

Developing solutions to tonal noise from wind turbines using COMSOL Multiphysics

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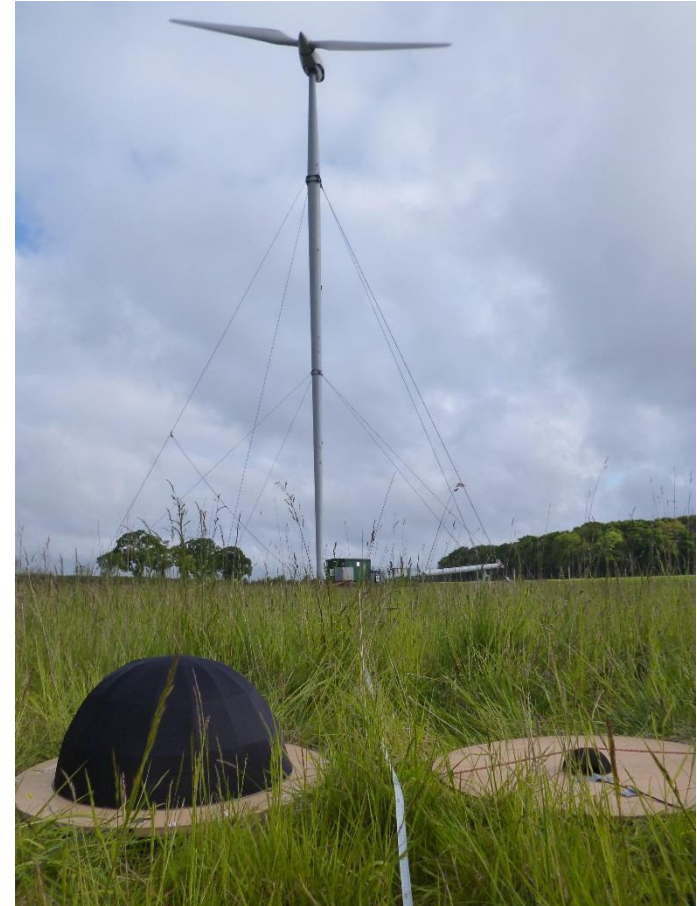
Introduction

- Tonal noise can be caused by frequency matching between tower and rotating components in drive train
 - Tonal noise from wind turbines can lead to health issue
- Strict regulatory penalties



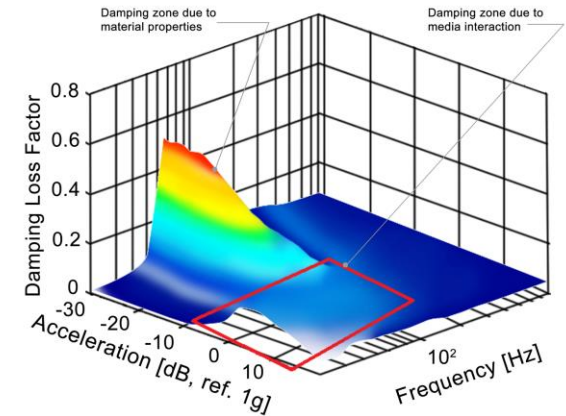
Introduction

- Possible mitigation retrofitting solutions:
 - Limit rotor speed
 - Constrained layer damping
 - Tuned mass dampers
- Mitigation solution modelled here based on advanced particle damping



Advance Particle Dampers

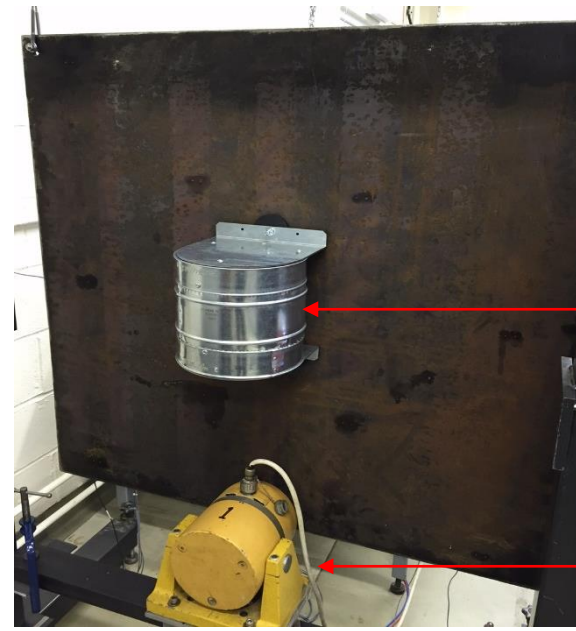
- Containers filled with EniDamp™, an advance particle damping material (so-called APD pods)
- APD pods magnetically attached to tower walls
- Broadband damper
- Mass of APD pods 5% of active mass of tower



