Dedicated to innovation in aerospace

From (CTS) wind tunnel data to noise impact assessment

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Introduction

Current best practice:

- Aerodynamic test in Closed test sections (CTS)
- Acoustic tests in open test sections (OTS)

Preferable to use acoustic results obtained in CTS

- Scaling effects
- Geometric near field effects

Measurements only available at limited number of radiation angles

Desired are EPNL and noise impact assessment

Approach

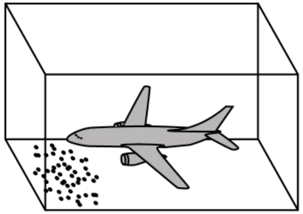
- Public domain semi-empirical noise radiation models
  - calibrated against the CTS data
- We have limited ourselves to airframe noise
  - Flap side edge noise
  - Slat noise
  - Trailing edge noise
  - Landing gear noise

- Reconstruction of aircraft noise directivity by ad-hoc calibrations
- EPNL and assessment of environmental impact

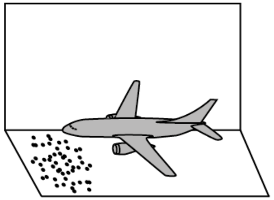
4-step approach

Acoustic windtunnel measurement

Isolation of sound sources

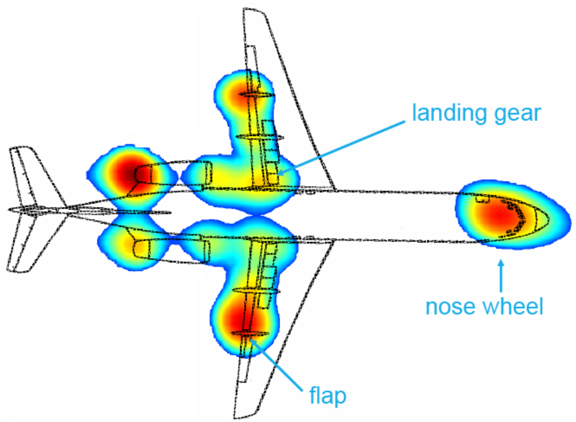


Acoustic wind tunnel measurements

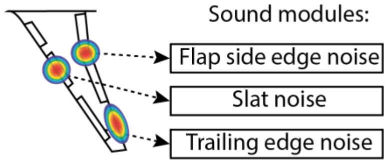


- The sound strength from different sound sources on the model are obtained with phased microphone measurements.
- Diagonal removal is employed to remove boundary layer noise

- Measurements in CTS are performed in geometric near field:
  Every source
  - is located at a different distance
  - emits with a different angle to the array

