Jet-flap interaction noise in model scale and full scale - and the implications for evaluating noise reduction technologies

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Abstract

Jet-flap interaction (JFI) noise consists of both broadband effects and tonal components. The frequency range of the tonal components can be characterized with a cut-on and cut-off frequency [1]. The JFI tones are well-audible and significant for the model scale engines. In addition to this, for very large commercial jet engines (e.g. UHBR class), the (in model scale) high-frequent broadband-like JFI-noise becomes very relevant in full scale.

It can be shown that JFI noise spectra of different model size experiments collapse as expected: Two geometrically similar JFI-experiments were conducted at AWB (large scale) and JEXTRA (small scale) where the model geometries differ by a relevant factor (2.5).

These results indicate, that it is safe to derive full scale spectra from experimental model scale spectra. In order to account for the human hearing, weighting functions can be applied.

A sensitivity study wrt. height gives hints about the relevance of two different frequency ranges of JFI noise, JFI noise below and above the tonal cut-off frequency.

Scaled experiments

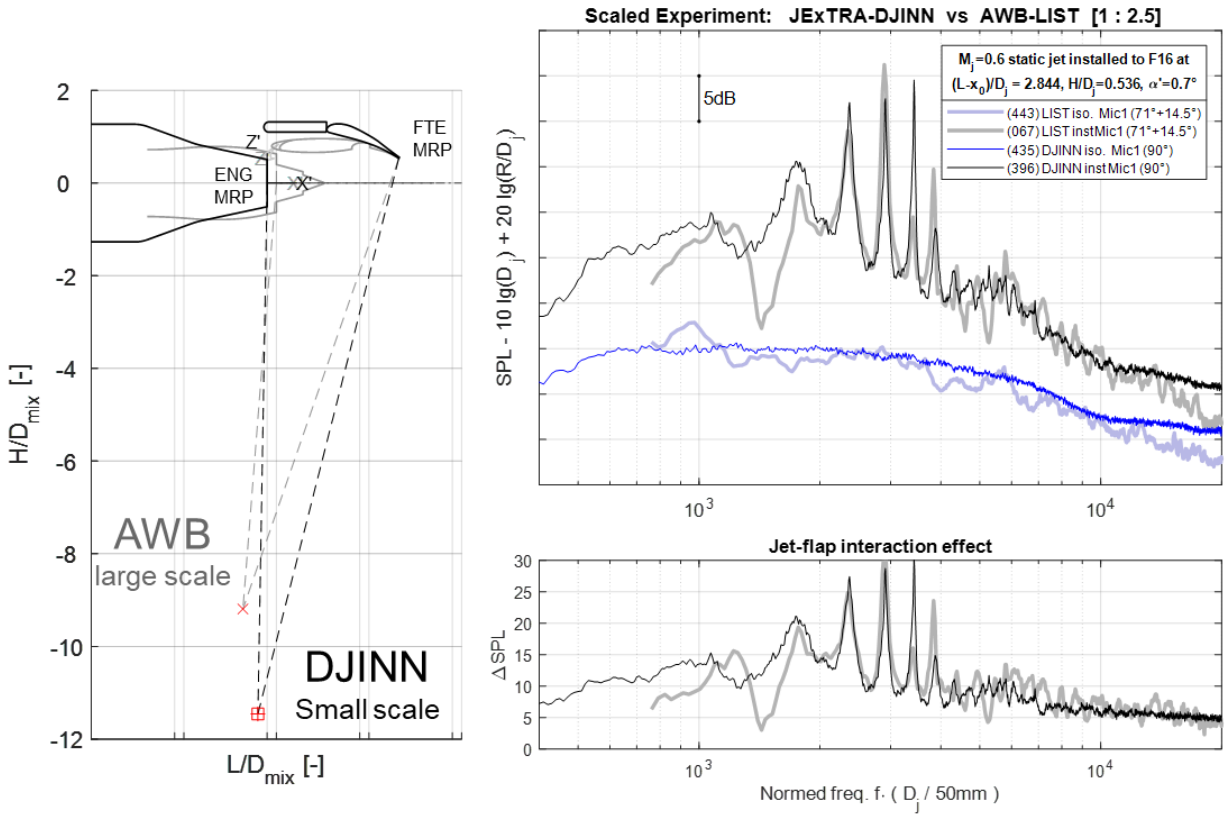

Fig. 1 Scaled experiments: Non-dimensional geometry (left), scaled spectra for jet-flap interaction and isolated engine (top), JFI-effect (bottom)

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Even though the premises for the comparison are somewhat questionable (open-circuit vs. closed circuit wind tunnel, remotely vs. closely located compressor, inclined vs non-inclined model installation, mics not corrected, temperature differences not corrected), the measured JFI effect is remarkably similar.

