Auralization of Propeller Fly-over Noise Using Open Jet Wind Tunnel Data

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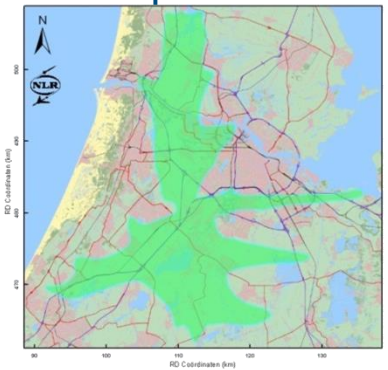
Dedicated to innovation in aerospace

Auralization, why?

- New designs / procedures: no measurements
- Artificial generation of (aircraft) noise: auralization

Noise prediction



Auralization

Presentation

Auralization

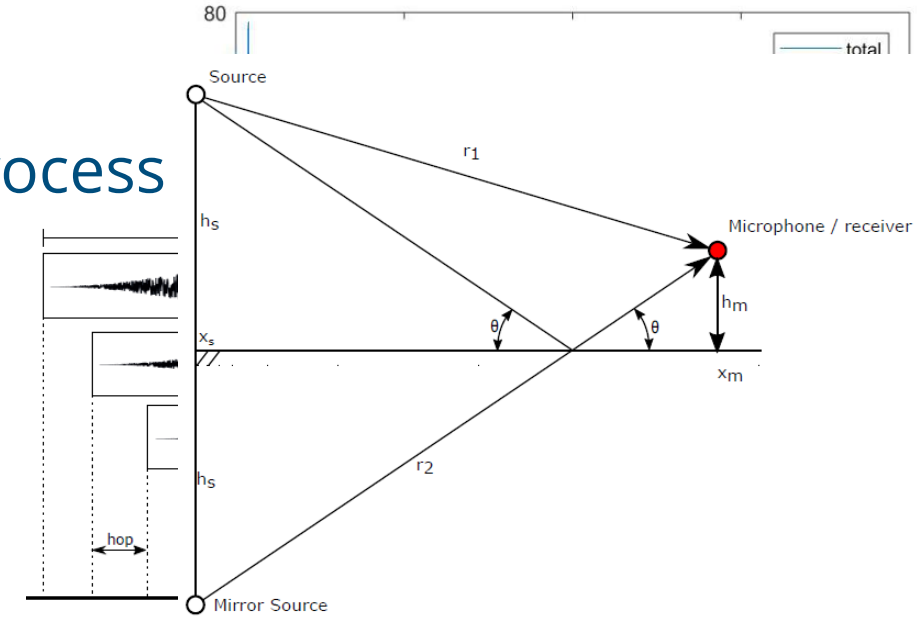
- Broadband sound

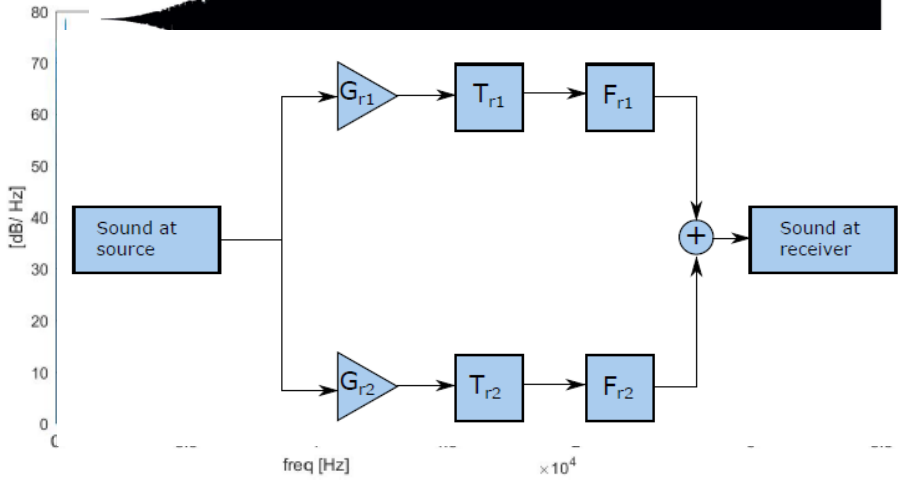
- Tonal sound

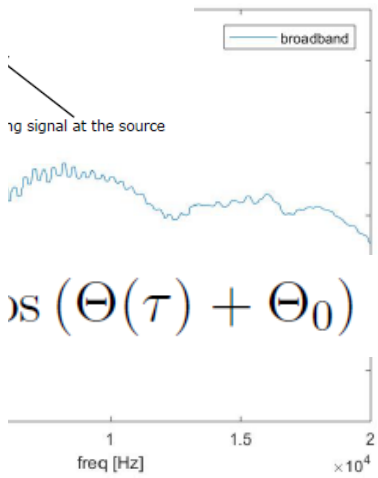
How can we make a realistic auralization of propeller noise?