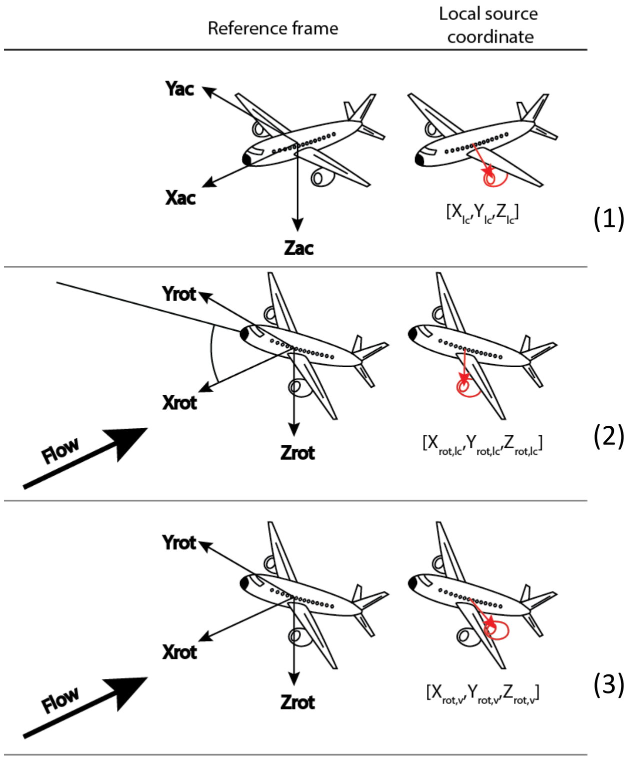


Calibration of sound modules



- Sound source modules are calibrated at the local emission angle

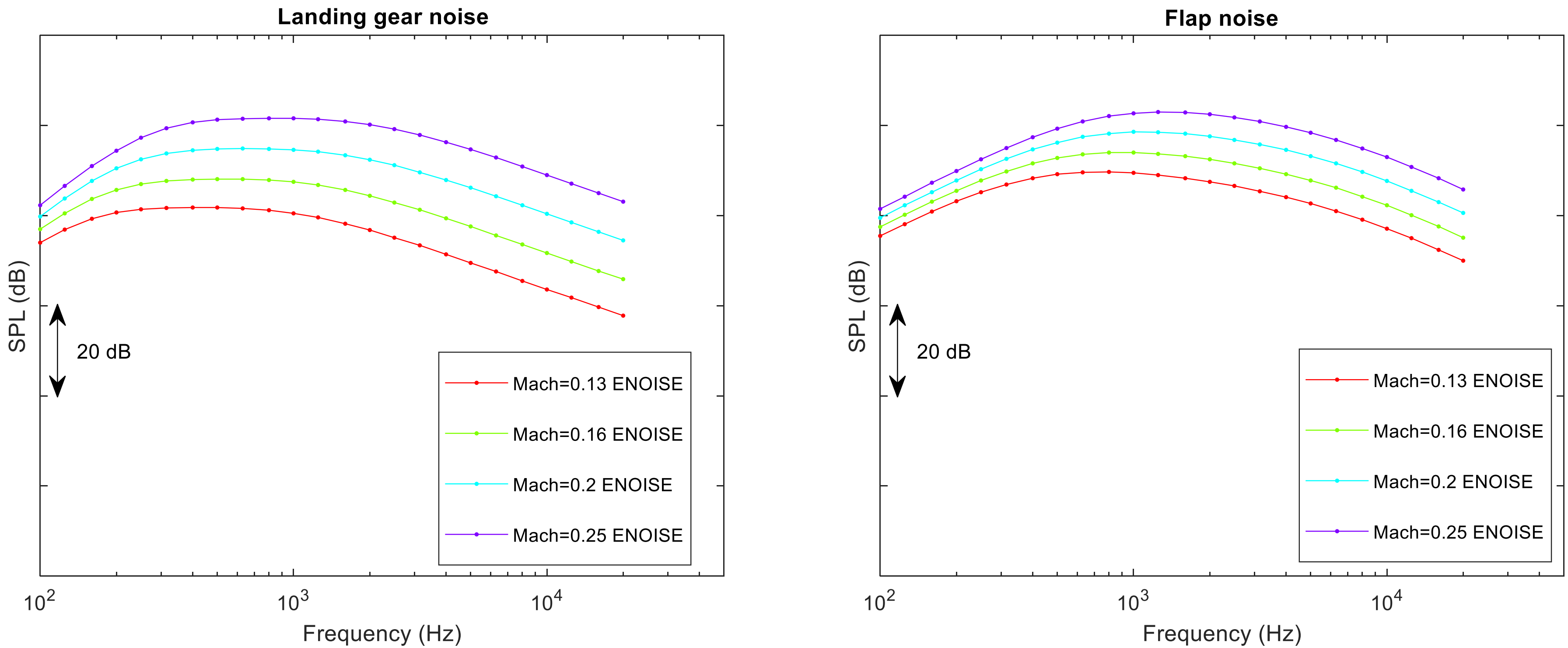
1) Local axis system at the centre of the sound source
2) Transformation to inertial system
3) Calculation of virtual sound source position



Sound source modules

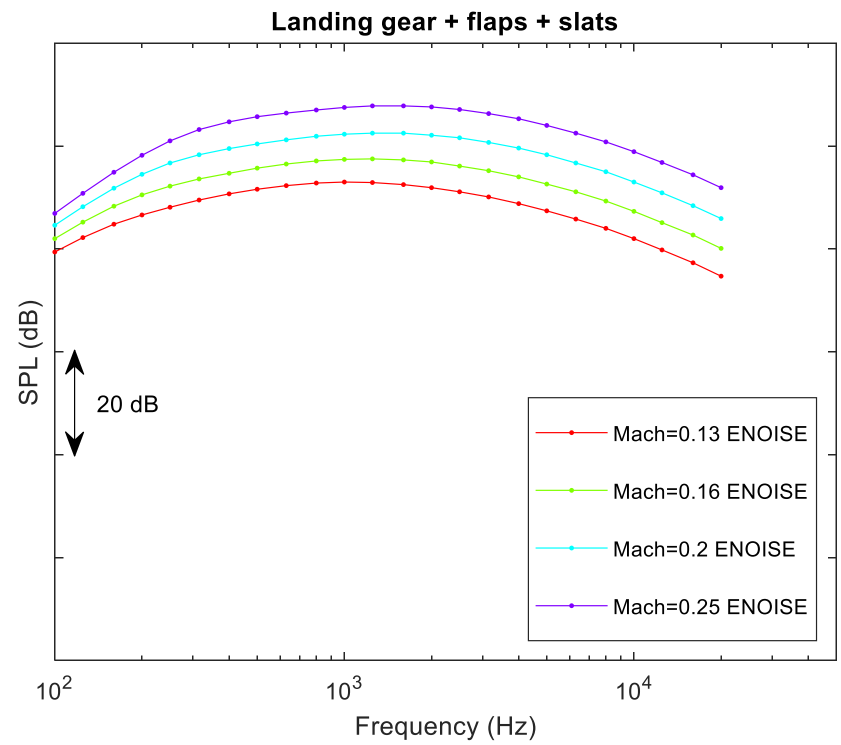
Sound source	Source model	Reference
Landing gear noise • Separate description for nose and main LG • Local flow correction	Guo	- Empirical prediction of aircraft landing gear noise, NASA 2005 - Effects of a local flow variation on landing gear noise prediction and analysis, JOA 2010
Slat noise	Guo	-Aircraft slat noise modelling and prediction, AIAA 2010 -Component-based empirical model for high-lift system noise prediction, JOA 2003
Flap side edge noise	Guo	Aircraft flap side edge noise modelling and prediction AIAA 2011
Trailing edge noise	Brooks, Pope and Marcolini	Airfoil self-noise and prediction, NASA 1989

