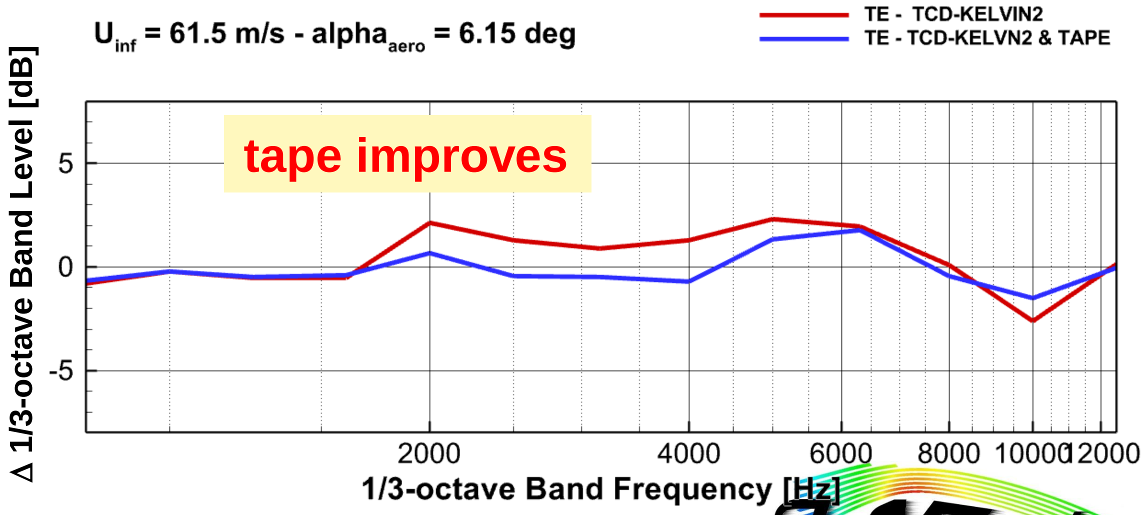
1 How-to: Dimensioning – Installation – Noise Reduction





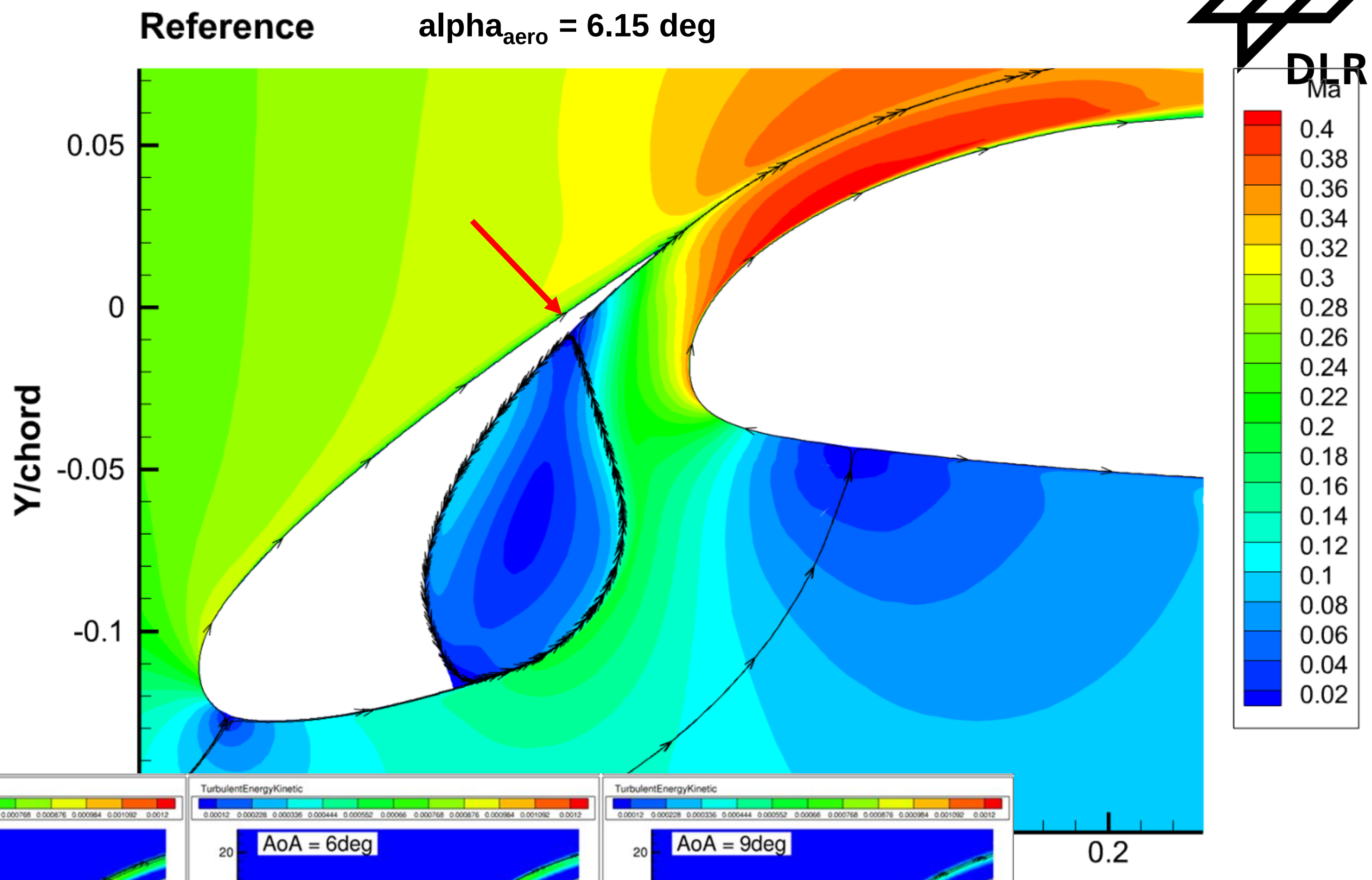
Open questions:

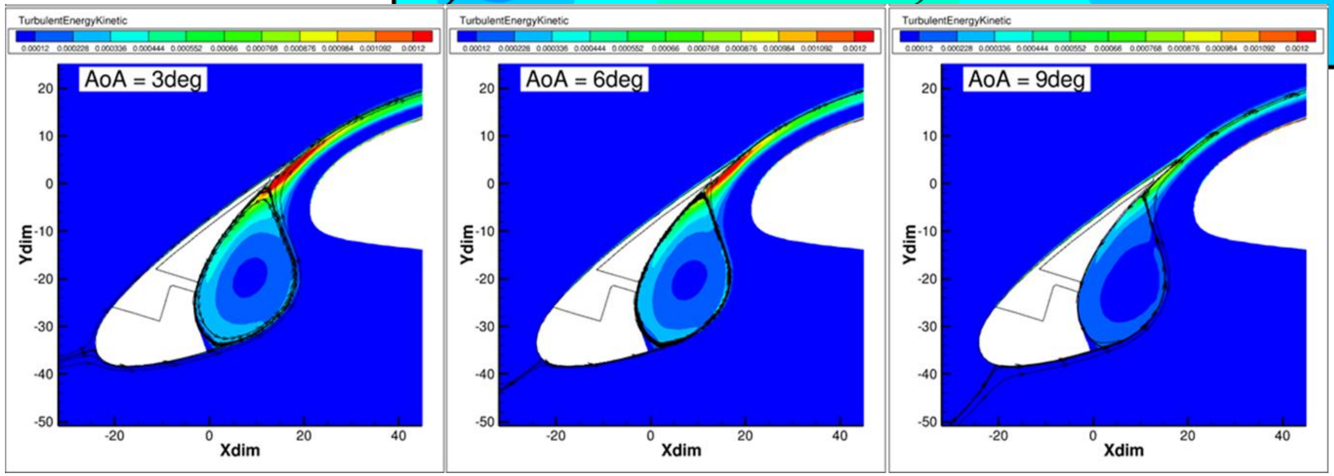
- Extend of porous surface
- Effect of contour discontinuities and tape



1 Assumptions

- Place the absobing treatment at the stagnation point
- Account for movement with angle of attack
- Try to simulate different extents by tapeing regions
- Mixed effects (as shown)