Auralization process

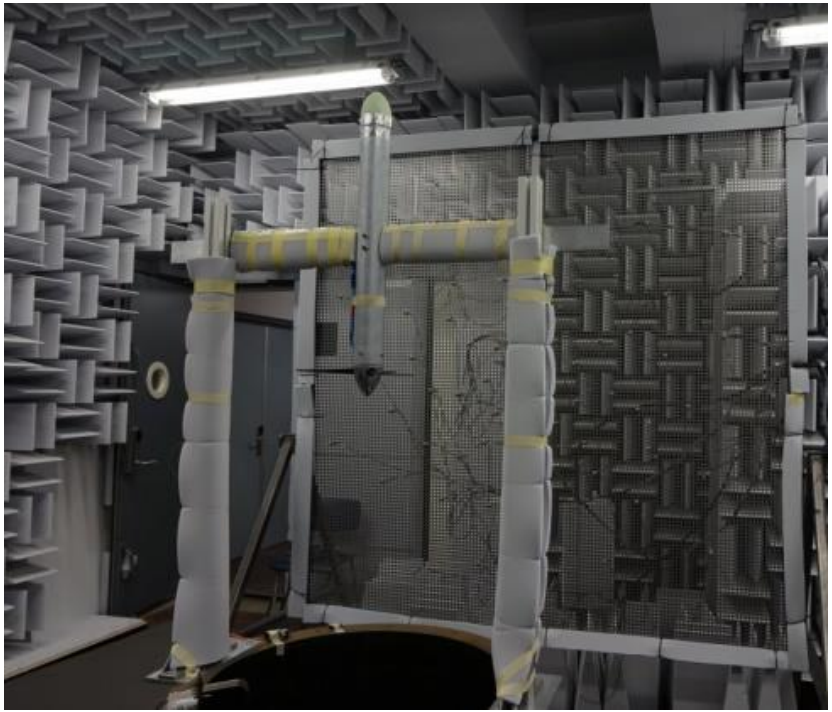
- Open Jet Wind Tunnel
- Noise near Source
- Spectral Content
- Noise Synthesis
- Propagation

