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Acoustic optimisation of a fan test rig

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FFT ACOUSTIC SIMULATION
CONFERENCE 2014
Actran Users' Meeting

FFT
MSC Software Company

AneCom aerotest facility

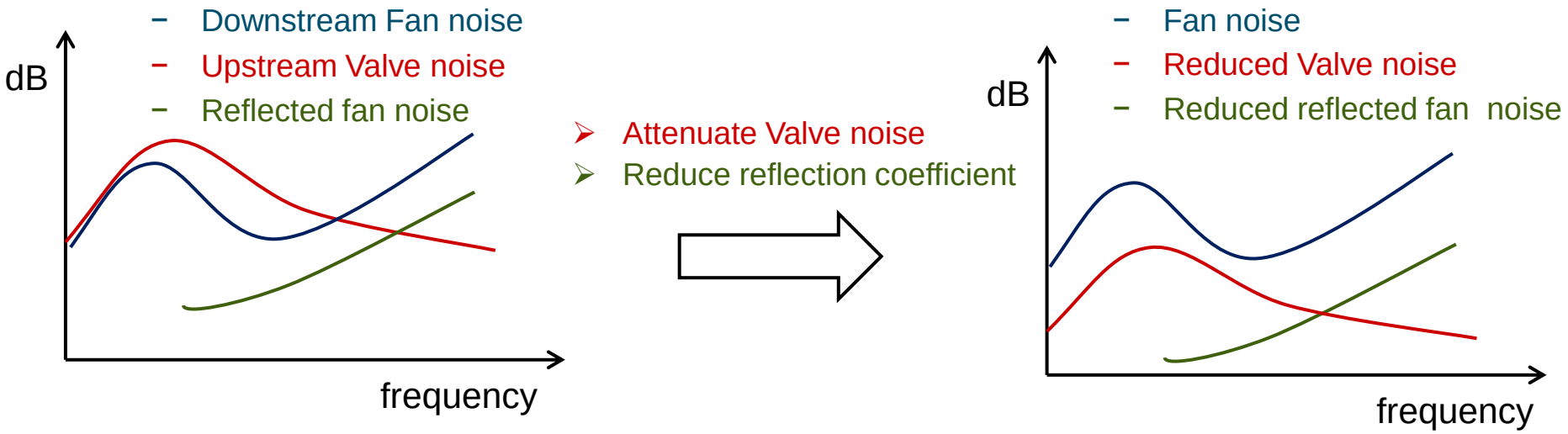
Specialist test rig for measuring the aerodynamic performance and noise of aero-engine fans

- **Undergoing re-design to increase flow capacity without bypass duct noise measurement contamination**
  - Noise generated by the flow control throttle
  - Acoustic reflections from the throttle
- **Despite a strong constraint in space available**
- **Actran TM used in order to**
  - Attenuate throttle noise by 20dB
  - Reduce power reflection coefficient to below -8dB
  - Wide range of frequency of interest (250 – 4000 Hz)

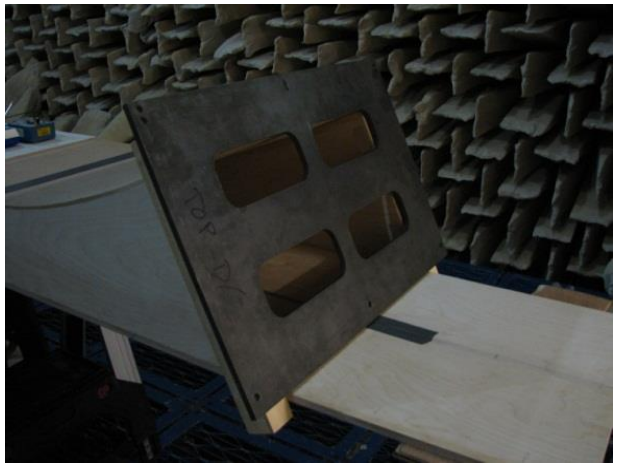
Fan noise test challenge

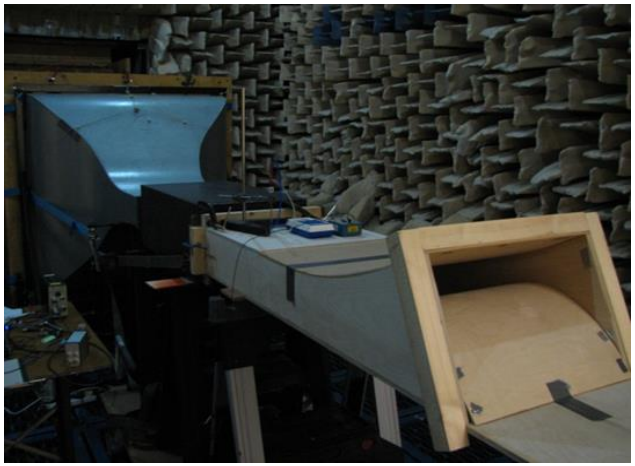
Accurate measuring of fan noise propagating downstream is helped by a reduction of noise propagating upstream:

1. **Valve noise**
2. **Reflected fan noise**



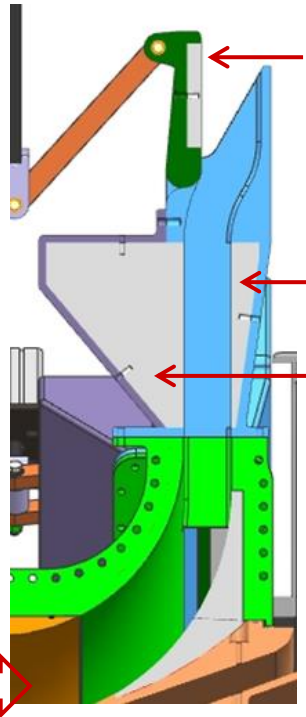
Throttle design: valve noise reduction at source





- **Achieving throttle noise reduction with acoustic liners alone is difficult at lower frequencies**
- **The reduction at source can be achieved with a new flap throttle**

Acoustic liner optimisation: valve and reflected noise reduction



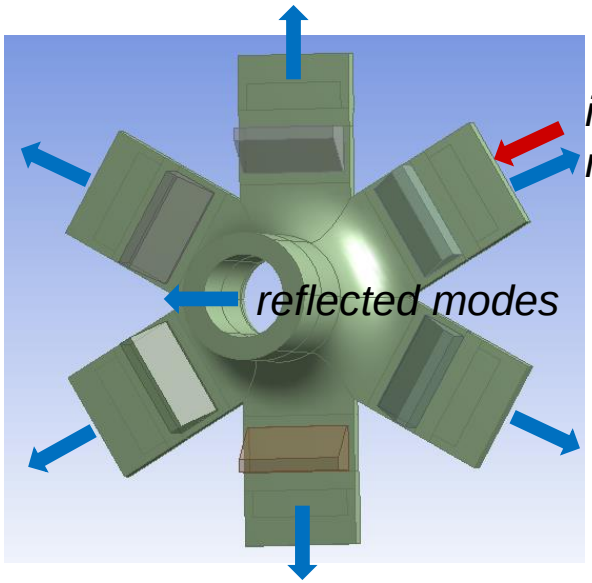
- **single/double layer perforate**
  modelled using local impedance
  - PROS: difficult to contaminate
  - CONS: expensive to replace
- **bulk absorbing material**
  defined by flow resistivity and facing sheet resistance
  - PROS: cheap to replace
  - CONS: easy to contaminate

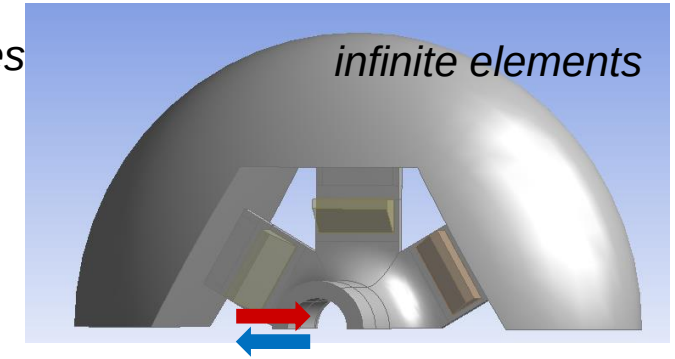
Actran TM models

Throttle noise

Reflected noise

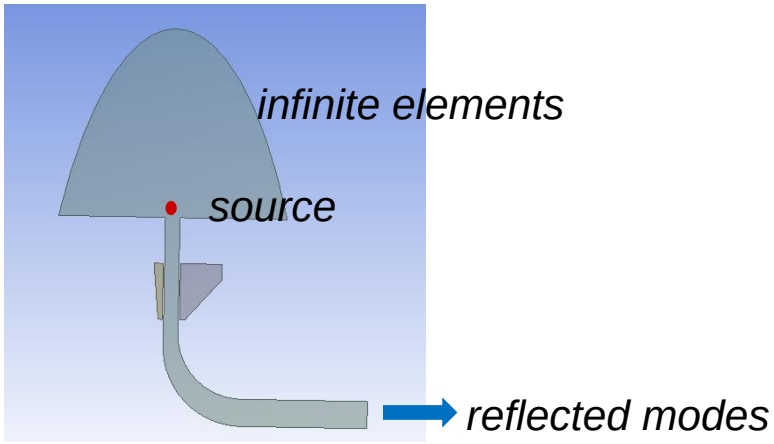
Low frequency
(125 – 1000 Hz)



