Vibration and Acoustic Response
to Non-stationary and non-Gaussian Random Flow Loading

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When describing turbulent fluid flow loading as a random power spectral density spectrum, there is an implicit assumption that the randomness is both stationary and Gaussian. However, real flow turbulence phenomena of interest in the field of flow induced noise and vibration can quite often be non-stationary and/or non-Gaussian. A hot supersonic exhaust jet typically generates non-Gaussian fluctuating surface pressure (FSP) loading, which needs to be considered in structure sonic fatigue life estimation. The ascent aero-acoustic loads on a space launch vehicle are highly non-stationary while passing through transonic and maximum dynamic pressure regimes, making it difficult to quantify the maximum expected random vibration environments for critical avionics components. In the field of automotive wind noise, sound quality studies have shown that passenger perception of wind noise is more strongly correlated to the non-stationary and non-Gaussian character of wind noise, than to its stationary loudness or dBA level.

This paper first reviews measurements of non-stationary and non-Gaussian of sample fluid flows. The paper then reviews recent methods developed to model the corresponding vibration response and transmission of sound from these flow excitations. It is shown that the non-stationary and non-Gaussian character of the random vibration and acoustic response can be modified significantly by the aero-vibro-acoustic transmission process.

References

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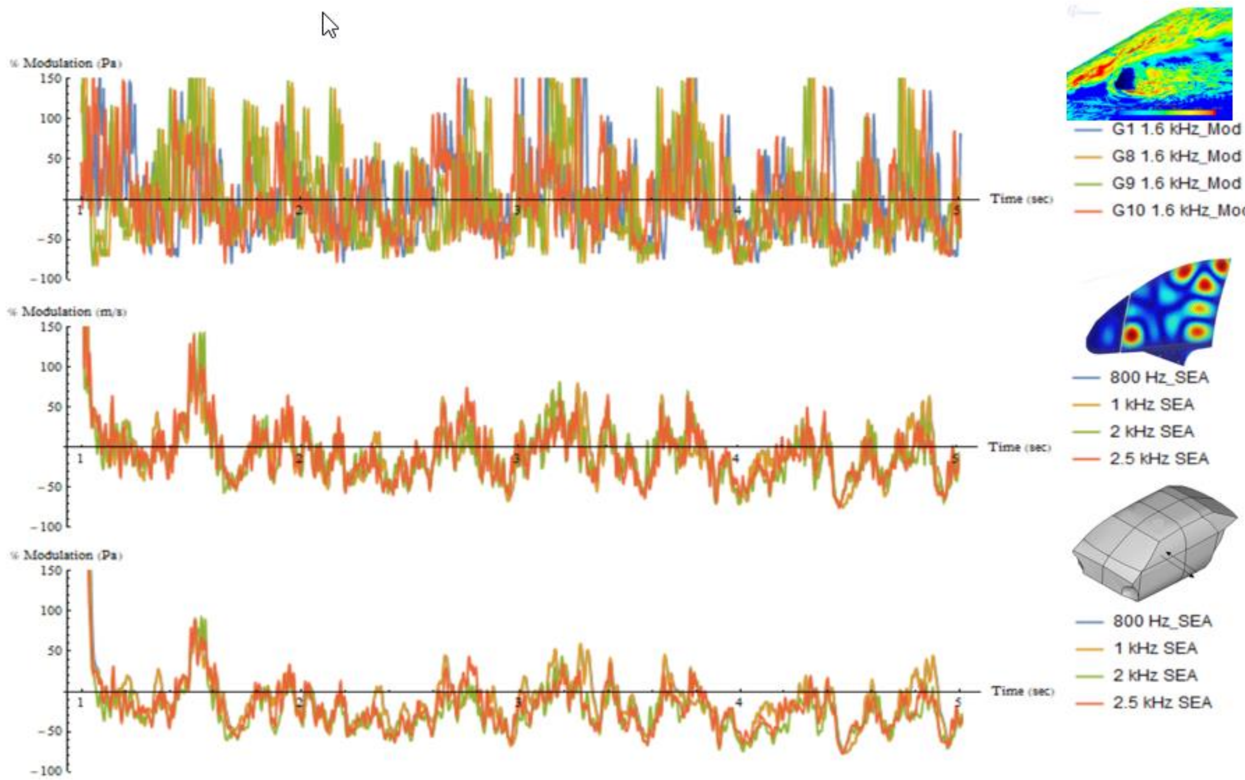

Figure 1: Measured % modulation of exterior FSP loading on an automobile side glass (top) for four flow zones; prediction of % modulation in side glass vibration response (middle) and predicted % modulation of interior wind noise SPL (bottom); for four 3rd octave frequency bands