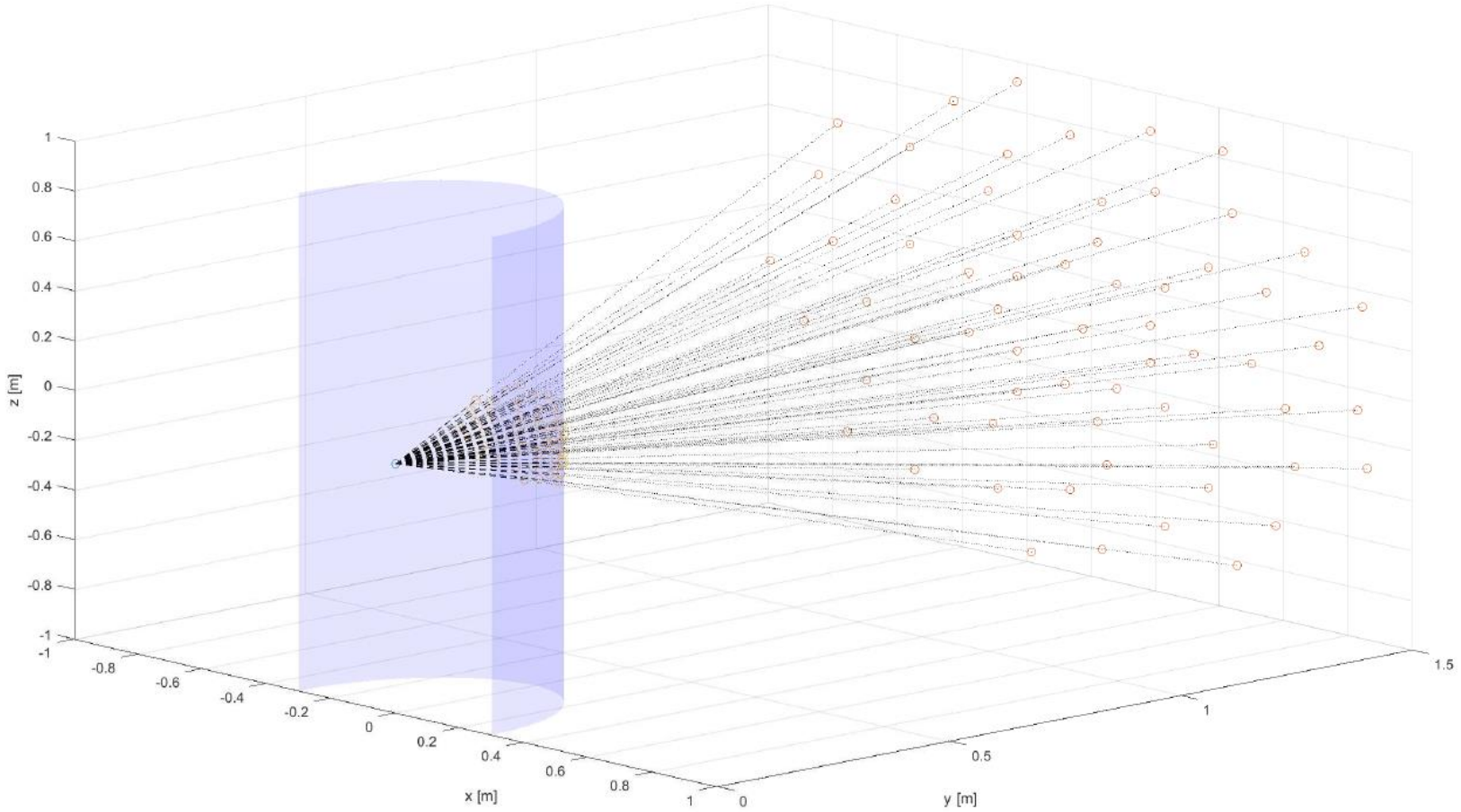






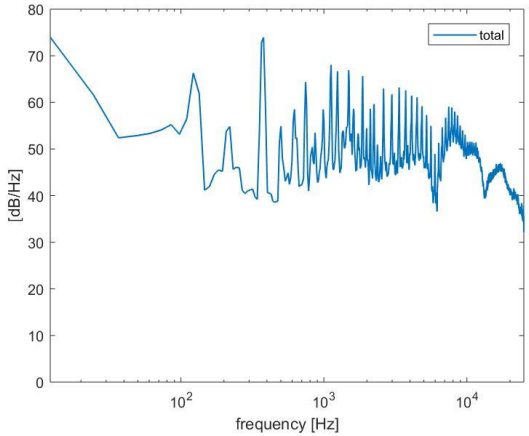
Open Jet Wind Tunnel



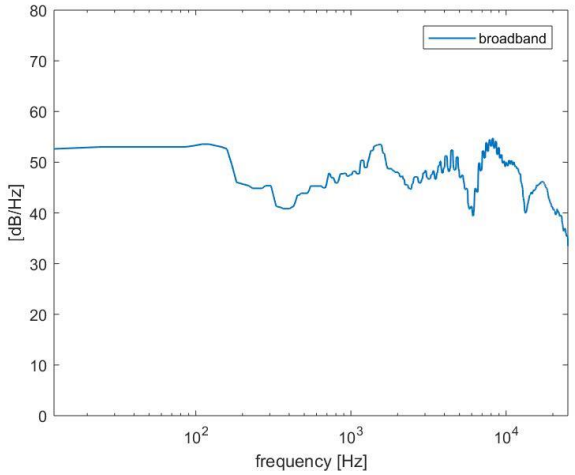


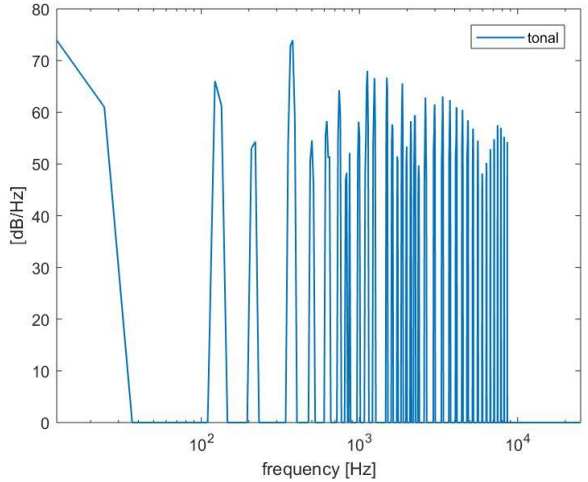
Open Jet Wind Tunnel → Noise near Source → Spectral Content → Noise Synthesis → Propagation

Spectral Content



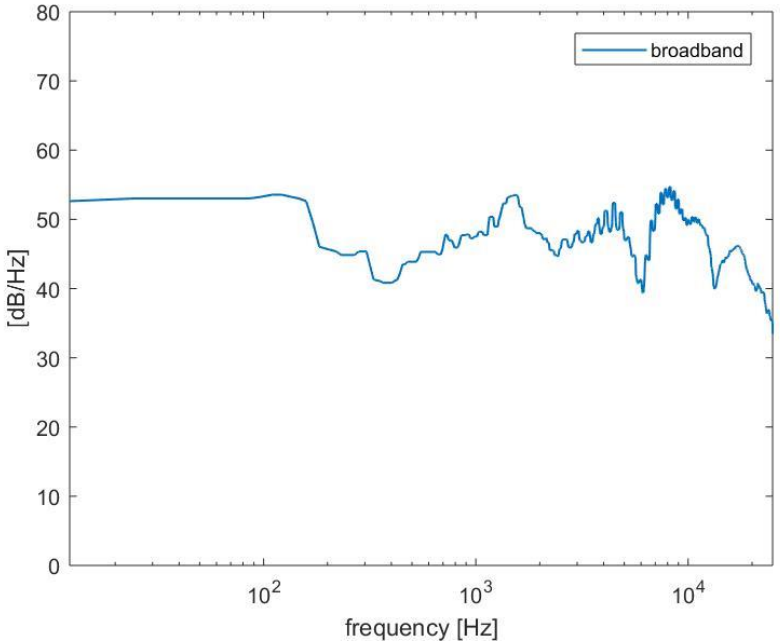
Moving Median Filter

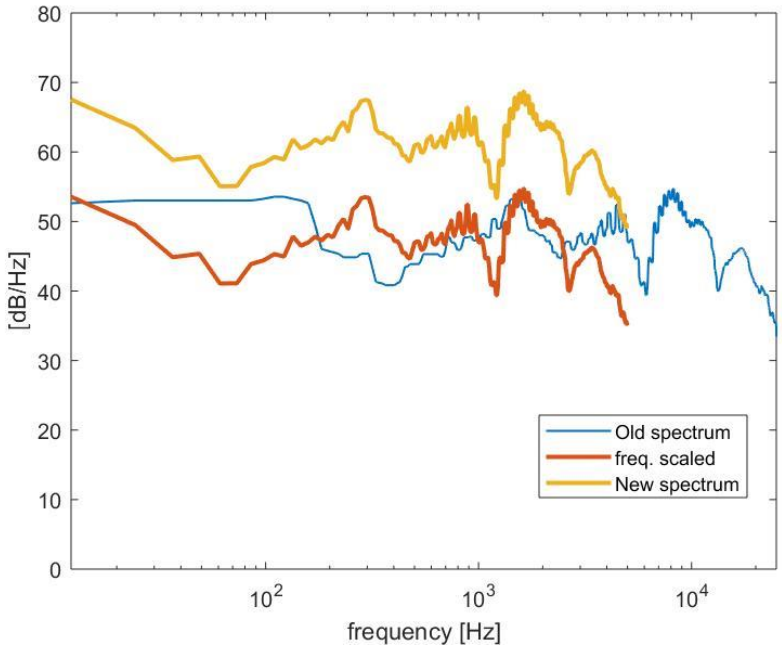




Scaling (1)

$$f_{\text{Full Scale}} = f_{\text{Rig}} \left[\frac{D_{\text{Rig}}}{D_{\text{Full Scale}}} \right] \qquad SPL_{\text{Full Scale}} = SPL_{\text{Rig}} + 20 \log_{10} \left[\frac{D_{\text{Full Scale}}}{D_{\text{Rig}}} \right]$$