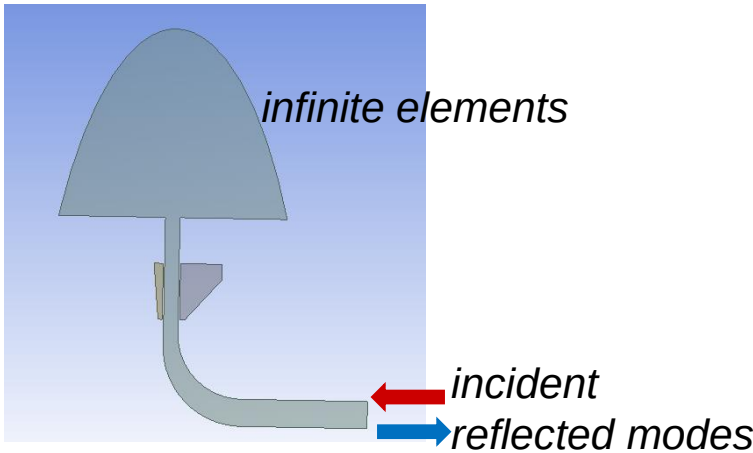


sym_asym

Optimisation &
High frequency
(1000 – 4000 Hz)

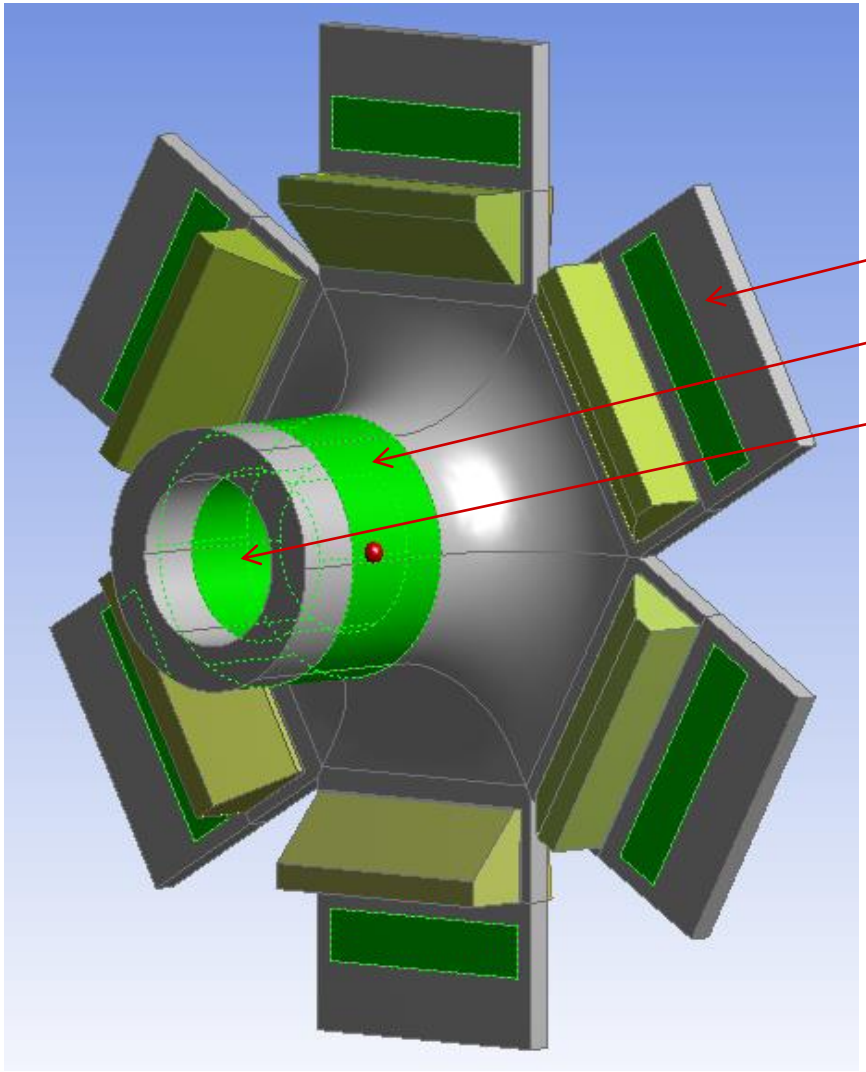


2D



axisym

Porous and impedance surfaces



Liners as impedance boundary condition are highlighted in green

1. throttle liner
2. outer bypass duct liner