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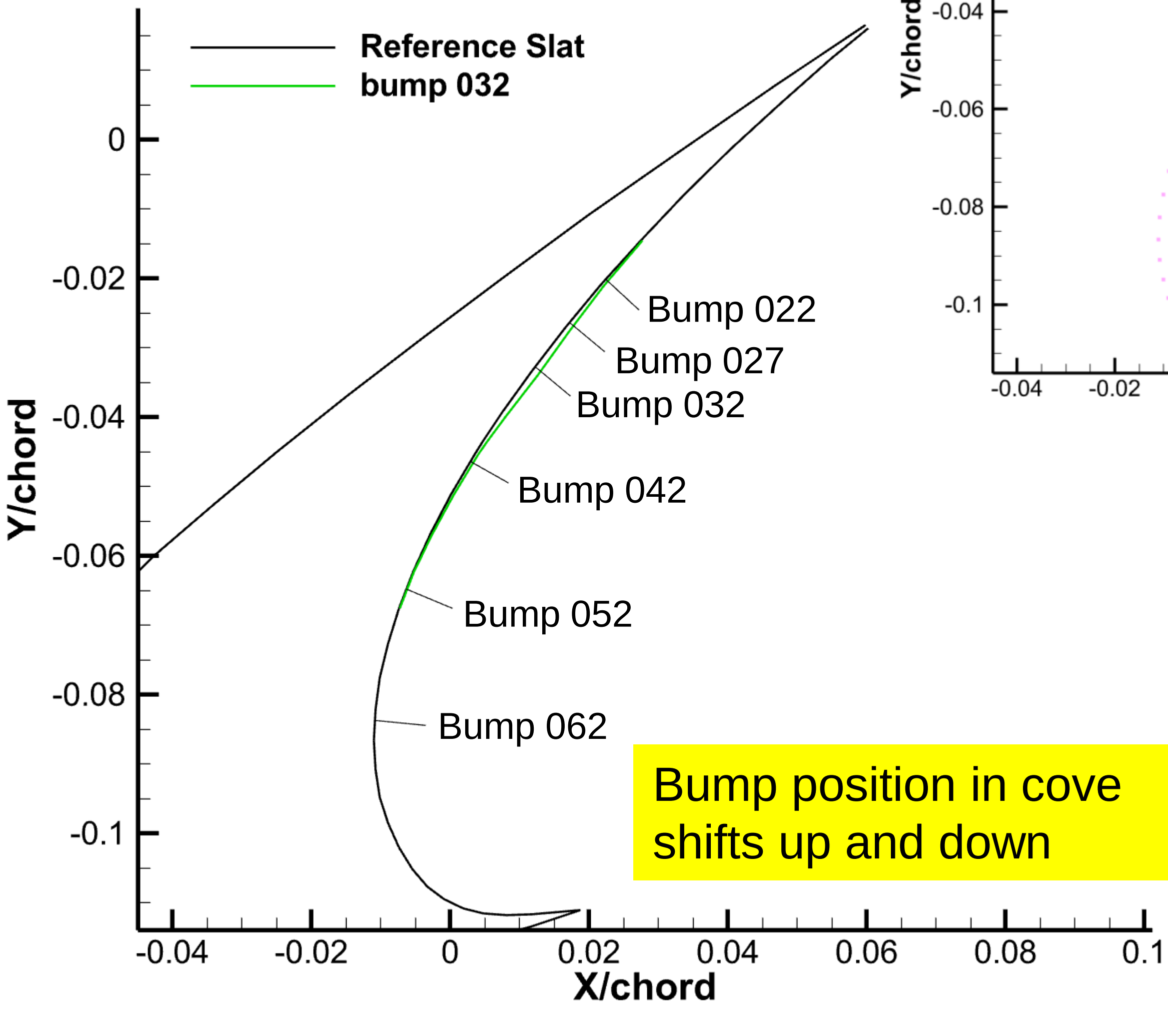
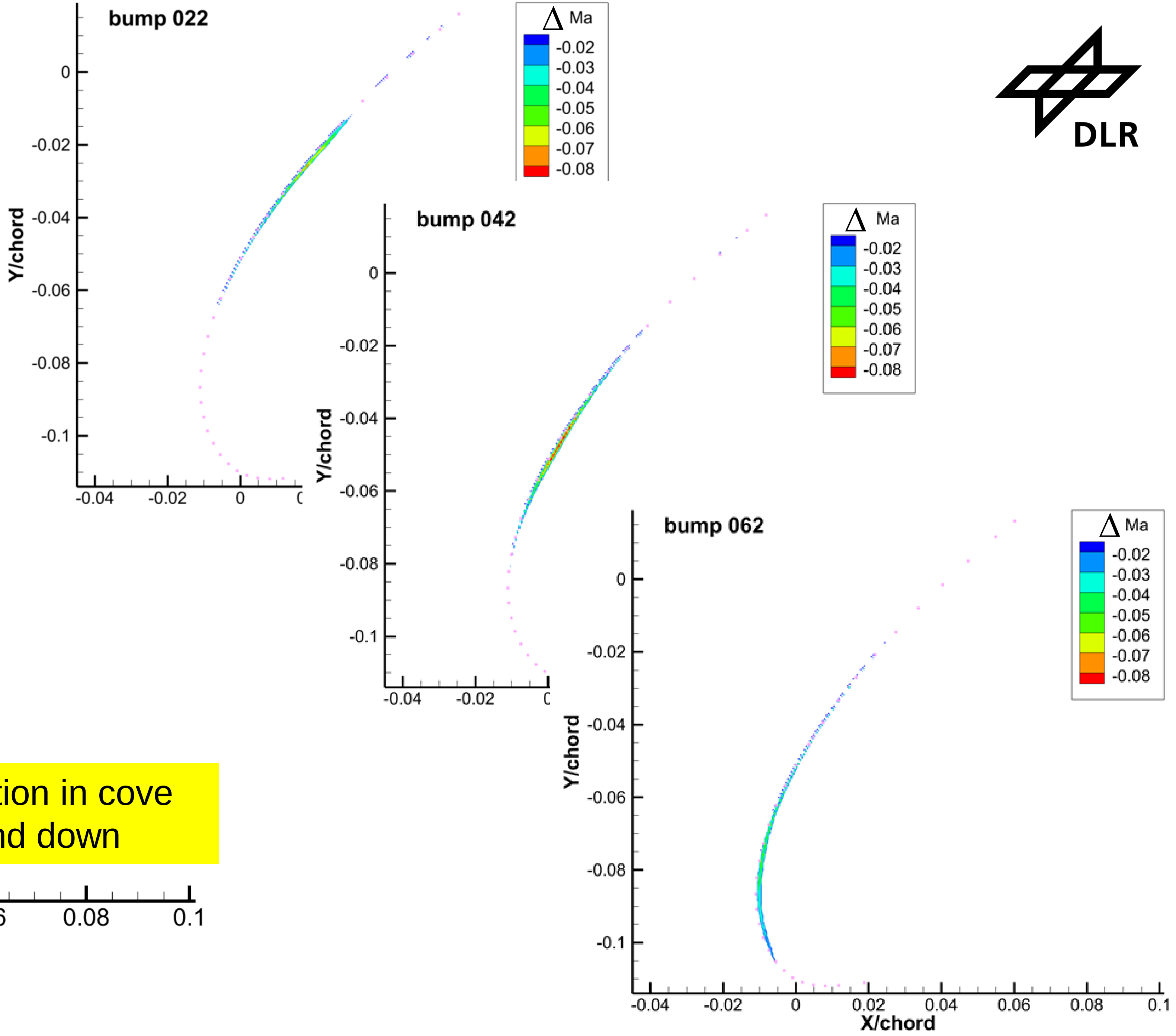
