reactec

MODELLING AND ANALYSIS OF ACOUSTIC EMISSIONS AND STRUCTURAL VIBRATIONS IN A WIND TURBINE

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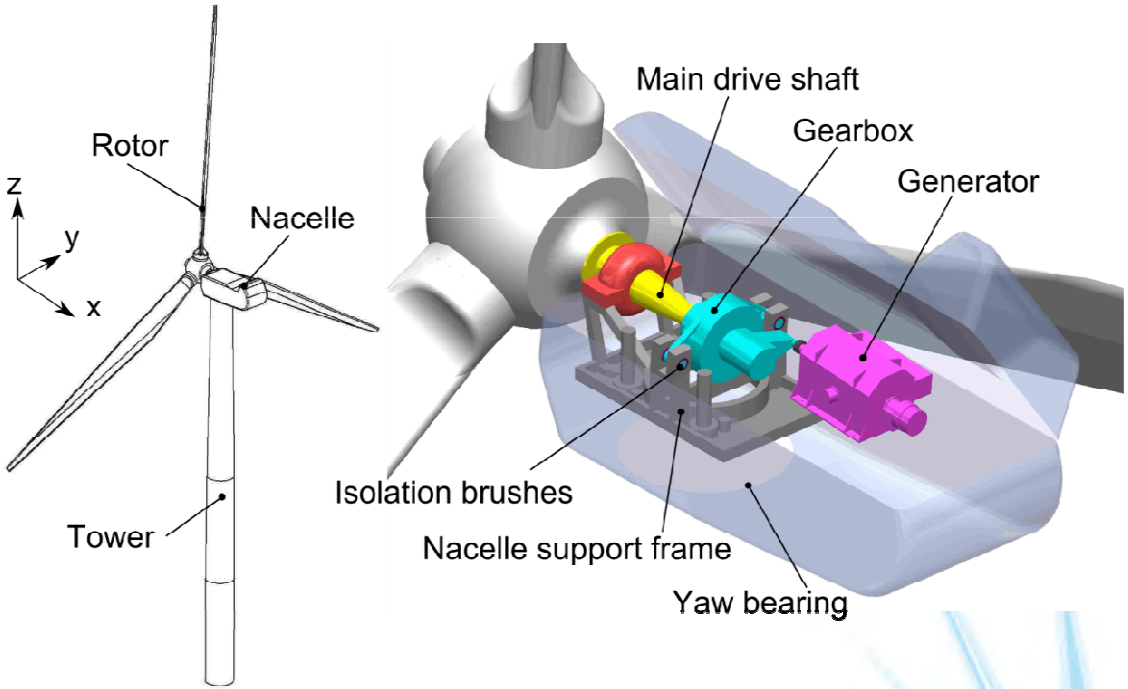
Introduction

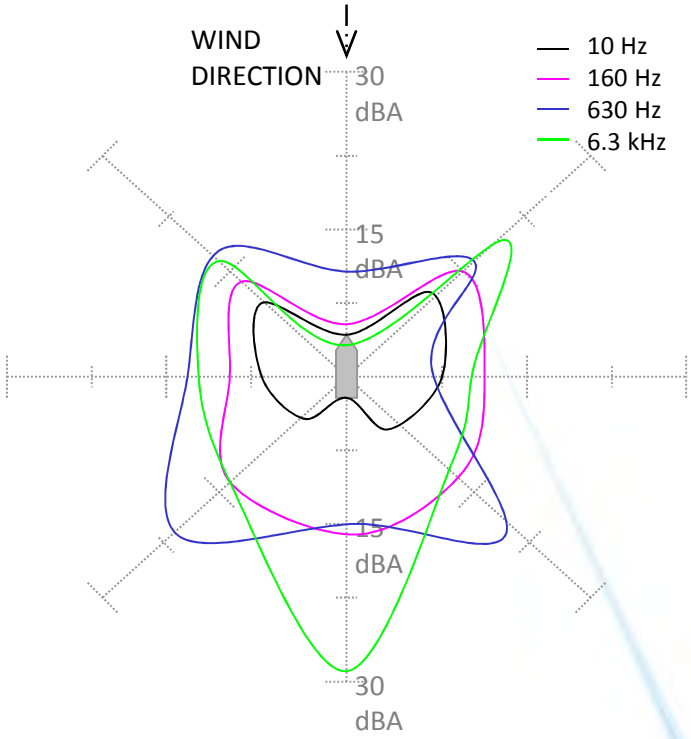
- Environmental noise produced by wind turbines can impinge of residential communities
- Tonal noise is a particular nuisance and therefore incurs heavy regulatory penalties
- Reactec were employed to identify the source of problematic ~600 Hz tonal noise from a megawatt scale wind turbine
- COMSOL Multiphysics was used to identify structural amplification sources and to design a cost-effective solution