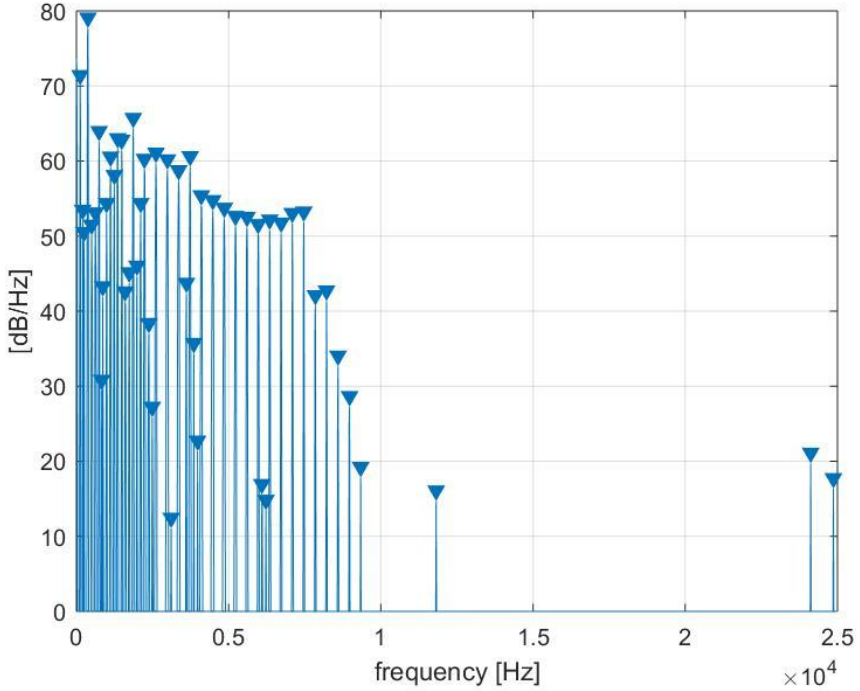




Open Jet Wind Tunnel → Noise near Source → Spectral Content → Noise Synthesis → Propagation

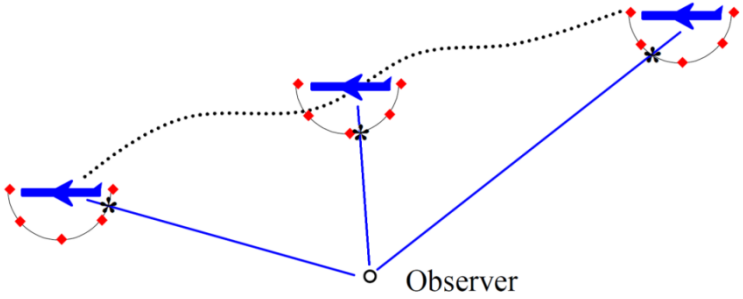
Scaling (2)

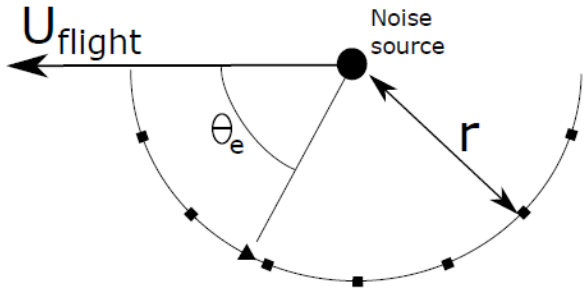
- Find peaks with Matlab
- Directly apply scaling eq.



Auralization

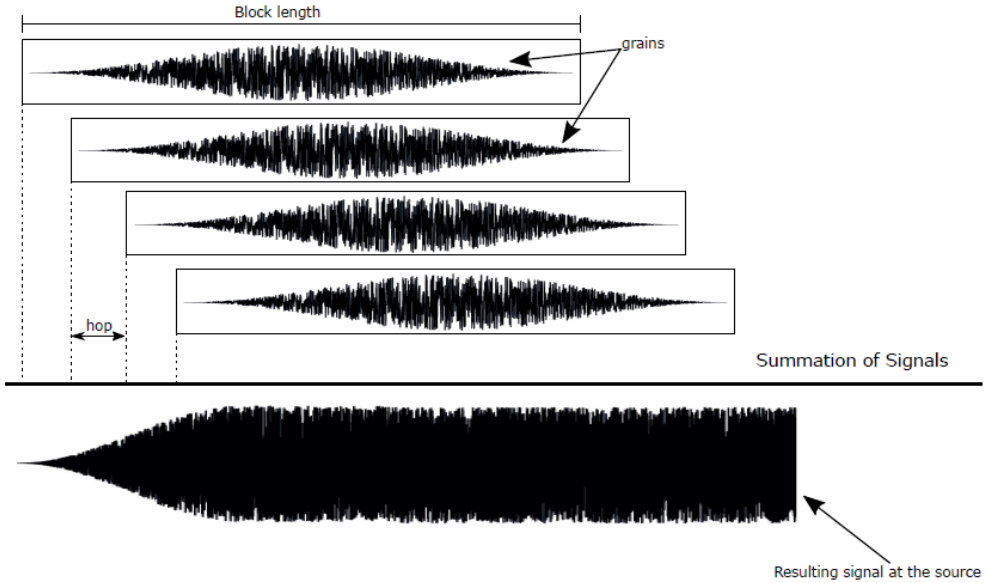
- Create Virtual Fly-over
- Flight path
  - FL 4
  - U = 50 m/s
- Directionality
- Noise Synthesis at the source
  - Broadband
  - Tonal
- Propagation towards observer