3. inner bypass duct liner

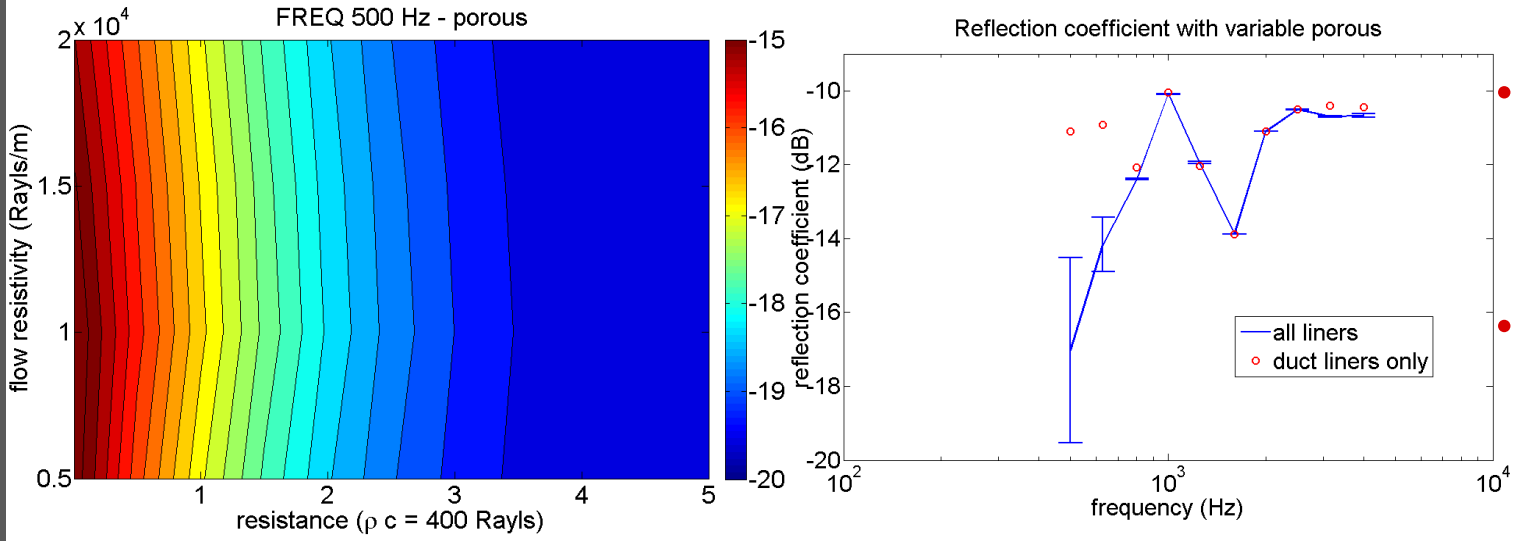
Liner Optimisation

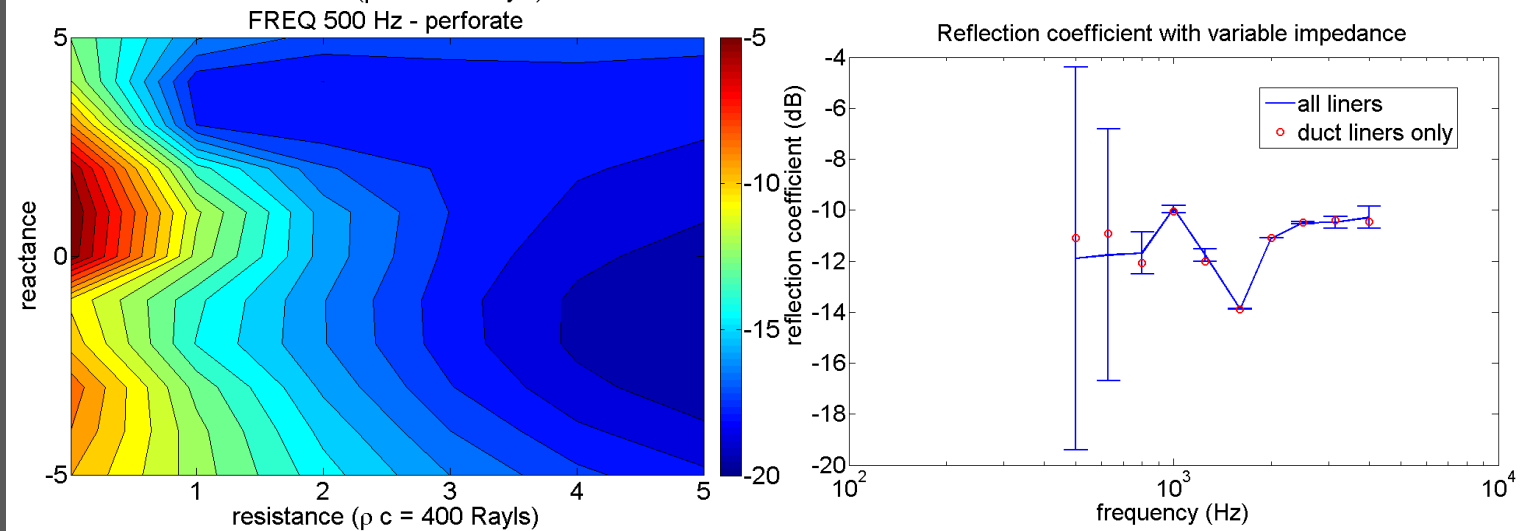
Broadband analysis

High mass flow condition

Reflection coefficient: reflected fan noise

Reflection coefficient @ inlet = 10 * Log (reflected / incident modal power)