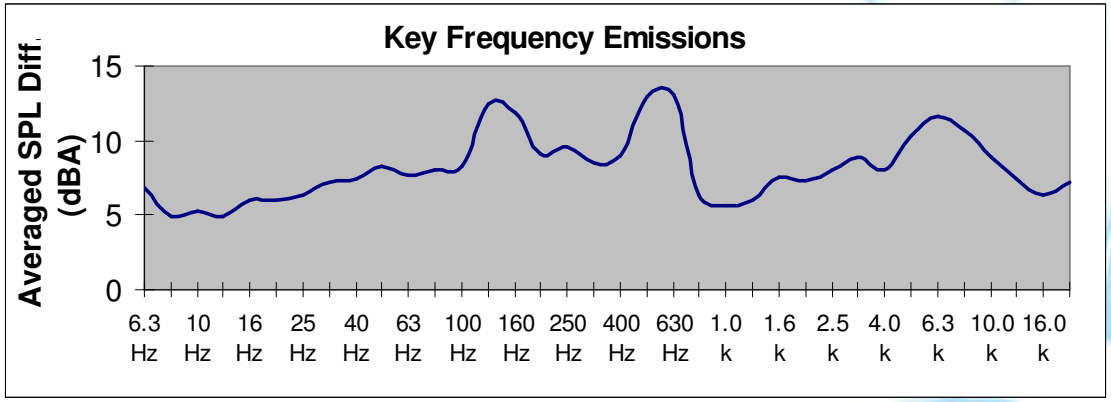
Mechanical sources of vibration and noise in a wind turbine

- The turbine manufacturer identified a tonal frequency ~ 600 Hz
- This coincides with the gear meshing frequency in the gear box