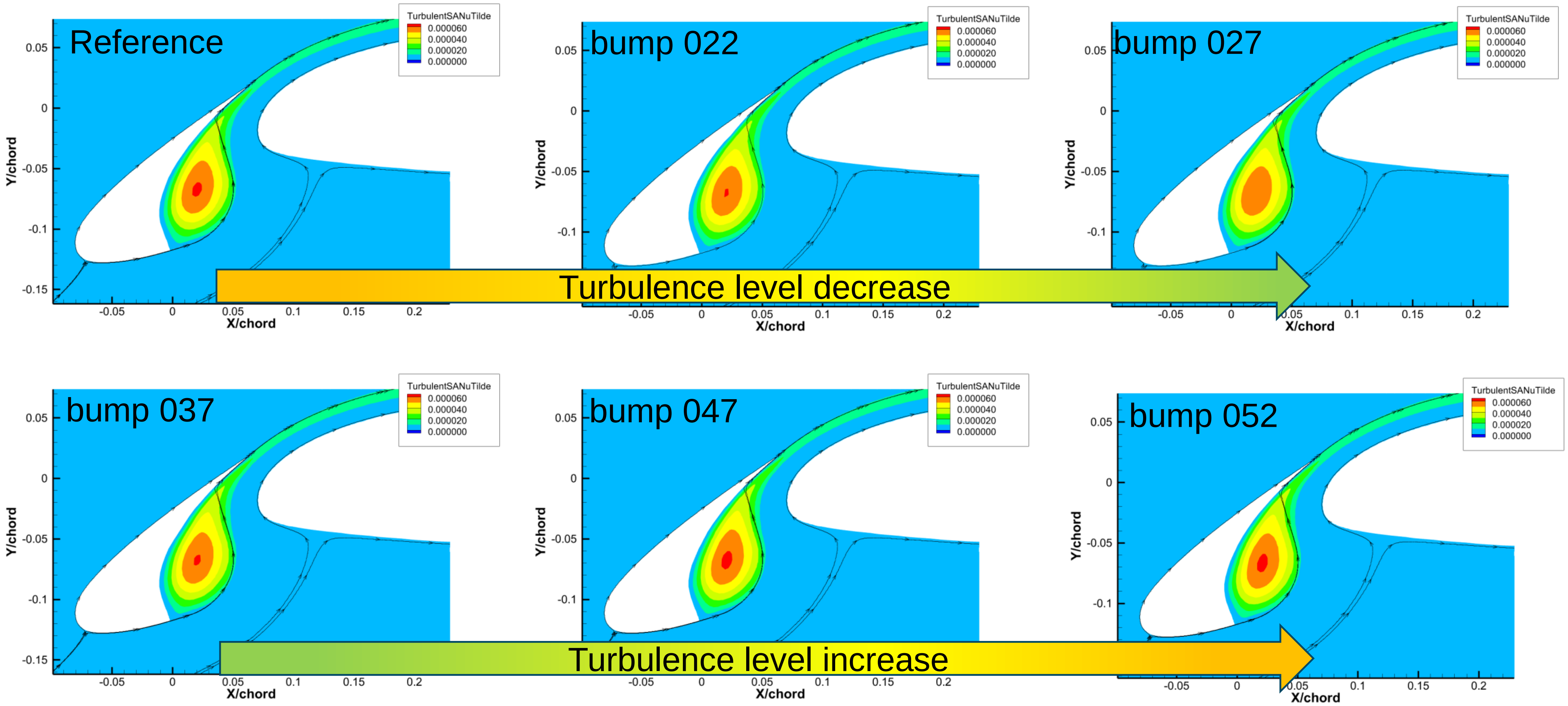
1 Slat Geometry Modifications