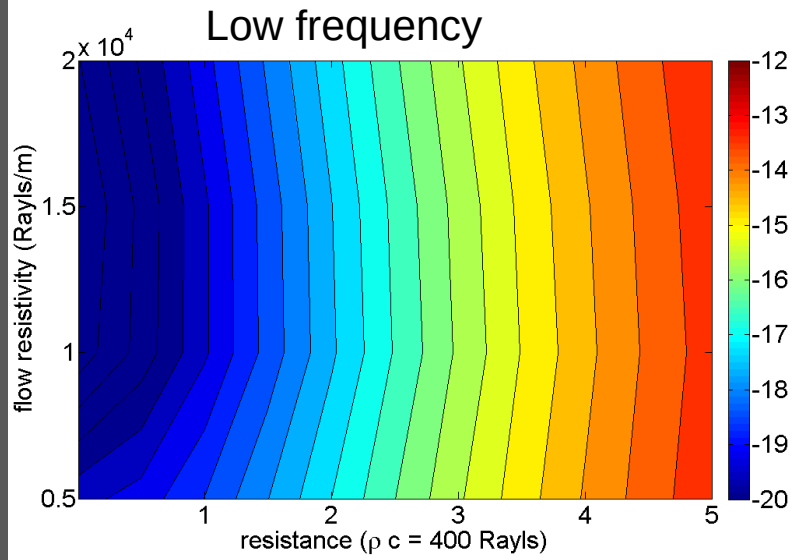


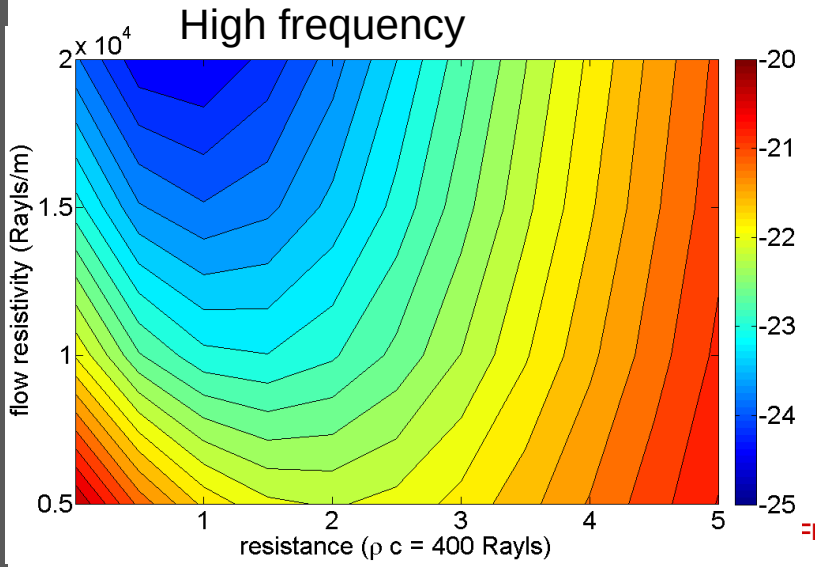


- **Low frequency**
  - optimum @ high resistance
- **High frequency**
  - totally dominated by bypass duct liners

Transmission coefficient: valve noise

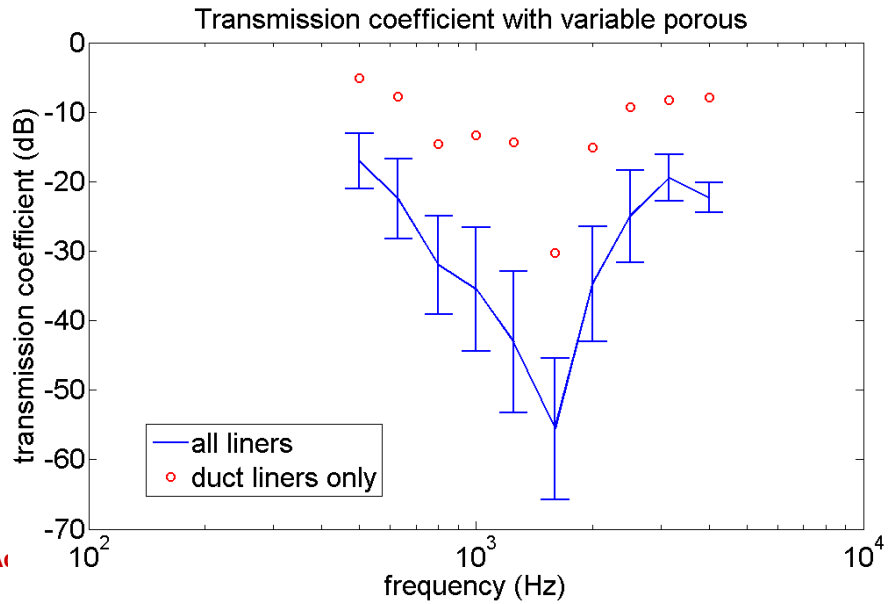
Transmission coefficient @ inlet = 10 * Log (transmitted / incident power)