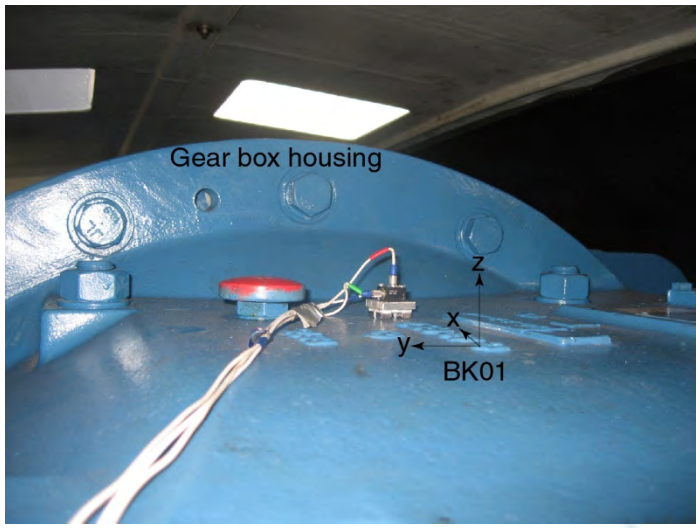


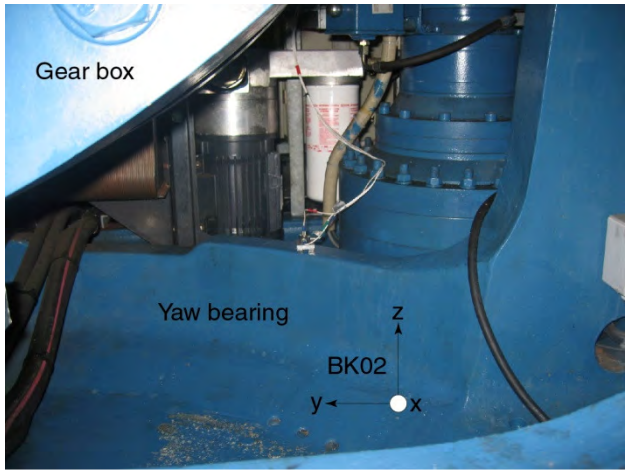
Identifying tonal component