Bump position in cove shifts up and down



1 Turbulence generation - eddy viscosity $\tilde{\nu}$



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1 Turbulence generation - eddy viscosity $\tilde{\nu}$

- Based on the 1-equation Spalart-Almaras turbulence model the eddy viscosity $\tilde{\boldsymbol{\nu}}$ is selected to represent the turbulent kinetic energy
- The proportionality $\tilde{\boldsymbol{\nu}} \sim \frac{l_t^2}{t} \sim \frac{k^2}{\varepsilon} \sim \frac{k}{\omega}$ links the eddy viscosity with the turbulent kinetic energy k and the dissipation rate ω (*Boussinesq hypothesis*)
- Moving the bump leads to
  - a turbulence level **decrease** between positions 22% and approx. 30%
  - and a turbulence level **increase** for positions greater approx. 40%

  inside the cove vortex
- This turbulence is swallowed out of the vortex, accelerated and passes the slat trailing edge finally leading to higher noise levels
- Numerical methods are required to assess these problems and support the liner design
- Similar problems will occur for impedance jumps from solid to porous surfaces

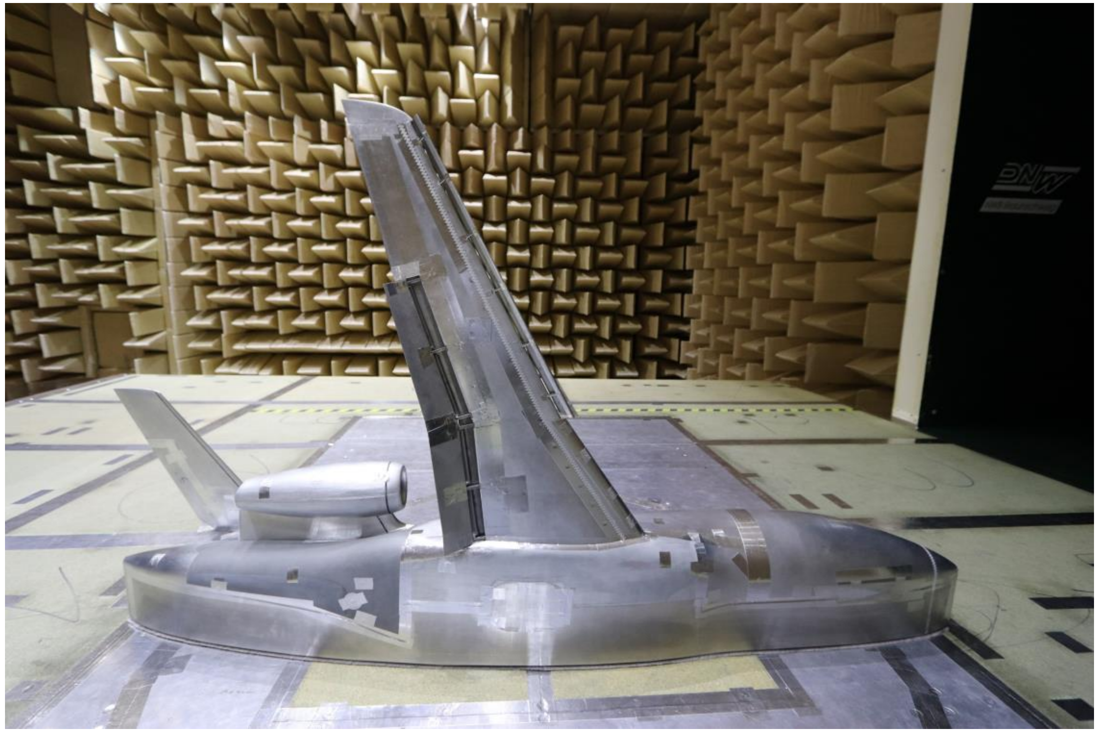
2 Application

- InVentor: Generic Business Jet Aircraft Platform in WP5

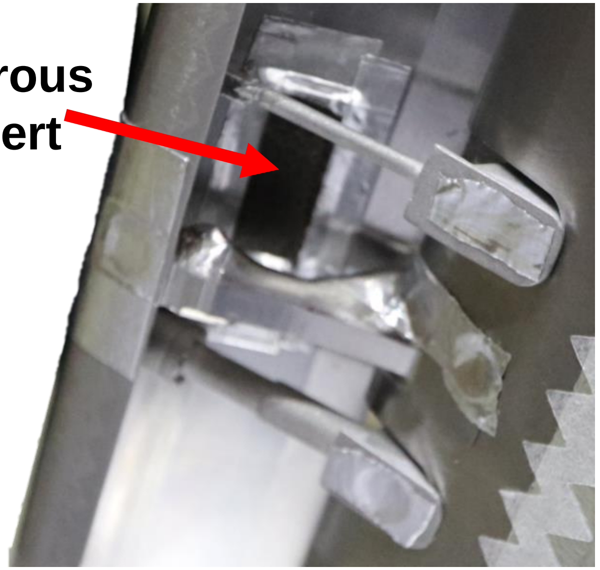
- Use the near field absorber to mitigate slat track noise

- DAv wind tunnel model in DNW‘s low speed acoustic wind tunnel in Braunschweig (DNW-NWB)