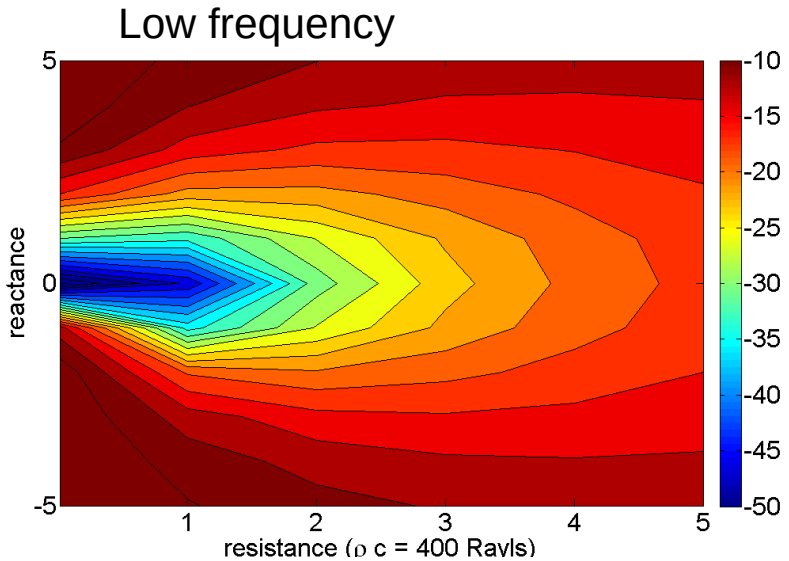


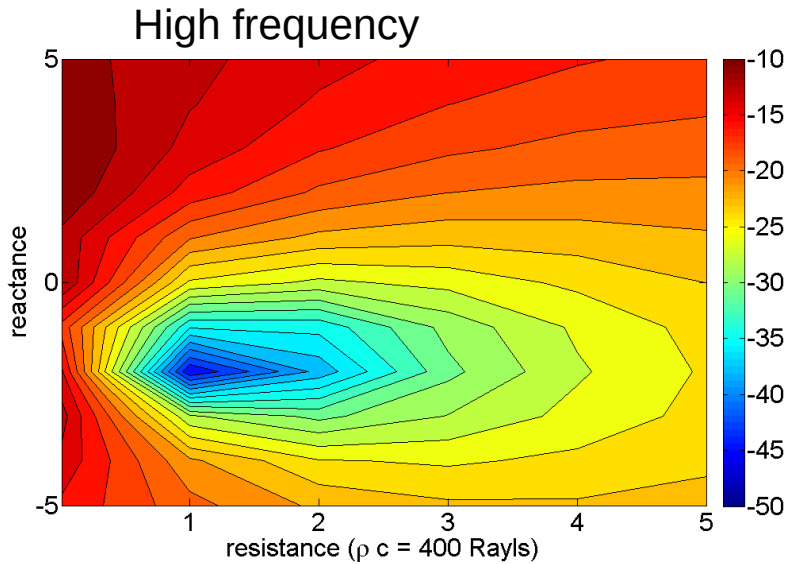
Porous liner

- **Optimum at low resistance**
- **High frequency**
  - optimum at high flow resistivity



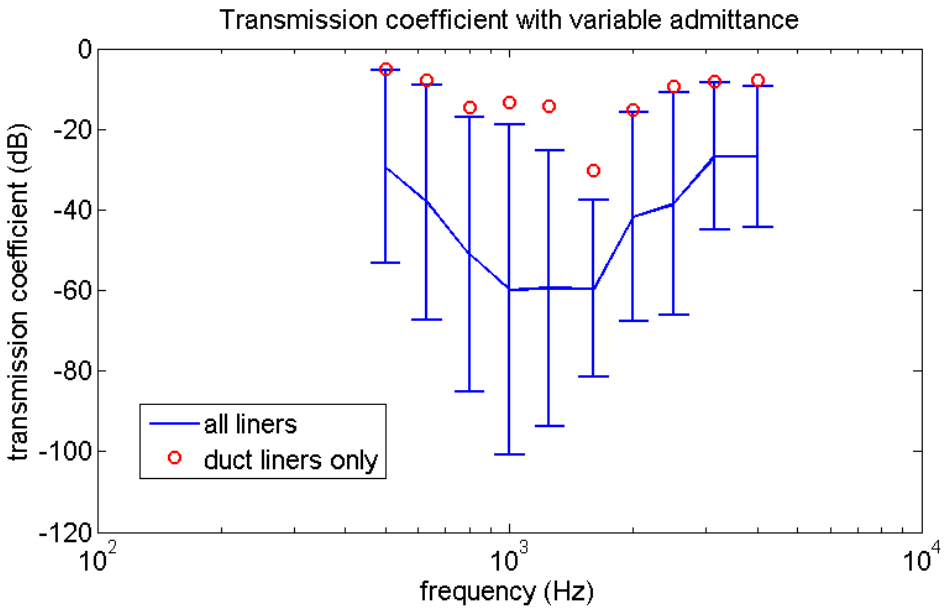
Transmission coefficient: valve noise





Perforate liner

- **Low frequency**
  - optimum at very low resistance R and reactance X
- **High frequency**
  - optimum shifting at R = 1ρc, X = -2ρc