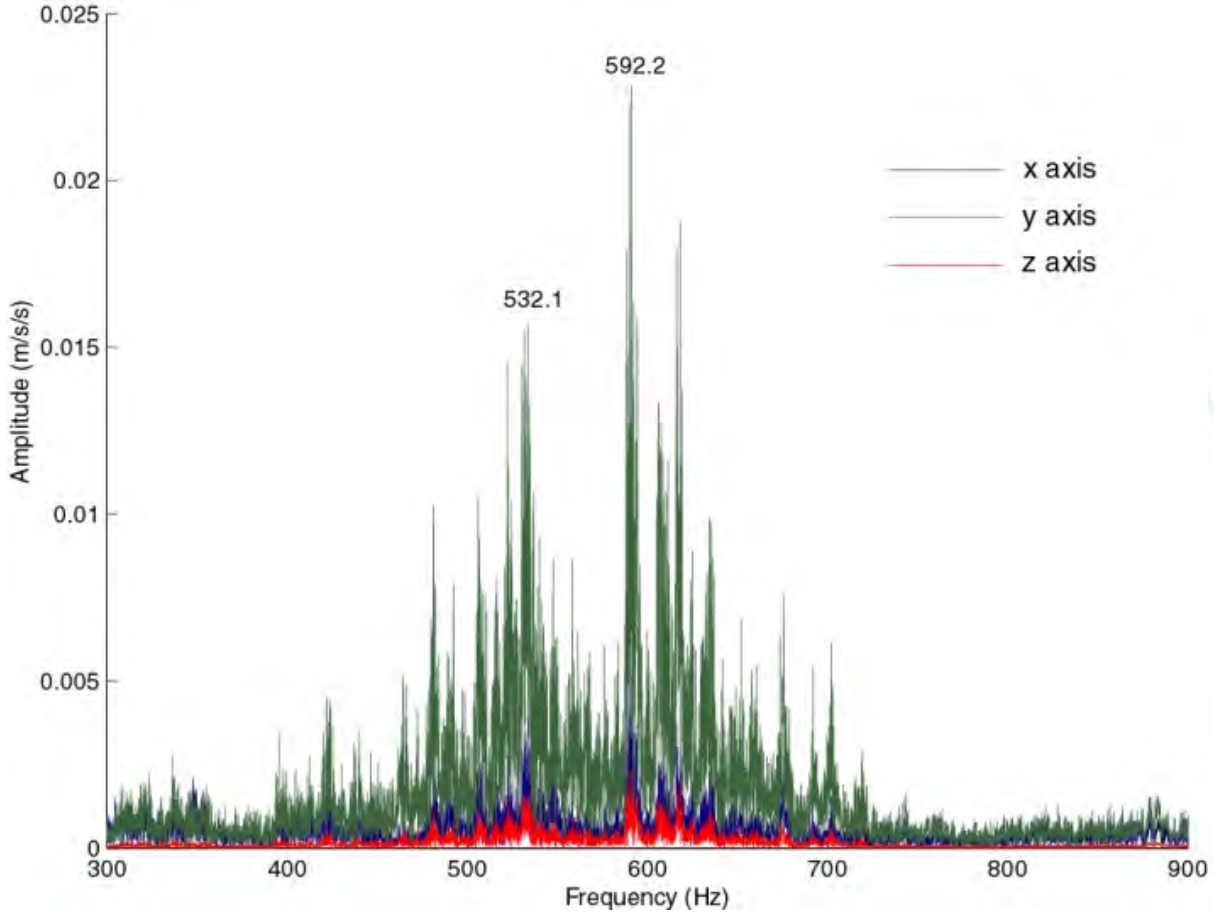


Vibration survey

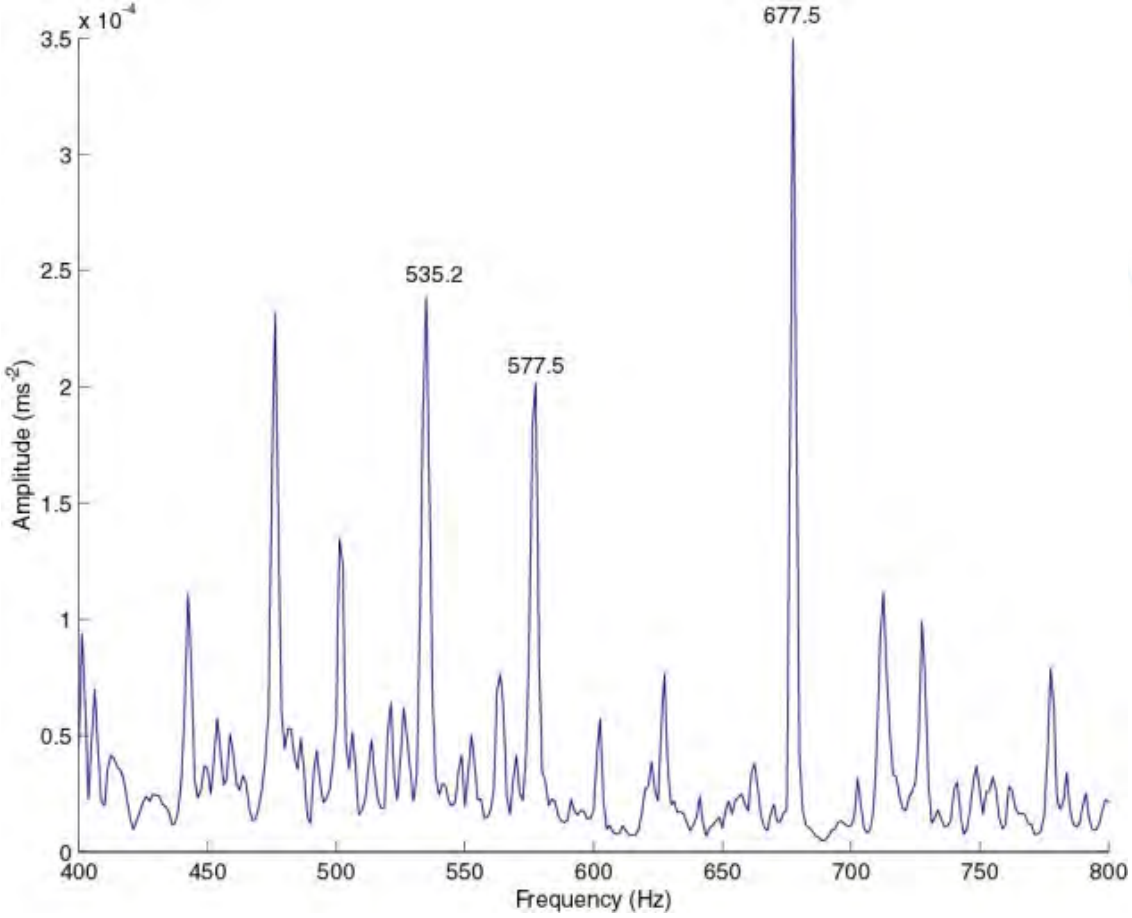




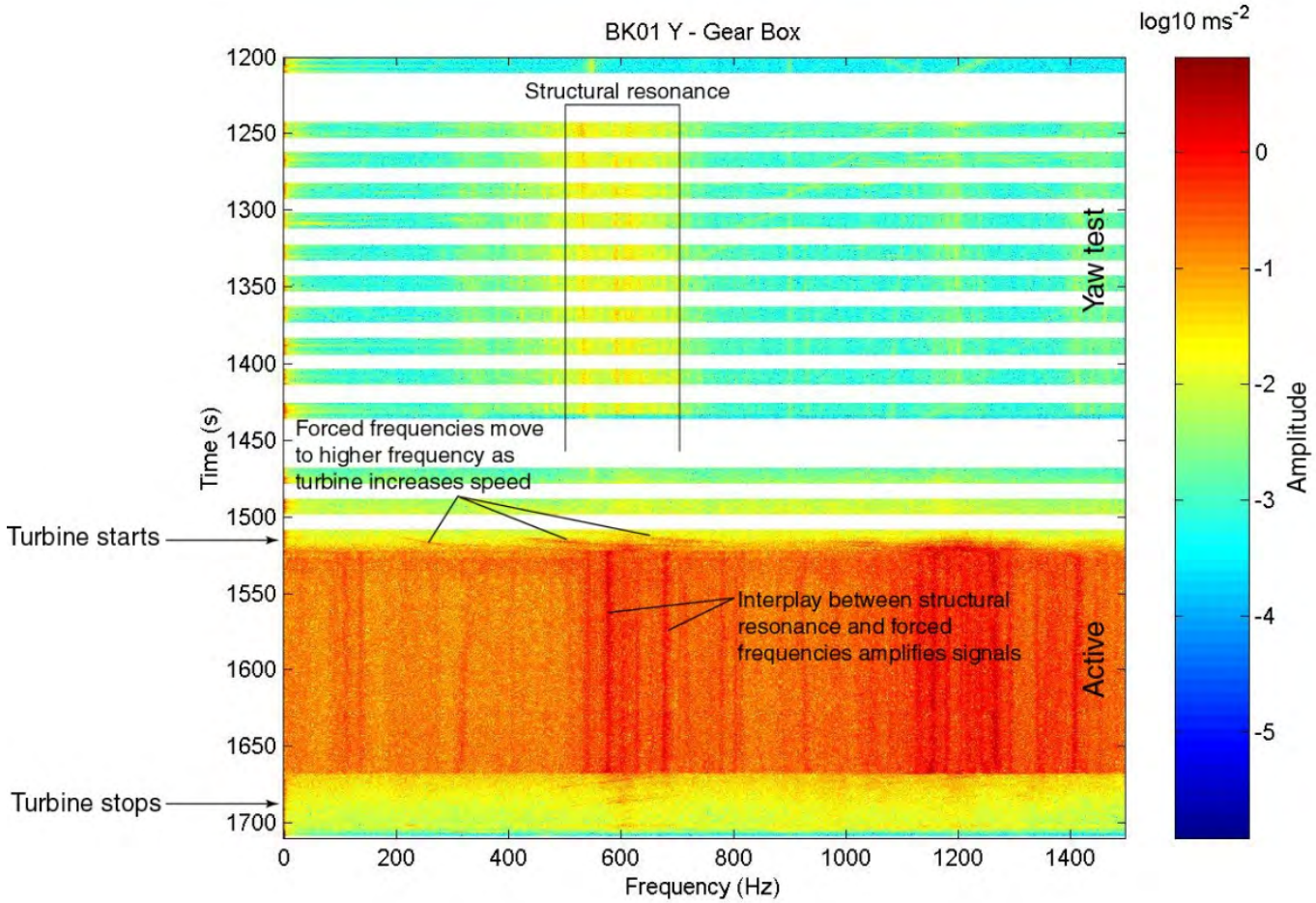