Height sensitivity study

A height sensitivity study shows that beneath the impressive low-frequent broadband and tonal JFI-effect, there is a significant broadband-like offset for very high model frequencies. This offset can be seen in this data for full-scale frequencies of f>200 …300Hz. The frequencies higher than approximately the tonal cut-off frequency can show an inverse sensitivity when compared to the low-frequent part of the spectrum (see Fig. 2).

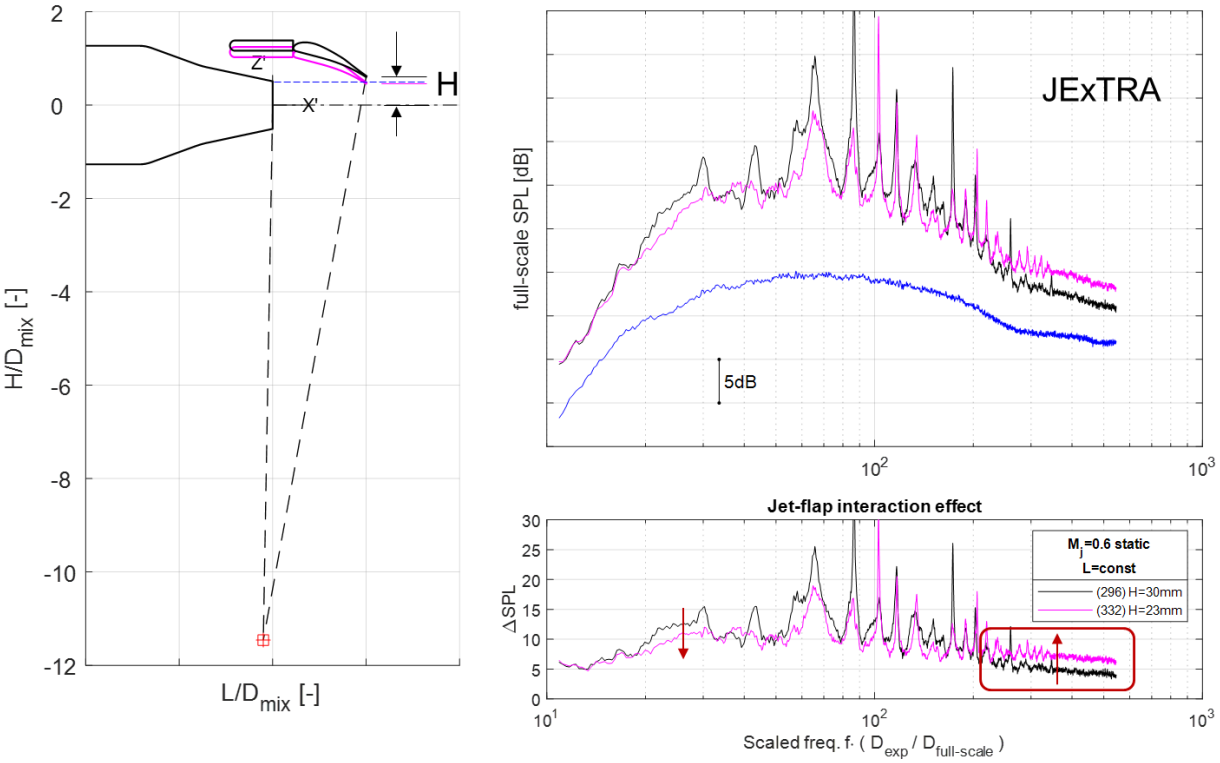

Fig. 2 height sensitivity study, full-scale; two relevant frequency ranges for evaluation of noise reduction

Both frequency ranges, JFI noise below and above the tonal cut-off frequency, should be used for the purpose of down-selecting noise reduction technologies. The reduction of low-frequent tonal JFI-effect is the main focus for application of NRTs. Very close or even radical installations ($H<R_{mix}$) also benefit from high-frequent noise reduction.

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References

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