Ott M, Weisbeck J, Gerges SNY, Bustamante, M. The effectiveness of particle damping for use on vertical surfaces; Proc INTER-NOISE 2014; 16-19 November, Melbourne, Australia 2014

Experimental data for APD pods

- Aim: determine structural parameters of APD on tower
- APD pod on 1m x 1m x 12 mm steel plate
- Apply force by shaker
- Measure surface acceleration at 12 sensors



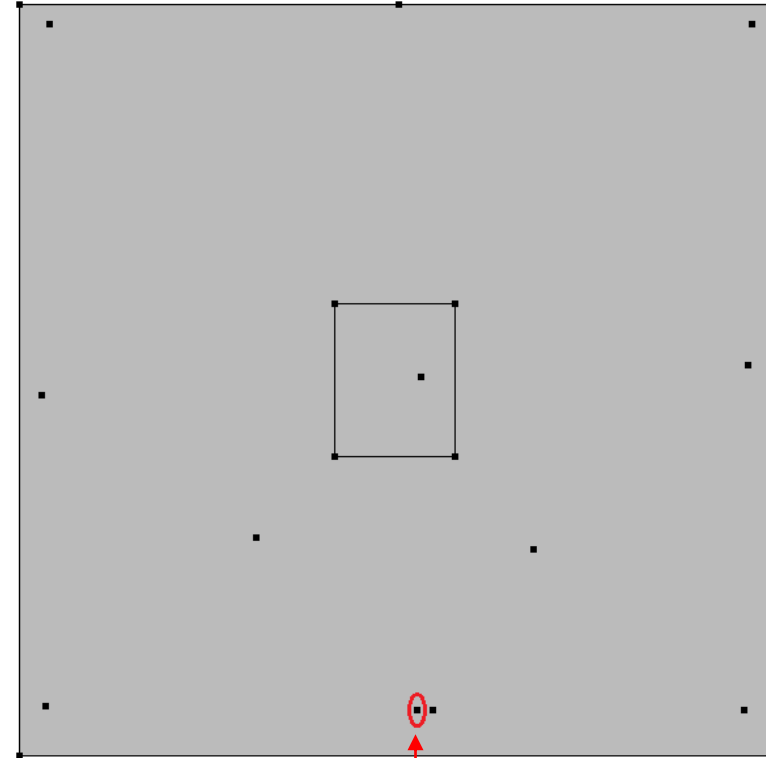
APD
pod

Shaker

Model of APD pod as part of tower

- Determine structural properties:
 - Density (combined mass of place and APD pod)
 - Young's Modulus not changed by presence of APD pod
 - Damping ratio as a function of frequency

→ determine reduction of surface acceleration of tower



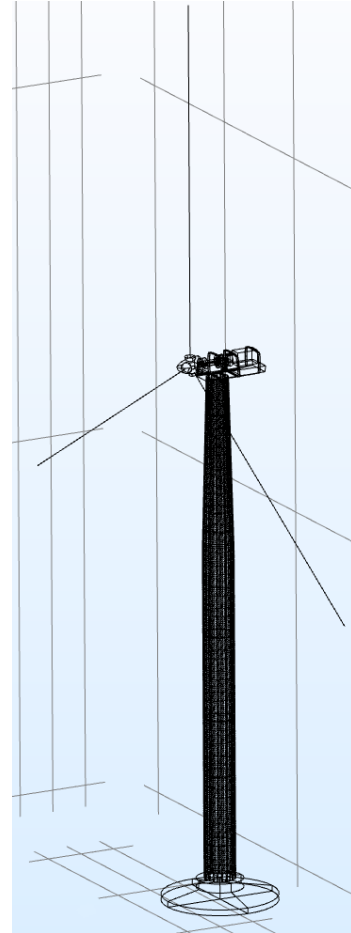
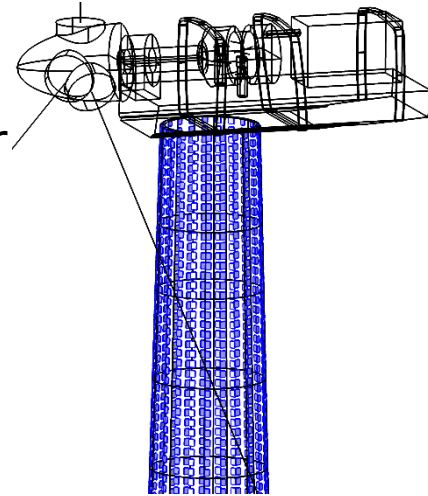
Shaker