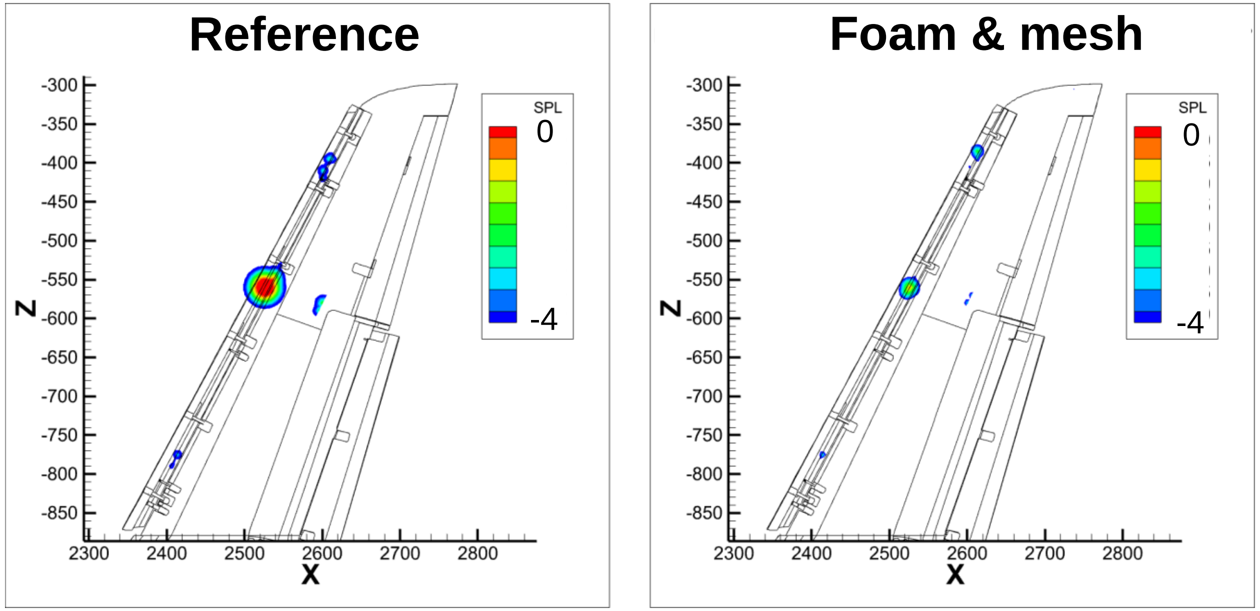
- Proof of concept on 3D semi span model (~1.2 m span)

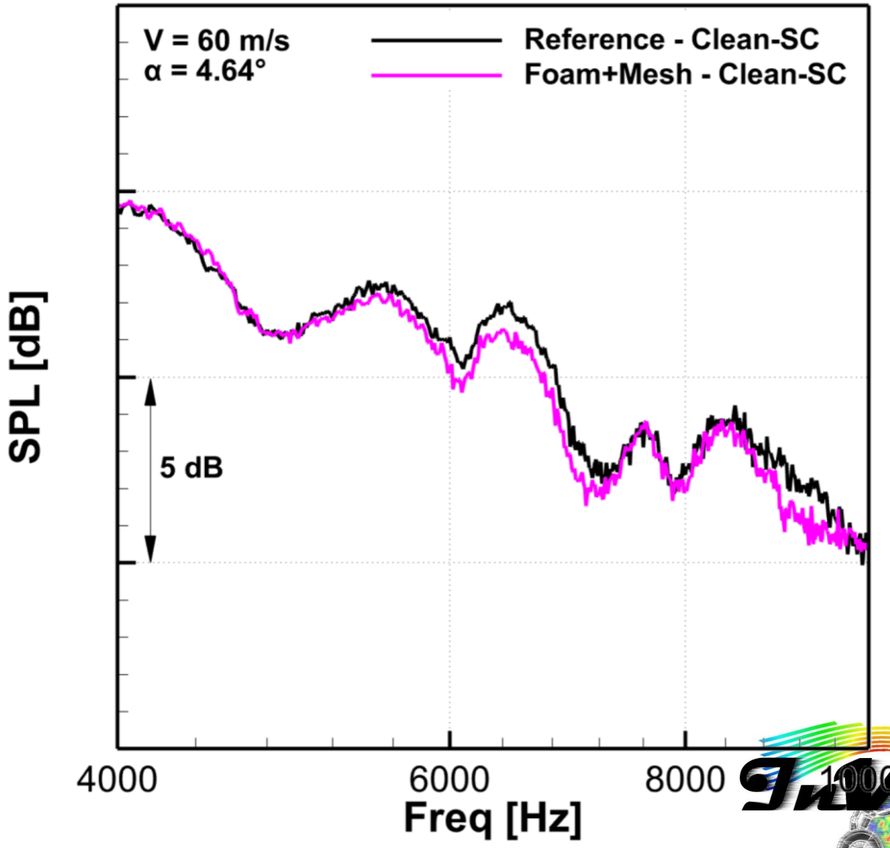


2 Comparison: Reference to Foam & Mesh – Clean-SC



- Near field absorber is efficient
- Noise source maps show clear reduction, f_m = 6.3 kHz
- Spectral representation confirms source map result over larger frequency domain