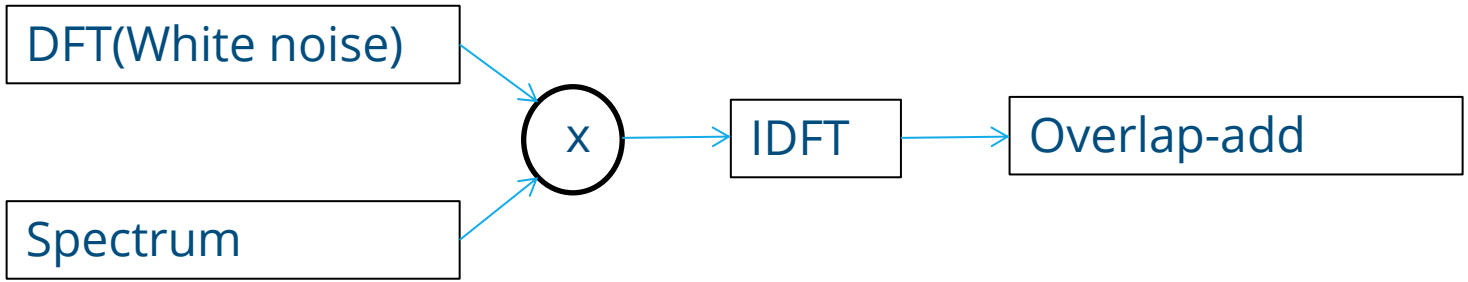




Sound Synthesis (1)

- Broadband:
  - Grain
  - Overlap-Add





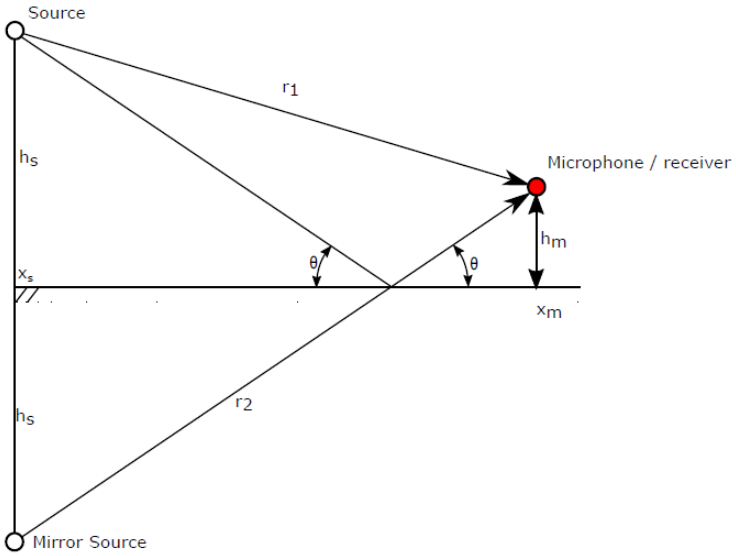
Sound Synthesis (2)

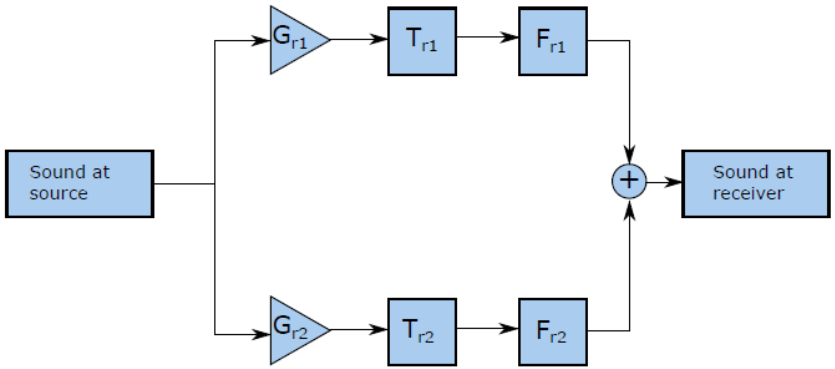
- Tonal:

$$p_i(\tau) = A\cos\left(\Theta(\tau) + \Theta_0\right)$$

$$p_T = \sum_{i=1}^{N} p_i(\tau)$$

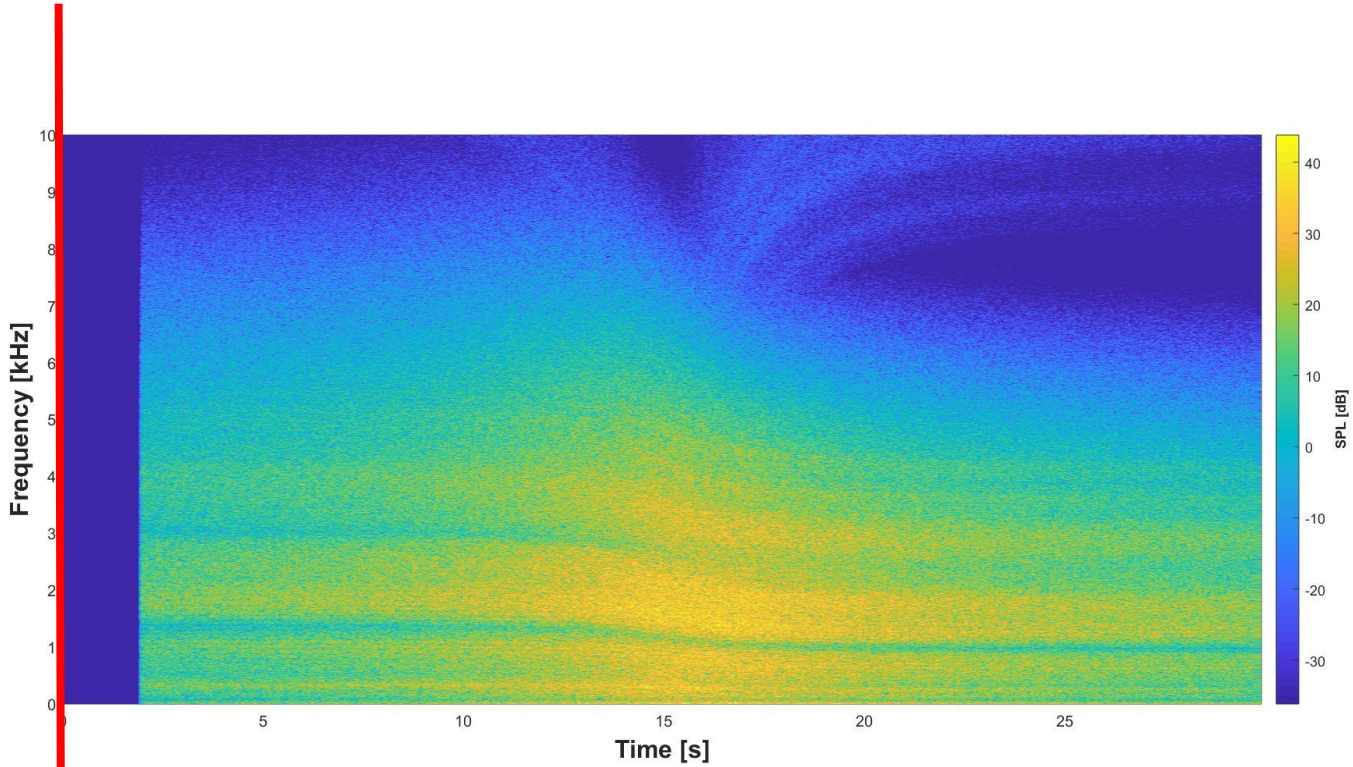
Propagation (1)





Propagation (2)

- Broadband Sound + Time Delay + Spherical Spreading



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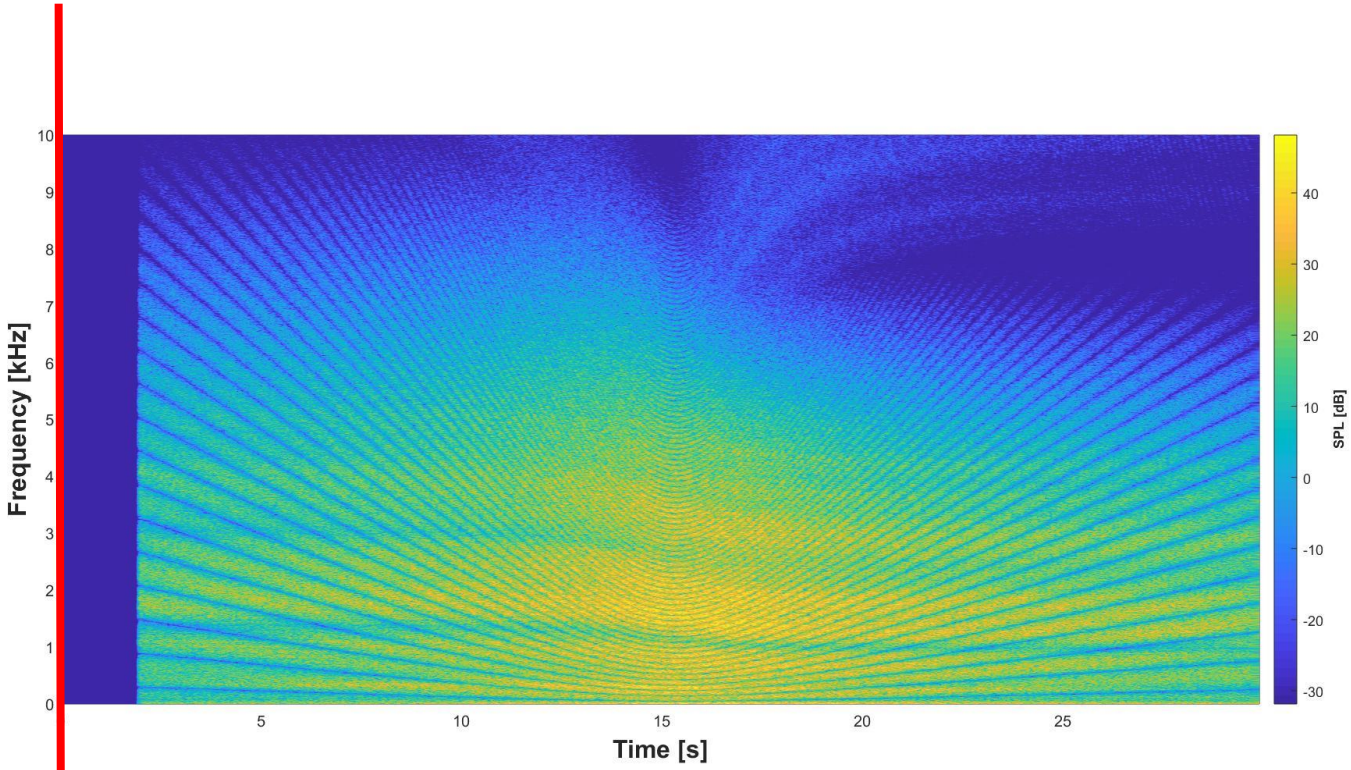
Propagation (3)