Structural-acoustic model

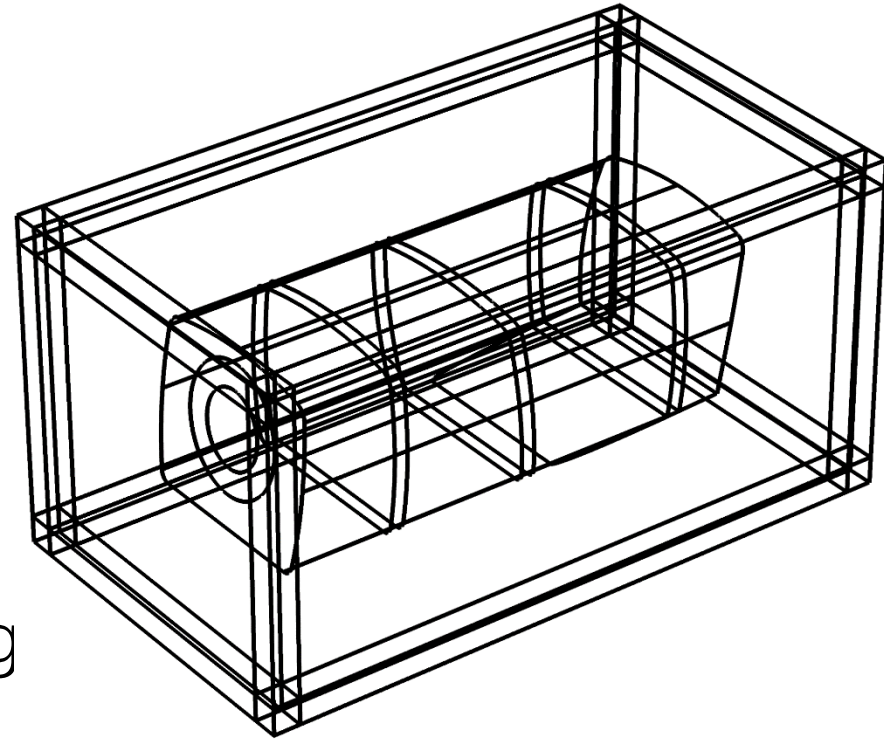


- Structural model to determine acceleration of blades and tower
- Acoustic models for the sound pressure level (SPL) from tower and blades
- Structural-acoustic model to determine the surface acceleration of nacelle and SPL in far field