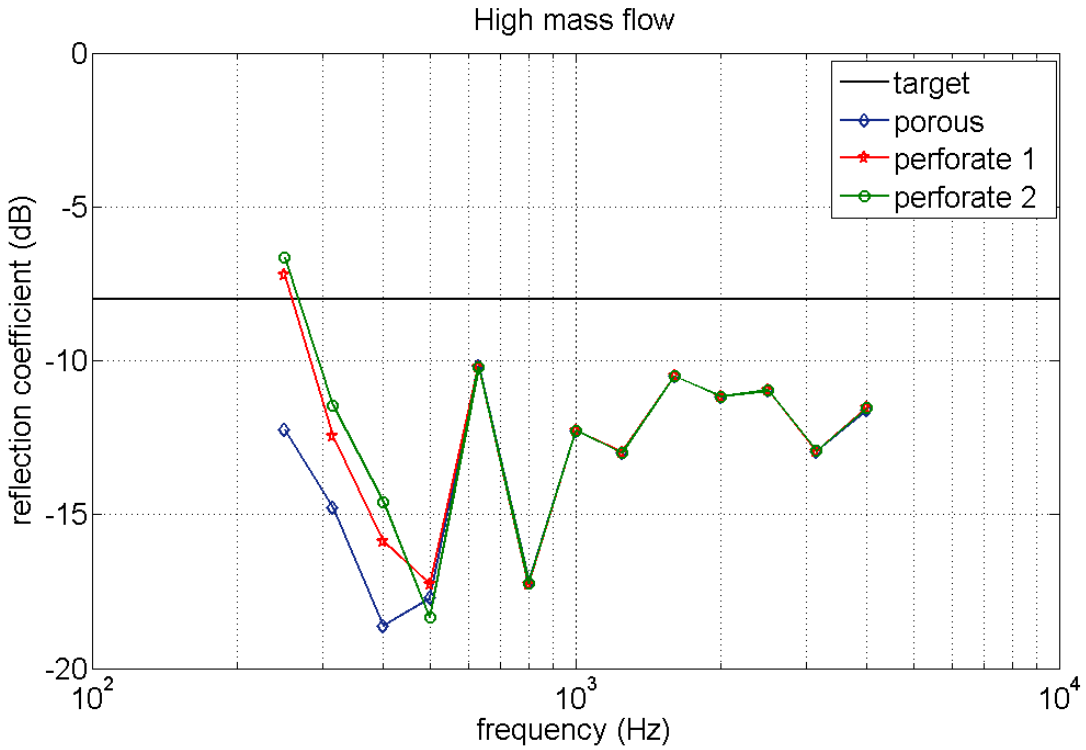


Optimised liner candidates

Liner type	Specification
porous	high flow resistivity low resistance facing sheet
deep perforate	low resistance facing sheet 2 cavity depth candidates
shallow perforate	high resistance facing sheet 2 cavity depth candidates

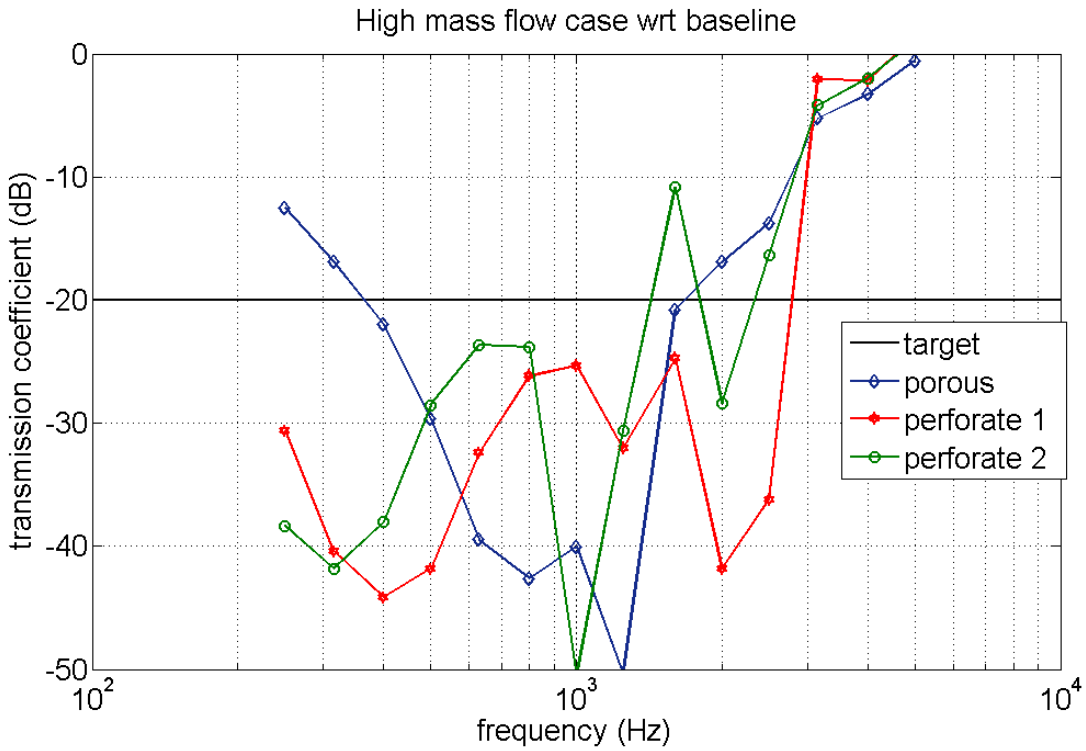
Reflection coefficient: reflected fan noise