- Ground reflection added



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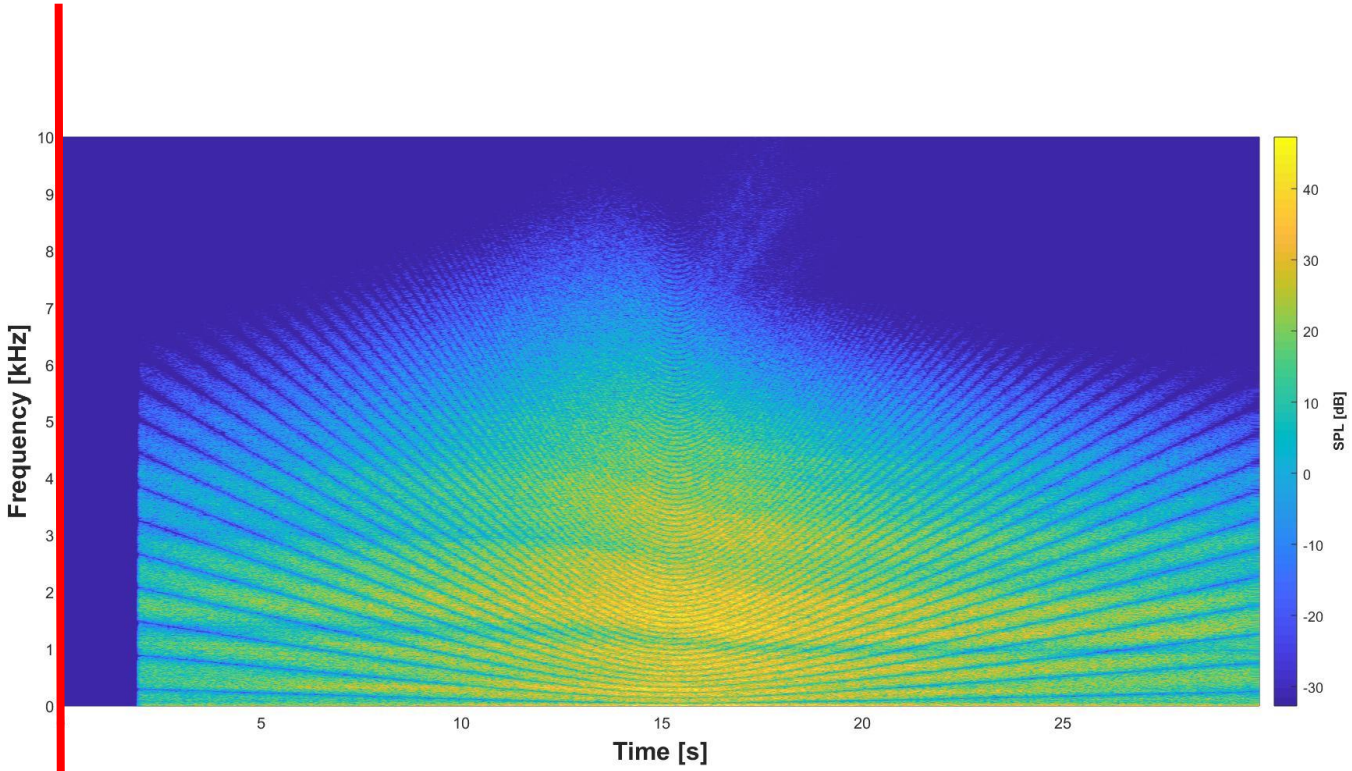
Propagation (4)