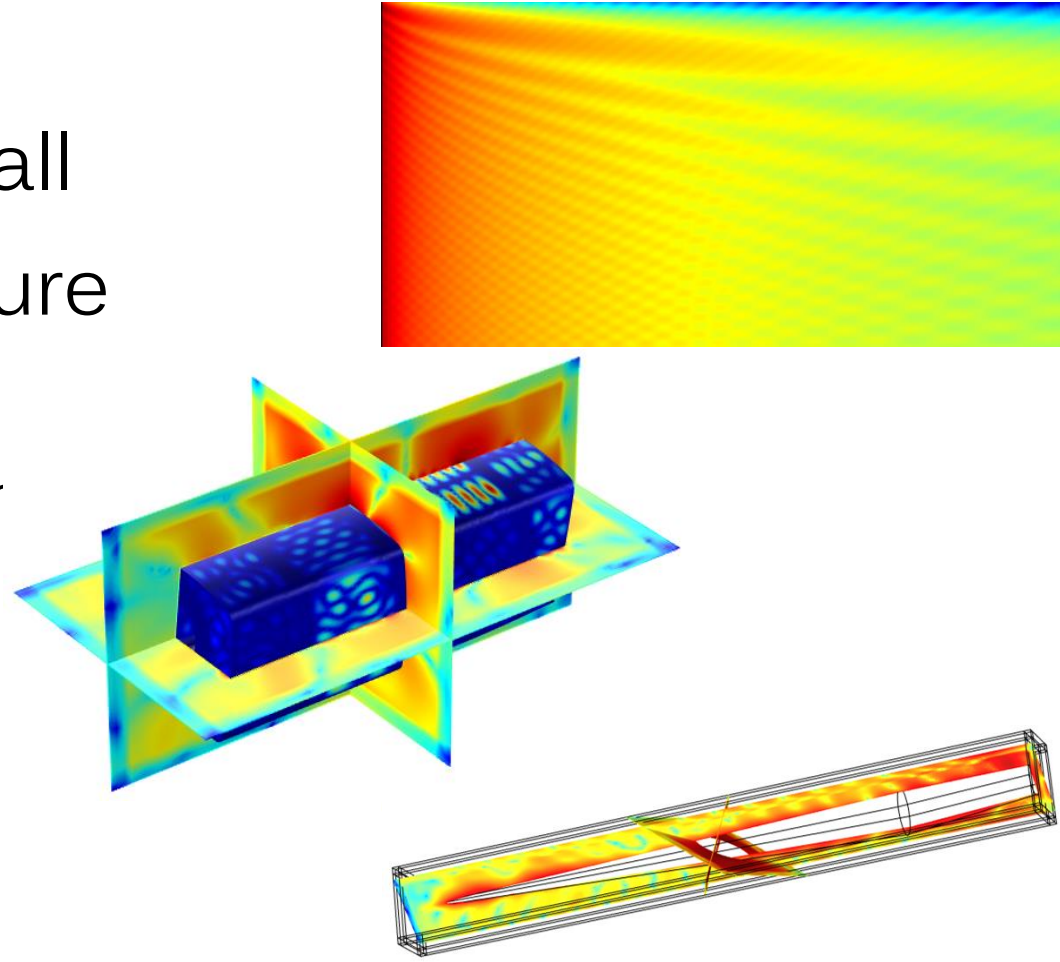
- Structural model of tower and blades:
 - Tower, blades, drive train, foundation
 - May include APD pods on tower wall
 - Shell, beam and solid elements
 - Excited using force related gear meshing