- **Porous performs better**
- **No remarkable difference between the two perforate candidates**
- **Target met by all configurations in (almost) all the frequency range**



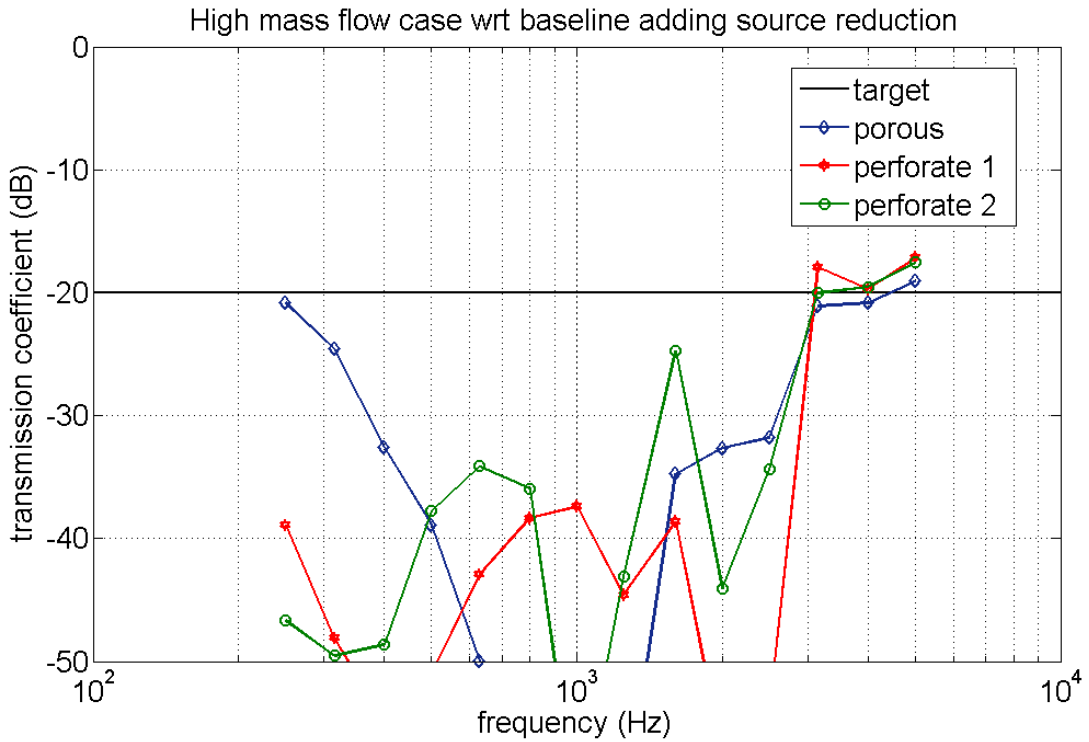
Transmission coefficient: valve noise

- Perforate performs better at low frequency, perforate1 generally better
- Porous performs better at medium frequency
- Target not met at high frequency



Transmission coefficient adding noise reduction at source

- **Noise reduction at source due to new throttle design allows to meet the target in the whole frequency range**



Computational statistics

- **Optimisation via *python* scripting of the session file and *Matlab* post-processing, using the *plt_get* utility**
- **Computations on 1 processor (Intel Core i7-2600 CPU @ 3.4 GHz, 16GB RAM)**

	FE/IE ndof	# porous	# imped	# freq	time per freq slot	total time
2D	100 k	24	66	10	1 min	90 min
Axisym	70 k	24	66	10	15 min	22 h
Half 3D	1,000 k	1	2	7	6 h	18 h
Full 3D	580 k	1	2	7	22 min	1 h

Conclusions

- **Actran TM has been successfully used to support the re-design of the AneCom fan test rig**
- **Liner optimisation via Actran TM allowed to identify 3 liner configurations, whose performance was further analysed to support the final design stage**
- **Reflection and transmission coefficient target was generally met, if noise reduction at source via new throttle was taken into account**
- **Good example of interaction between simulation and experiment insight**