Yaw test to excite resonances – Gear Box



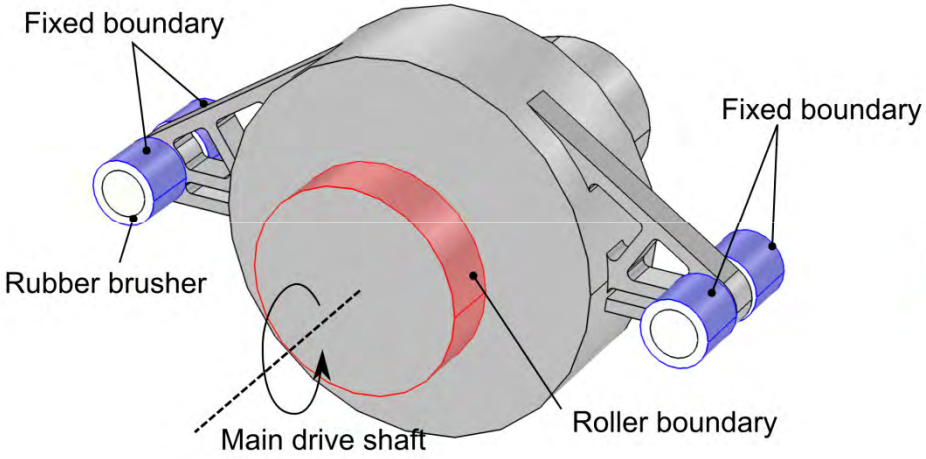
Yaw test to excite resonances – Tower Skin