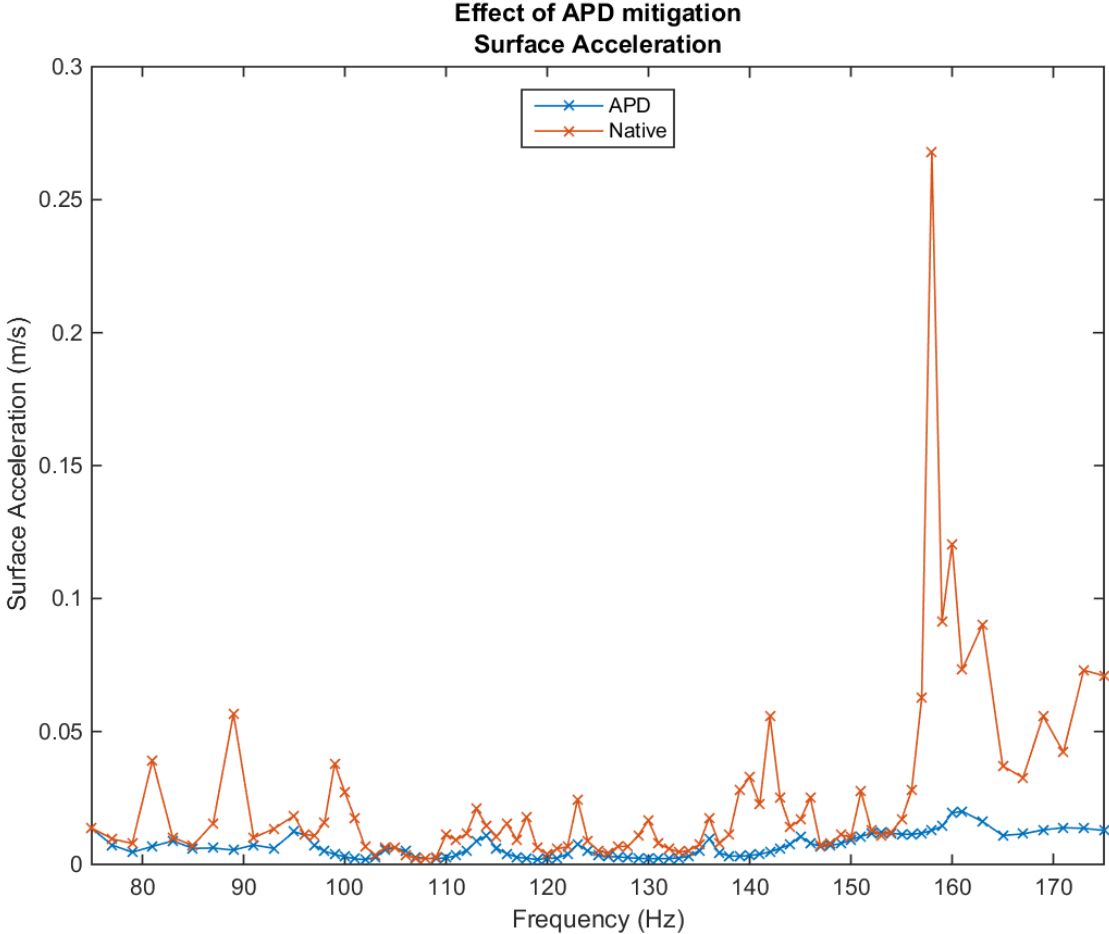
- Structural-acoustic model of nacelle:
 - Nacelle walls with air domain with perfectly matched layer (PML)
 - Shell elements
 - Coupled to component 1 through Multiphysics coupling



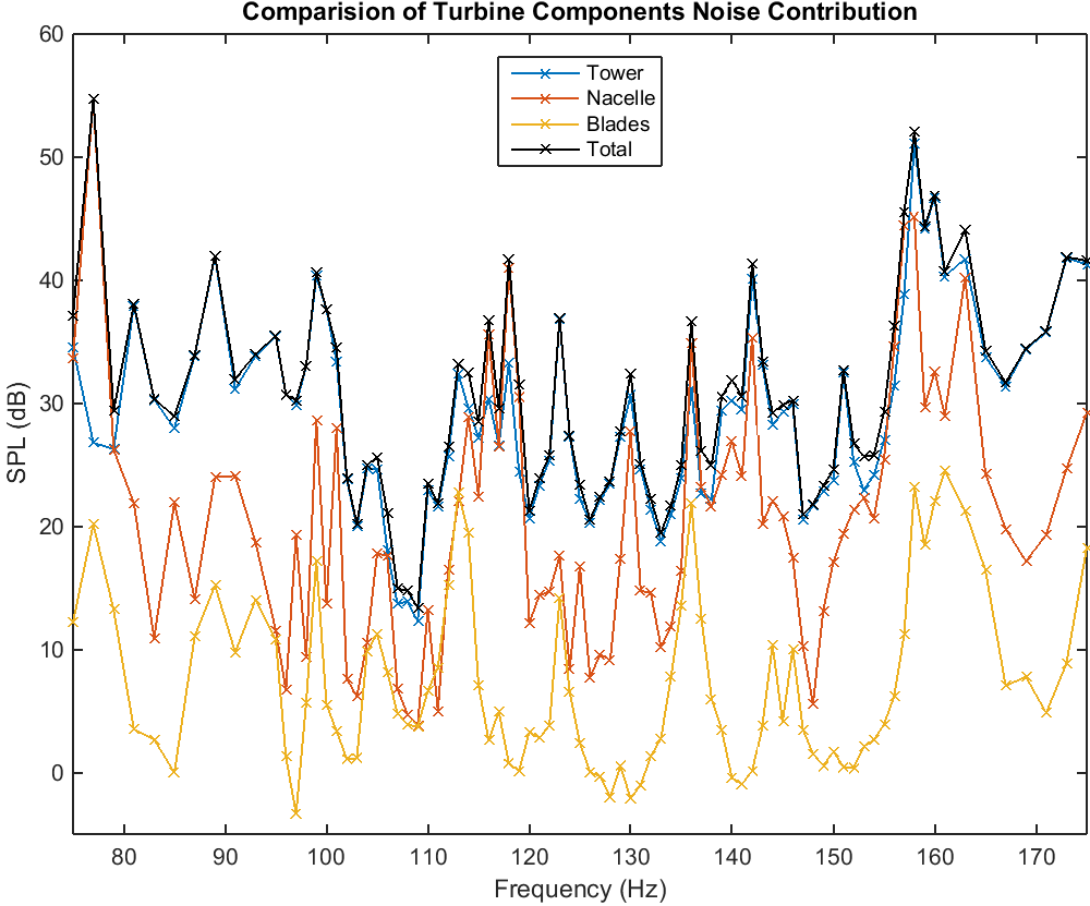
- Determine surface acceleration of tower wall
- Determine sound pressure level (SPL) at observer position (tip height) from
 - SPL from tower
 - SPL from nacelle
 - SPL from each of the blades



