

POWERFLOW FOR WINDOW AND SUNROOF BUFFETING



3DEXPERIENCE®

Simulating Window and Sunroof Buffeting

Vehicle OEMs invest significant effort and cost into reducing noise sources to improve the level of passenger comfort. Recent J. D. Power surveys have identified wind noise as a strong influence on consumer perception of vehicle quality. Among the wind noise complaints, vehicle buffeting due to an open sunroof or side window was identified as a significant contributor. Buffeting (also known as wind throb) is an unpleasant, high-amplitude, low-frequency booming caused by flow-excited Helmholtz resonance of the interior cabin. Vortex shedding in the shear layer over the cavity opening (sunroof or side window) couples with the cabin acoustics, leading to a self-sustained oscillation of shear layer and cabin pressure. Generally, buffeting is not evaluated by OEMs in the early phase of new vehicle development because prototypes do not have sufficient detail to provide realistic aerodynamic and acoustic behavior. One approach used is to design universal sunroof systems, which are intended to suppress buffeting on any vehicle. However, the experimental optimization process often results in late-stage tuning of the sunroof system, costly changes, or a suboptimal design. Therefore, a numerical prediction capability of the buffeting phenomena that provides design guidance in the early design phase is highly desirable.

Technical Challenges

Accurate prediction of the vehicle buffeting phenomenon requires capturing the bidirectional coupling between the transient shear layer aerodynamics (vortex shedding) and the acoustic response of the cabin. Quantitatively correct prediction of the flow-excited resonance requires an accurate prediction of complex transient behavior, including turbulent vortex formation, shedding, and convection through the shear layer; and direct capture of the acoustic interaction requires a compressible solver. In addition, the acoustic response of the vehicle cabin must be modeled correctly. Because small geometric details can significantly impact the shear layer/acoustic coupling behavior, a high degree of accuracy with fully detailed geometry is required. These considerations make simulation of vehicle buffeting a challenging problem, especially when predicting the severity (peak levels) for a given vehicle design and the effectiveness of various buffeting suppression methods.

SIMULIA Solution

PowerFLOW includes the coupling of external flow dynamics with vehicle internal cabin acoustics so you can reliably predict buffeting behavior from either sunroof or side window openings. This capability, which includes modeling the cabin acoustic response, enables you to assess buffeting severity (including onset/offset velocities and peak level) early in the development process, when the potential design solution space is greatest. The unique PowerFLOW technology, an inherently transient and compressible solution, provides accurate prediction of complex flow structures. This enables you to visualize the flow vortex shedding behavior that occurs over the sunroof/window and provides insight for design improvement, including the details of sunroof deflector geometry and location. Using PowerFLOW, you can use a virtual testing environment to predict buffeting behavior and test potential design improvements in all phases of a vehicle development cycle, including the early phases.