Category *INT: Aircraft Interior Noise*

Parametric study on effects of wall pressure wavenumber spectra on aircraft fuselage vibration

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The wall pressure wavenumber spectra in the front region of the aircraft fuselage at cruise condition are formulated based on the wall pressure cross-spectral model [1]. The formulated spectra are used as excitation sources for the calculation of the fuselage panel vibration with the Statistical Energy Analysis method [2]. The coherence length, the convection velocity and the flow angle are modified to study their effects on the wavenumber spectrum and the panel vibration. Furthermore, the practical impact of parametrically important factors on the calculated results such as the surface microphone array size and resolution, window functions and dealing with noisy signal is studied, see [3].

Figs. 1-2 show the effect of coherence length and convection velocity modifications on the wavenumber spectra and the panel vibration. For the frequencies between 800 Hz and 2 kHz in which a possible coincidence between the flow excitation and the panel vibration occurs, the wavenumber spectral peak region is important for the excitation. A change in the spectral peak level results in a respective change in panel vibration level. For frequencies outside of 800 Hz – 2 kHz, the lower streamwise wavenumber spectral range is important for the excitation.

Figs. 3-4 show the effect of the array size, resolution and noise. A too small resolution or a too small size will strongly affect the calculated wavenumber spectra and vibration. However, an overly large array size will increase the error due to a reduction of the signal-to-noise ratio when dealing with noisy signal.

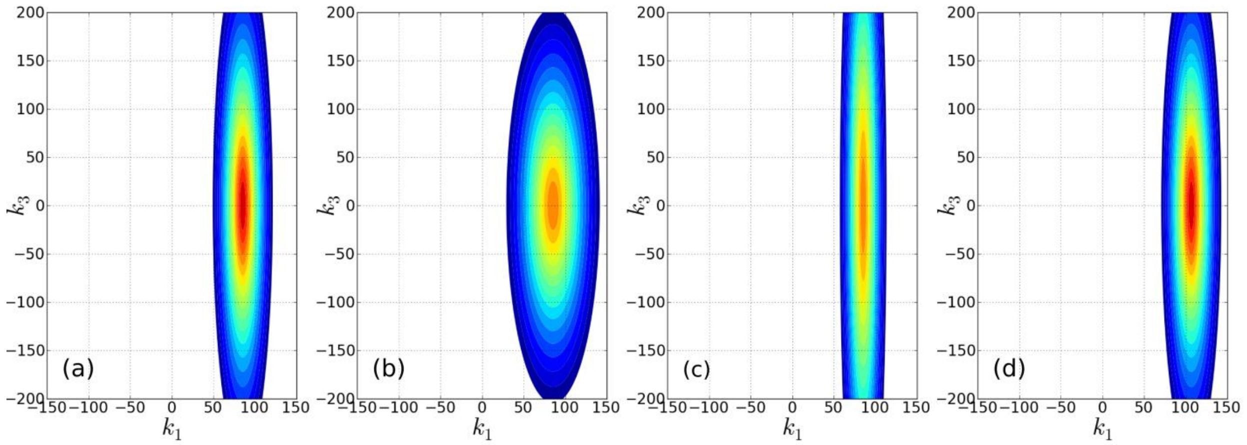

Figure 1: Contour plot of wavenumber spectra at 2500 Hz with levels between -54 dB and -35 dB; (a) Smol’yakov model; (b) 0.5 l_1; (c) 0.5 l_3; (d) 0.8 u_c.

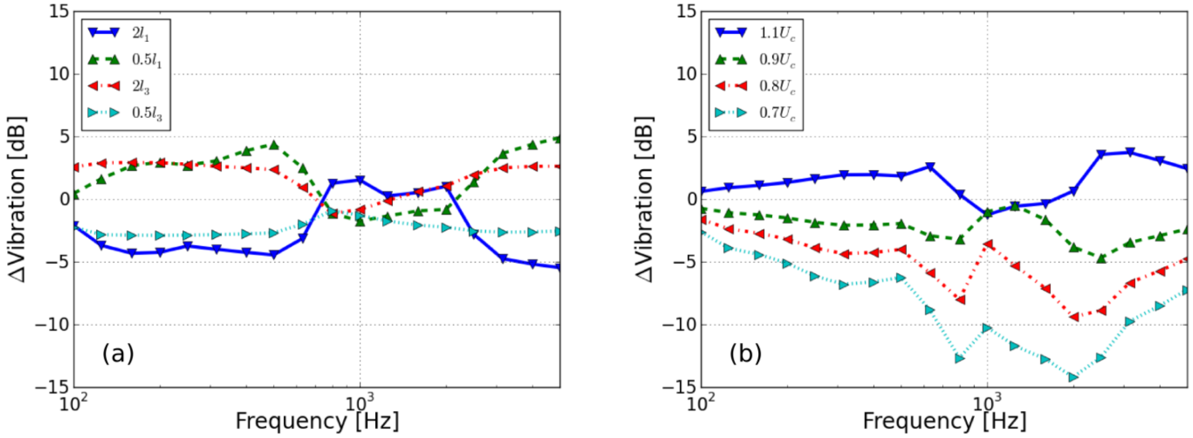

Figure 2: Comparison of panel vibration; (a) modification of coherence lengths; (b) modification of convection velocities.