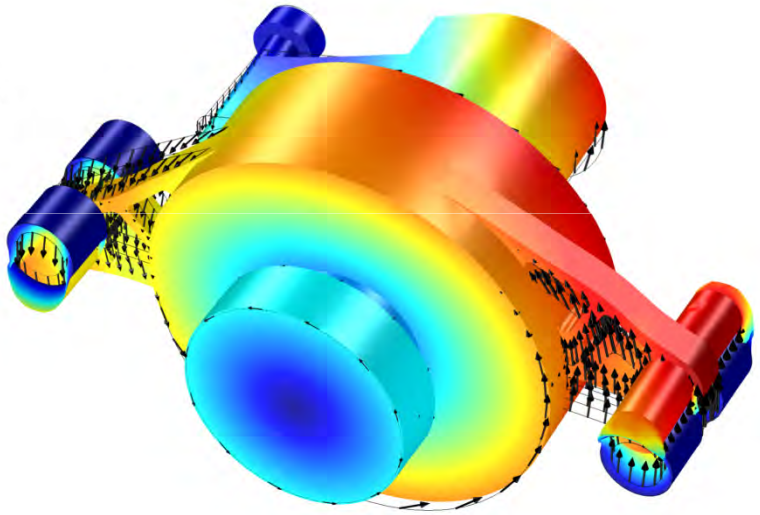


Turbine active test



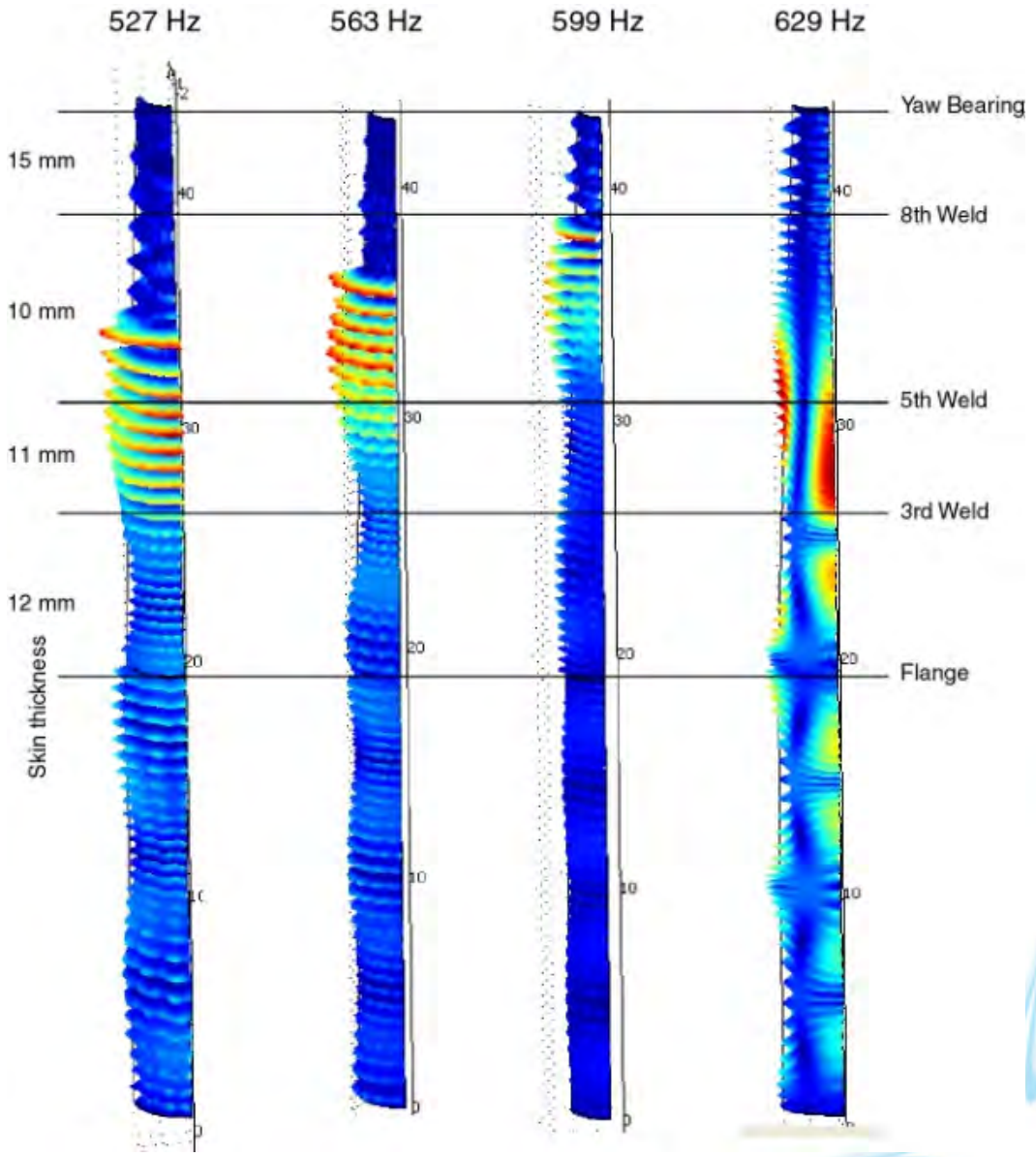
Gearbox 602 Hz modal shape



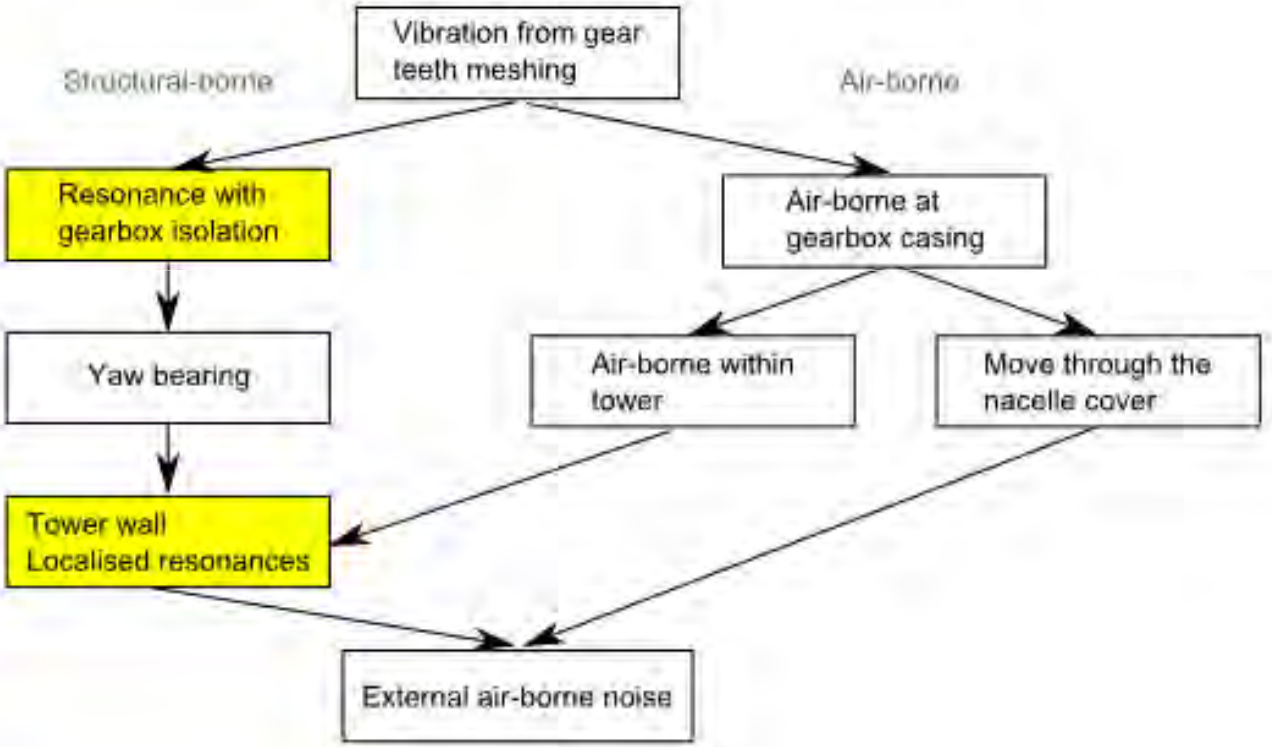


Skin frequencies

- The tower of this particular turbine is made up of two sections of tubular steel of varying thickness
- COMSOL Multiphysics was used to identify hot spots where ~600 Hz vibration are amplified