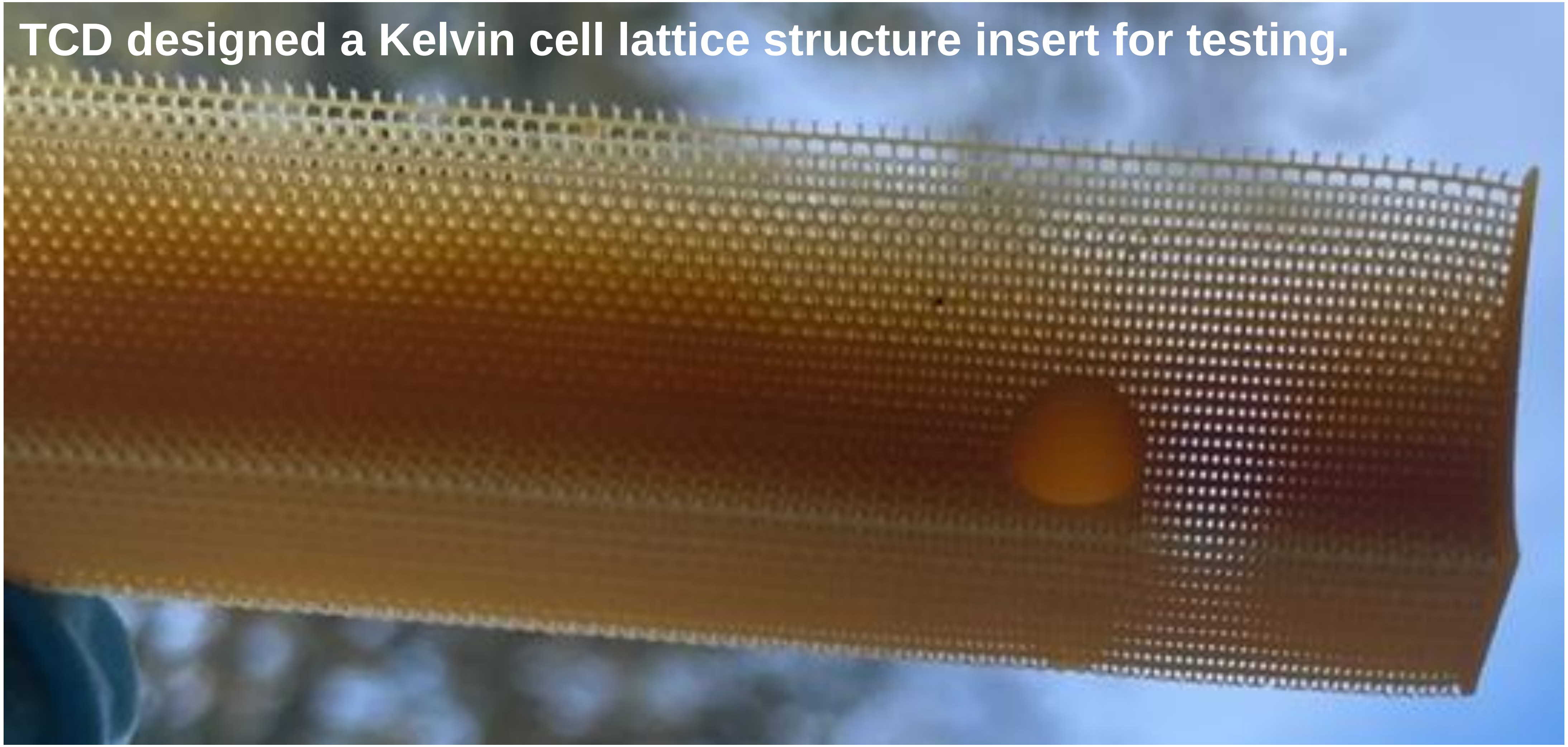




Summary & Conclusion

- 2 different types of slat cove liners were investigated in the mainframe of the EU co-funded research project InVentor
- Both liner types show a noise reduction of up to 3 dB when tested on the 2-D F16 high lift system model
  - the near field absorber acts in a limited frequency band
  - the TE insert works on a larger frequency range
  - both liner types suffer from installation issues, demonstrated for the TE insert
- Numerical methods (CFD & CAA) should be used within a combined design process to assess flow properties and noise generation
- Based on the InVentor work also porous media and their installation issues might be assessed in the near future

Thank you for your attention!



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