Calibration of noise modules

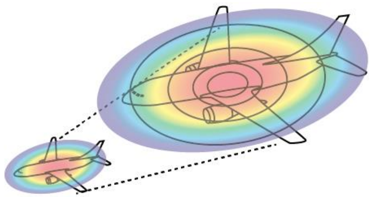


Calibration of noise modules

- Measured noise levels in WT can be reproduced
- Sound levels for different observer positions and conditions can be determined.

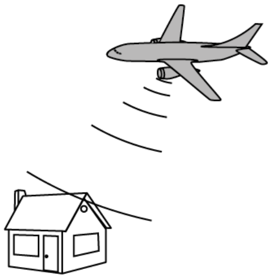


Full scale aircraft sound



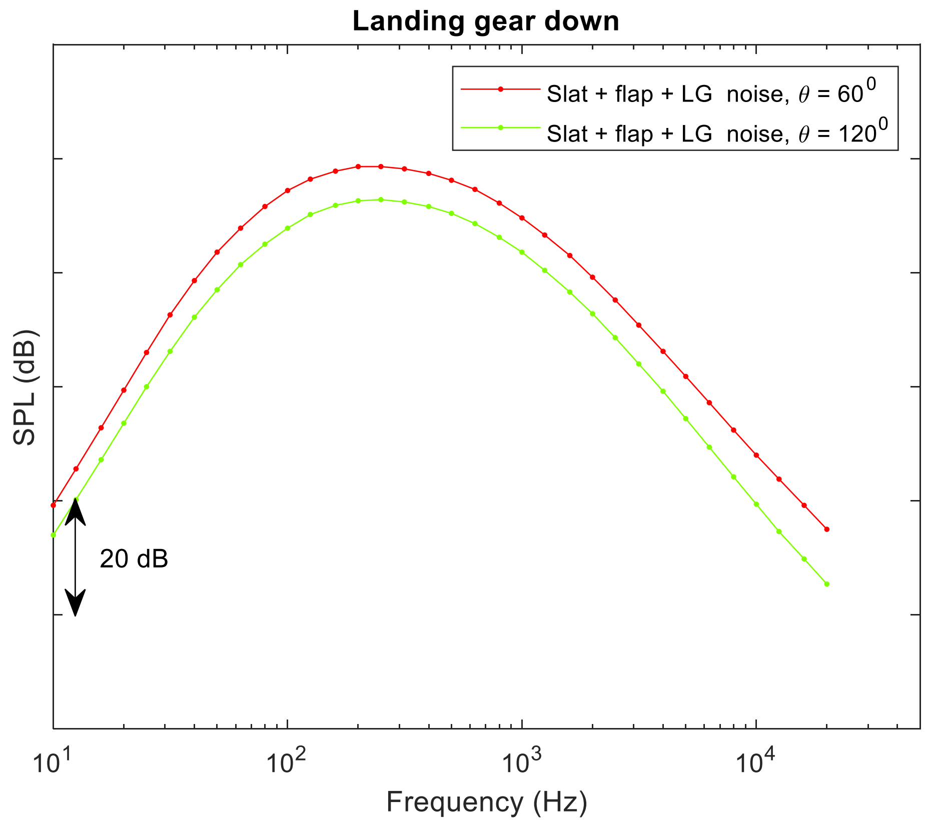
- Full scale predictions by changing to full scale input
  - Strouhal scaling of frequency
  - Correction of levels to account for larger source region
  - Reynolds dependent scaling is used for high lift devices
    (Flap side edge noise and slat noise)