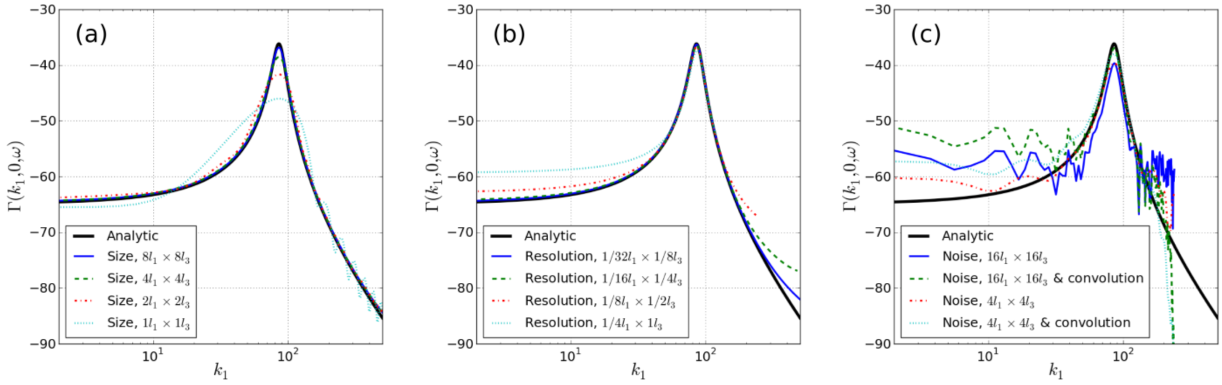

Figure 3: Comparison of streamwise wavenumber spectra at 2500Hz with different processing settings; (a) array sizes; (b) array resolutions; (c) noisy signal.

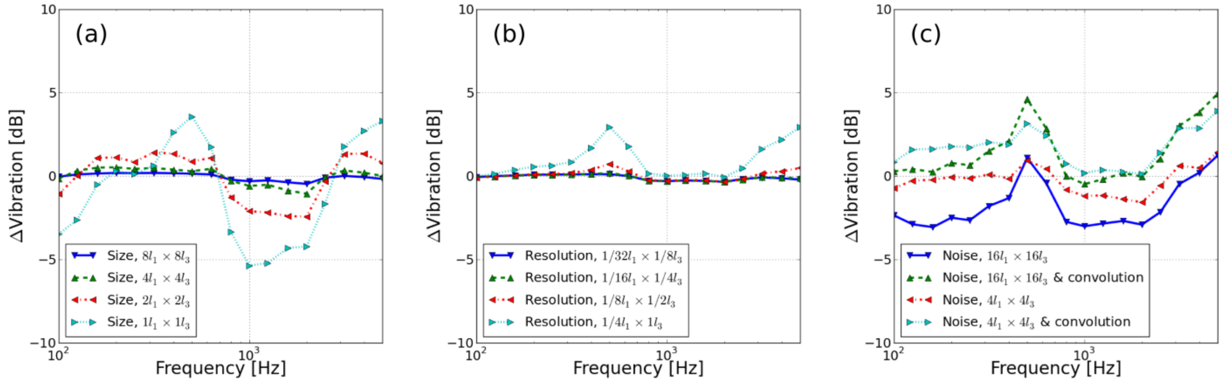

Figure 4: Comparison of panel vibration with different processing settings; (a) array sizes; (b) array resolutions; (c) noisy signal.

References:

1) Smol'yakov, A. V. and Tkachenko, V. M., “Model of a field of pseudosound turbulent wall pressures and experimental data”, Akust. Zh, 37, 1199–1207, 1991.

2) Klabes, A., “Aircraft fuselage vibration excitation by turbulent boundary layer flow in cruise”, PhD thesis, Institute of Aerodynamics and Flow Technology, Germany Aerospace Center, 2017

3) Hu, N and Callsen, S., ”A parametric study on wall pressure wavenumber-spectrum models with application to aircraft fuselage vibration prediction”, 26th International Congress on Sound and Vibration, 2019