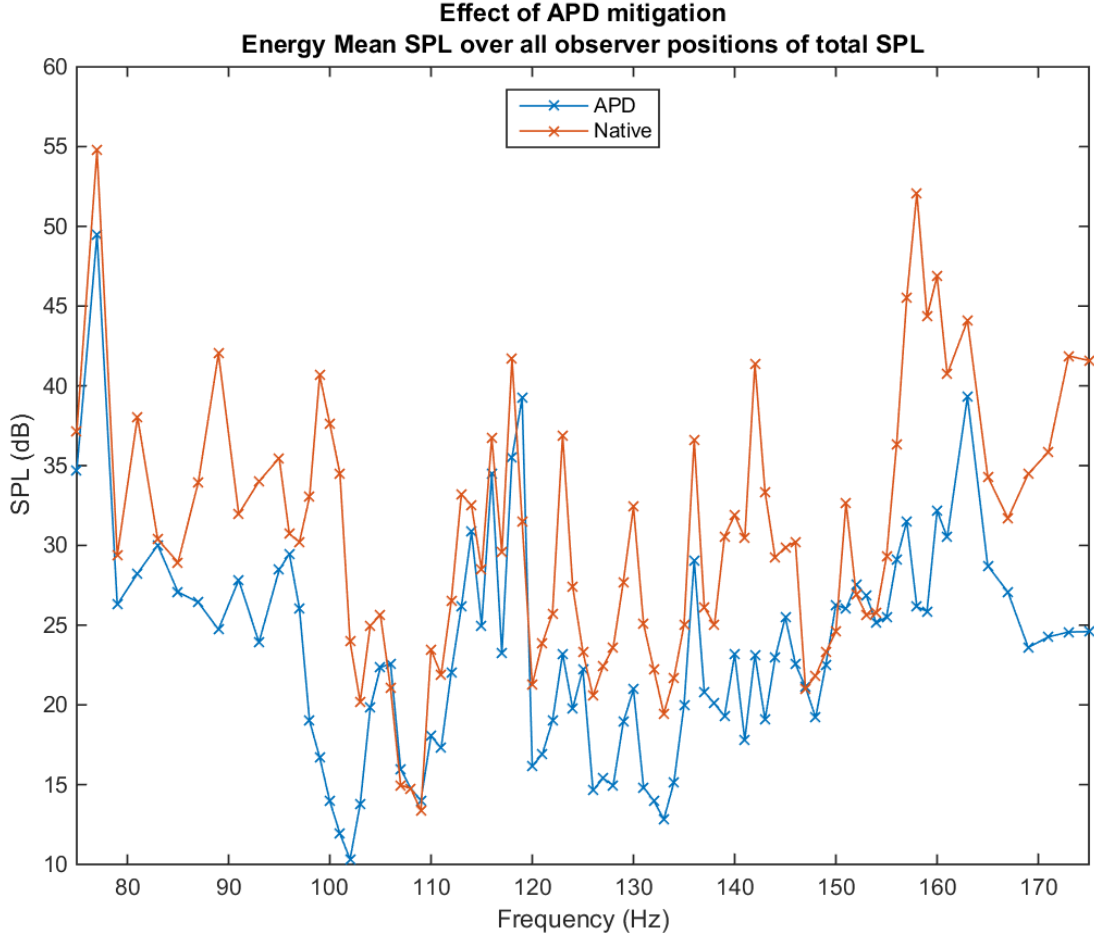
Results – Surface acceleration



Results – SPL contribution



Results – SPL



Conclusions

- Placement of APD pods increases damping properties of tower wall leading to reduction in tonal noise
- Increase tonal reductions by optimising APD pod placement