EPNL for noise impact assessment

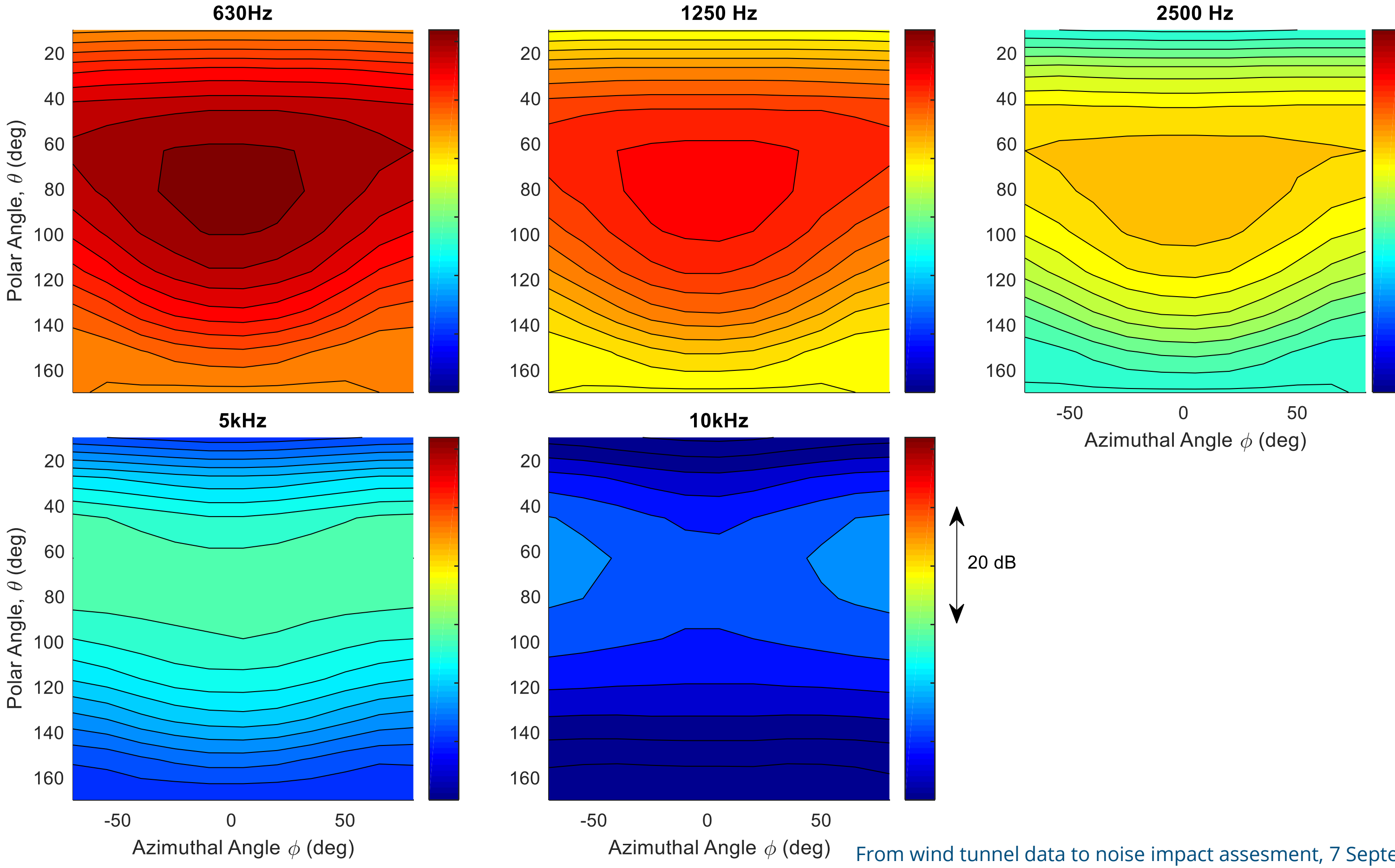


- To assess the noise impact at certification points, levels need to be translated from source to an observer on the ground.
- Propagation effects
  - Spreading losses
  - Atmospheric attenuation
  - Ground reflection
- Doppler frequency shift

Prediction of fly-over data



Footprints full scale aircraft prediction



Conclusions

- Models from the public domain are used to describe the behaviour of different acoustic sources.
- Acoustic sources are treated separately to correct for:

  Different distances, emission angles in the CTS and scaling effects

- Translation of acoustic CTS measurements to:
  - Emission footprints for full scale airplane and airplane parts
  - Effective Perceived noise levels for noise impact assessment
  - For different flight conditions

  - Good trend between translated CTS data and fly-over data.

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