GET THE INSIDE STORY ON WIND NOISE

Reducing vehicle interior noise levels to achieve driver and passenger comfort is at the forefront of concerns for acoustic engineers in the automotive industry. Great strides have been made in reducing powertrain and road/tire noise, such that wind noise has become the dominant noise source during highway driving, directly impacting consumer brand loyalty and sales. A significant amount of engineering time and product cost is therefore invested in achieving interior noise targets to remain competitive in quality. Typically, however, automotive OEM’s are not able to assess wind-related interior noise until late in the development process when high quality verification prototypes are built. At this point it may be too late to efficiently resolve noise problems, thereby requiring design re-work, additional sound packages, or acoustic glass attenuation—all expensive and time consuming solutions. To reduce the associated costs as well as development times, there is a strong need for a reliable numerical prediction capability for use early in the development process and throughout the program life cycle.

TECHNICAL CHALLENGES

For a vehicle traveling at highway speeds, separated flow provides a distributed turbulent and acoustic excitation on the greenhouse panels (e.g. side windows, windshield). These greenhouse noise sources are complex transient flow structures produced by flow separations and vortices resulting from various exterior geometry features such as the side mirror assembly, A-pillar and cowl. Accurate prediction of greenhouse noise sources requires predicting the time varying flow structures, resulting wall pressure fluctuations and acoustic pressures on the greenhouse panels, including effects of small geometric details. The turbulent excitation and acoustics are of widely varying length scales (i.e. wavenumber spectrum), providing a significant technical challenge to predict or experimentally measure accurately over the important frequency range. Sound transmission of the exterior acoustic field to the interior is particularly important near the acoustic/structure coincidence frequency and appears to be significant even though the turbulent wall pressure amplitudes far exceed those of the acoustic pressures.
EXA SOLUTION

Exa’s PowerFLOW® solver coupled with PowerACOUSTICS® offers a complete solution for simulating wind noise sources and predicting their contribution to the full vehicle interior noise. PowerFLOW predicts transient flow around the vehicle, including highly accurate prediction of key noise-producing flow structures, such as the A-pillar vortex and mirror/pedestal/sail wake which directly impact the front side glass. PowerACOUSTICS converts the resulting time-domain pressure signals on the panels into structural and acoustic power inputs, used as inputs to a fast-running Statistical Energy Analysis (SEA) model that predicts the noise inside the cabin. This approach quantifies the wind noise contribution coming from different panels at the driver/passenger head space locations inside the vehicle. The predicted spectra may be converted to audio files for listening comparison of various design options. Advanced noise source identification and visualization capabilities in PowerACOUSTICS, such as Flow Induced Noise Detection (FIND) and the acoustic wavenumber filter, identify the flow structures and geometries responsible for high wind noise loads on the panels. Exa’s complete solution goes beyond what is practical in physical testing, by enabling engineers to gain insight into behavior of key turbulent flow structures and corresponding greenhouse noise sources for targeted shape design improvement. This fully validated, industry-first capability enables analysis of potential noise reduction solutions. These include assessment of exterior shape changes, glass properties, and interior acoustic package modifications early in the development process—before costly physical models or prototypes are built.

SELECTED REFERENCES:

- S. Senthooran, R. Powell, E.S. Choi, S. Cyr, Computational prediction of interior noise for design variations on a simplified vehicle, Internoise 2015, San Francisco, CA, USA, August 9-12.