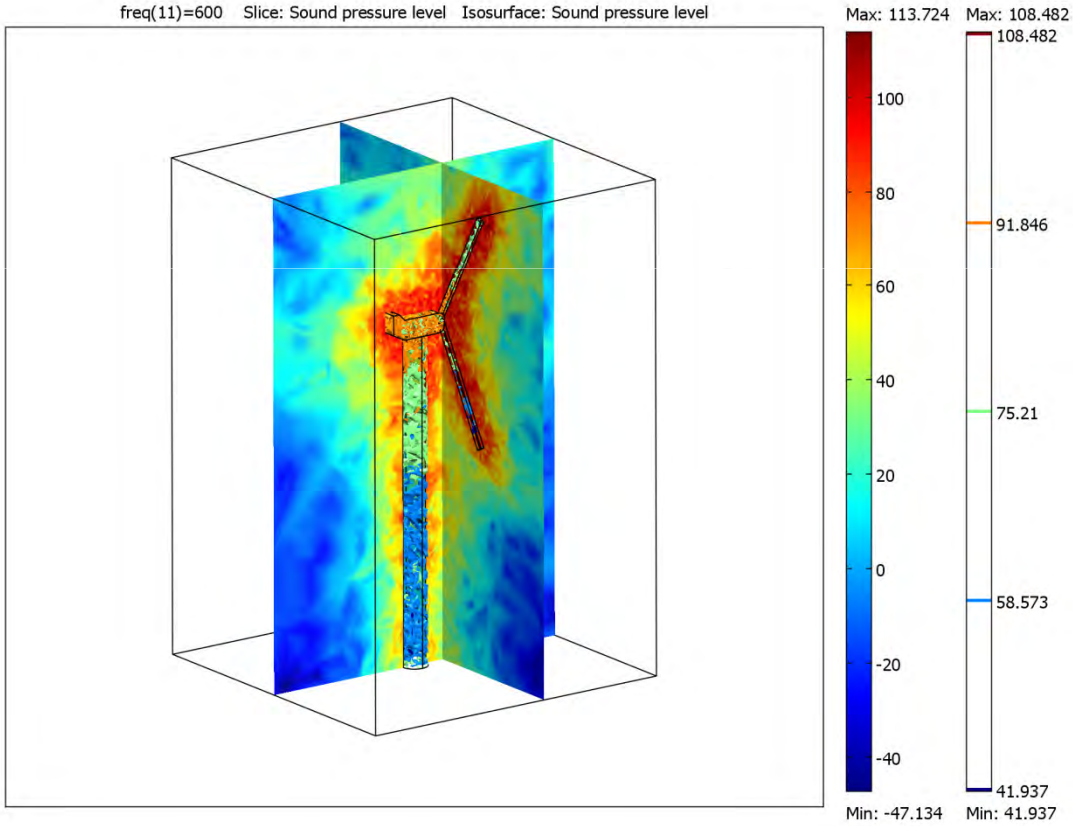


Vibration – noise pathway



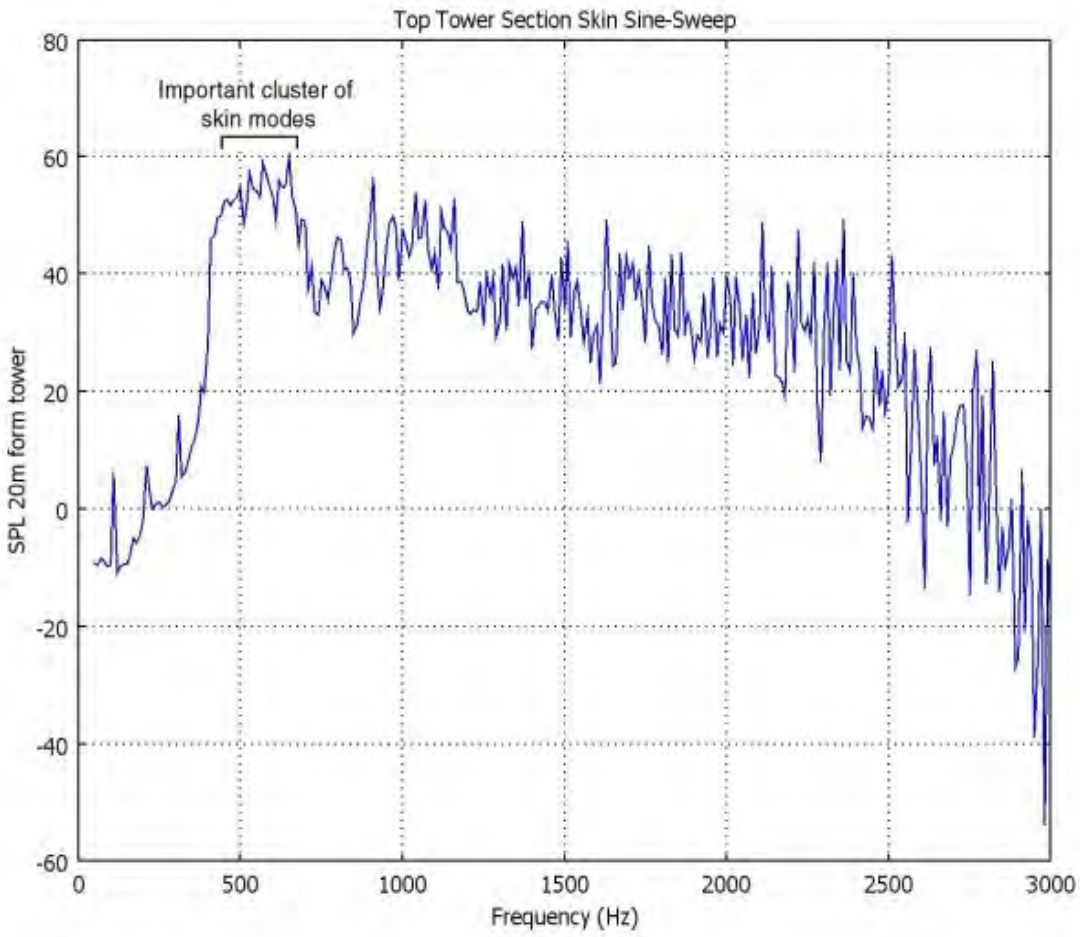
Acoustic-structural interaction model

- Combines three acoustic time-harmonic models with a frequency response model using shell elements:
  - Air in nacelle
  - Air in tower
  - Air external
- Excite with a vibration source in the tower over a range of frequencies from 5 to 3000 Hz