Thank you for listening!

Dr Jutta Stauber

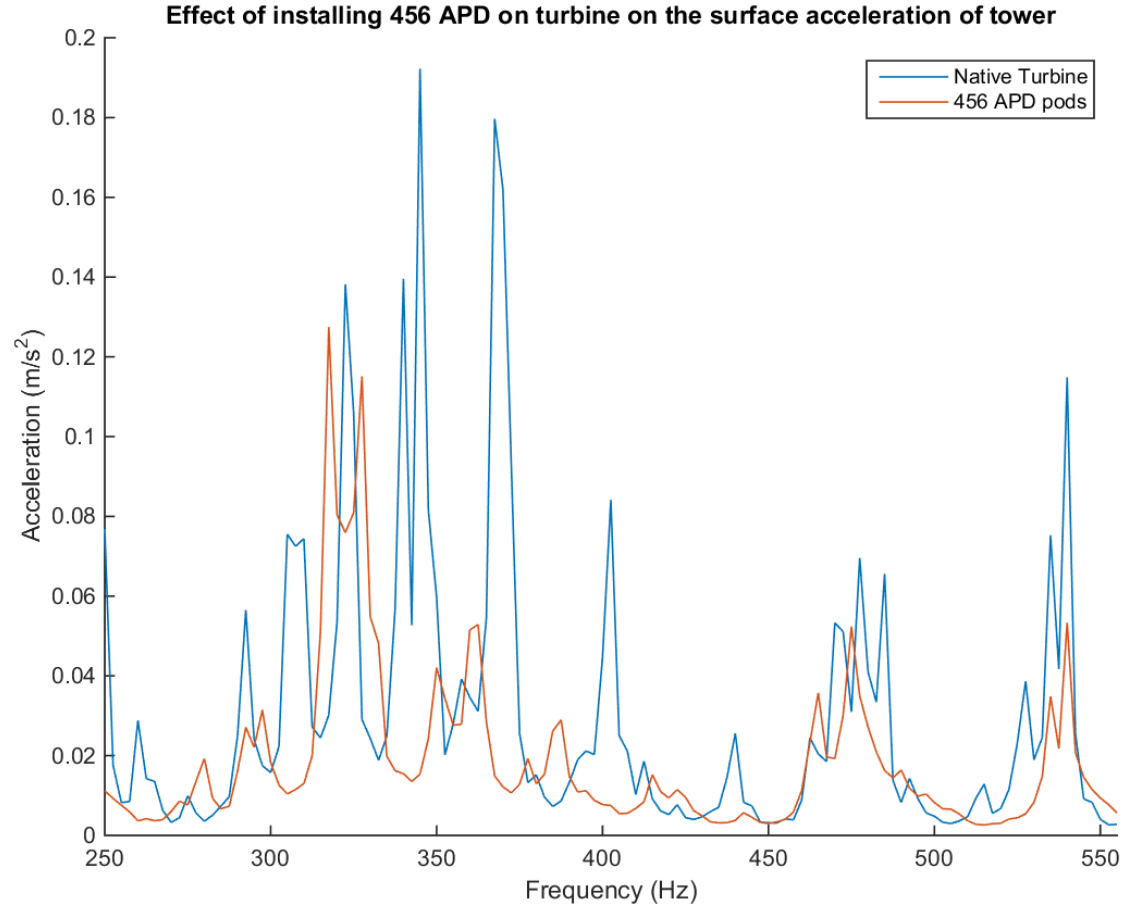
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Broadband – Surface Acceleration



Broadband - SPL

Effect of installing 456 APD on turbine on the sound pressure level measured at tipheight