- Atmospheric absorption added



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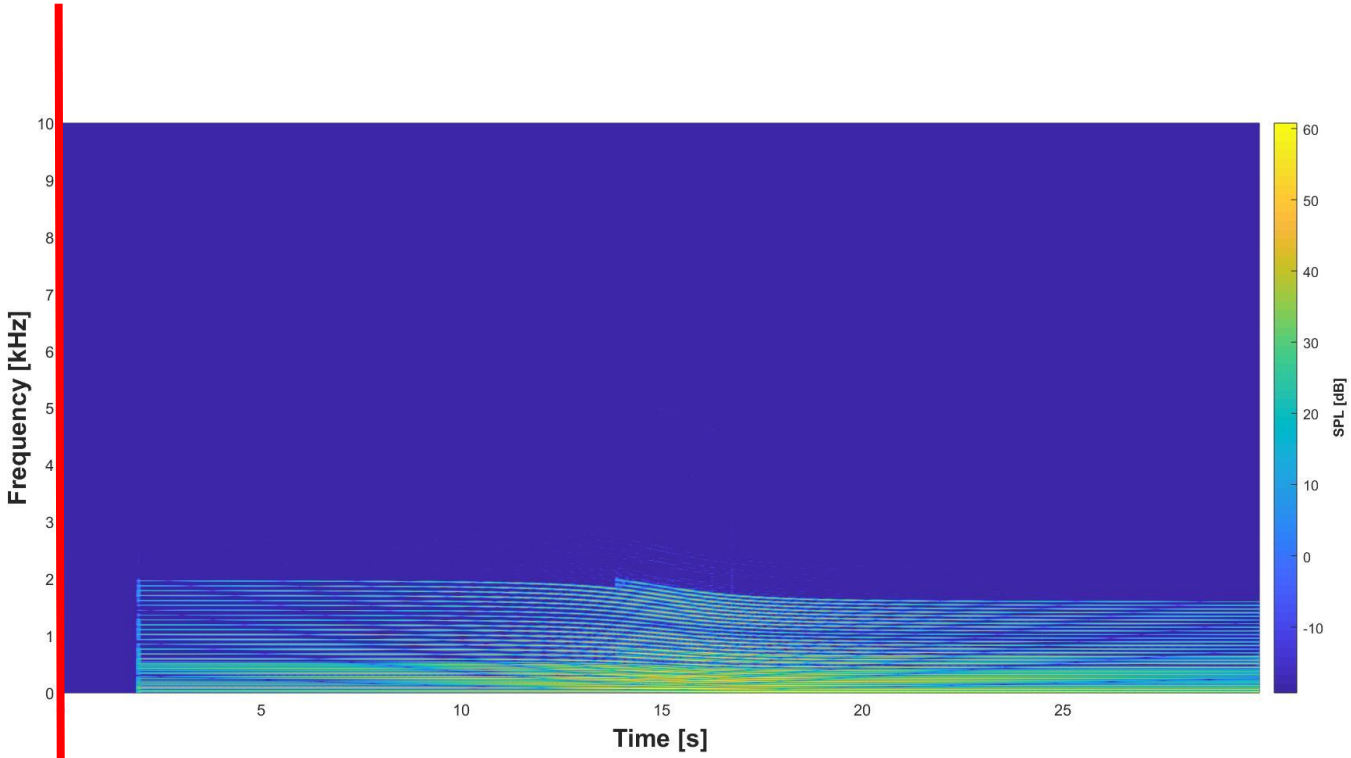
Propagation (5)

- Tonal Sound + All propagation steps



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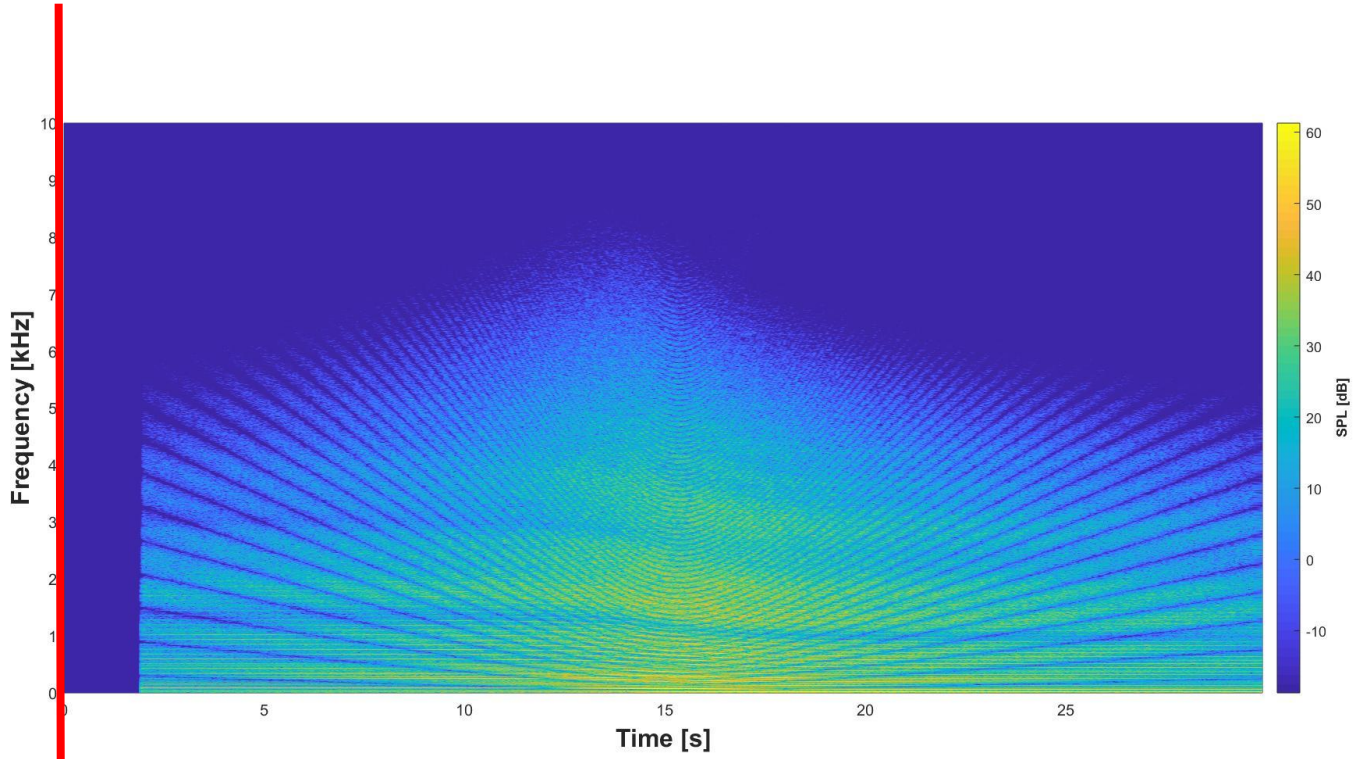
Propagation (6)

- End result: broadband + tonal



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Auralization of Propeller noise

- Both broadband and tonal sound are required for a realistic auralization of propeller noise.
- Comparison with real fly-over has to be made (e.g. Pipistrel fly-over recordings)
- Implementation in the VCNS

Thank you

- Questions?