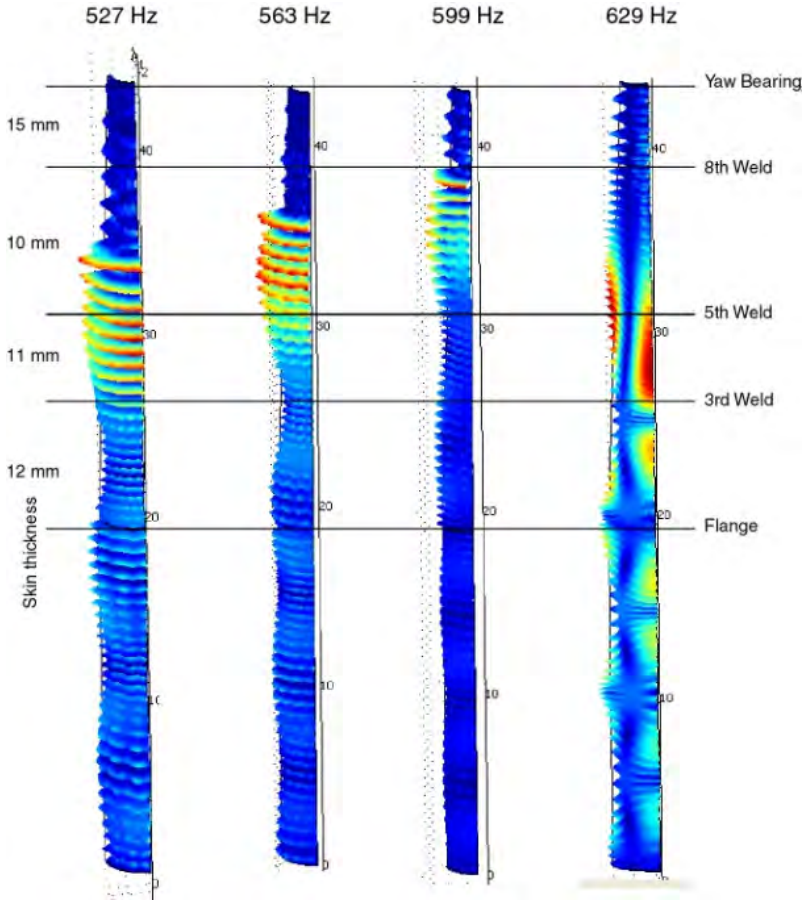


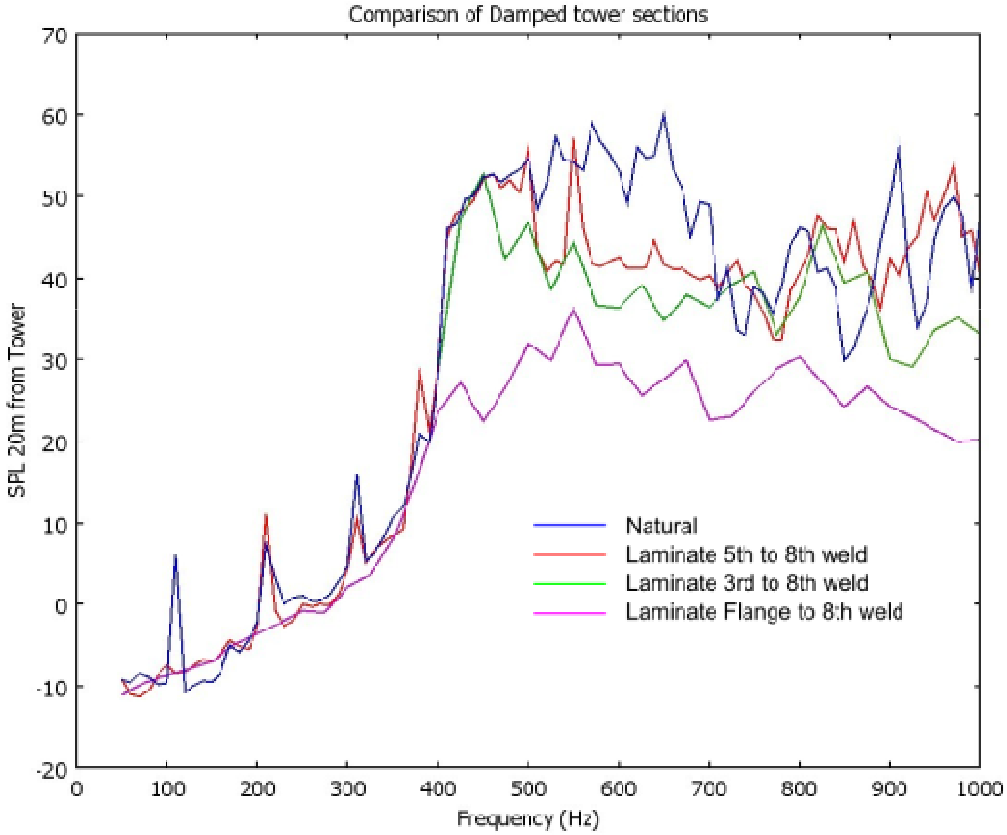
Acoustic-structural interaction model

- Results of native state model:
  - Sound pressure level as measured 20 m from the base of the tower



Acoustic-structural interaction model





Conclusion

- COMSOL Multiphysics was used to identify the modal shapes of structural resonances that amplify ~600 Hz tonal noise
- The identification of modal shapes help identify the vibration pathway from gearbox to external air-borne noise
- Acoustic-structural interaction models were used to target acoustic hot spots and develop a cost-effective solution