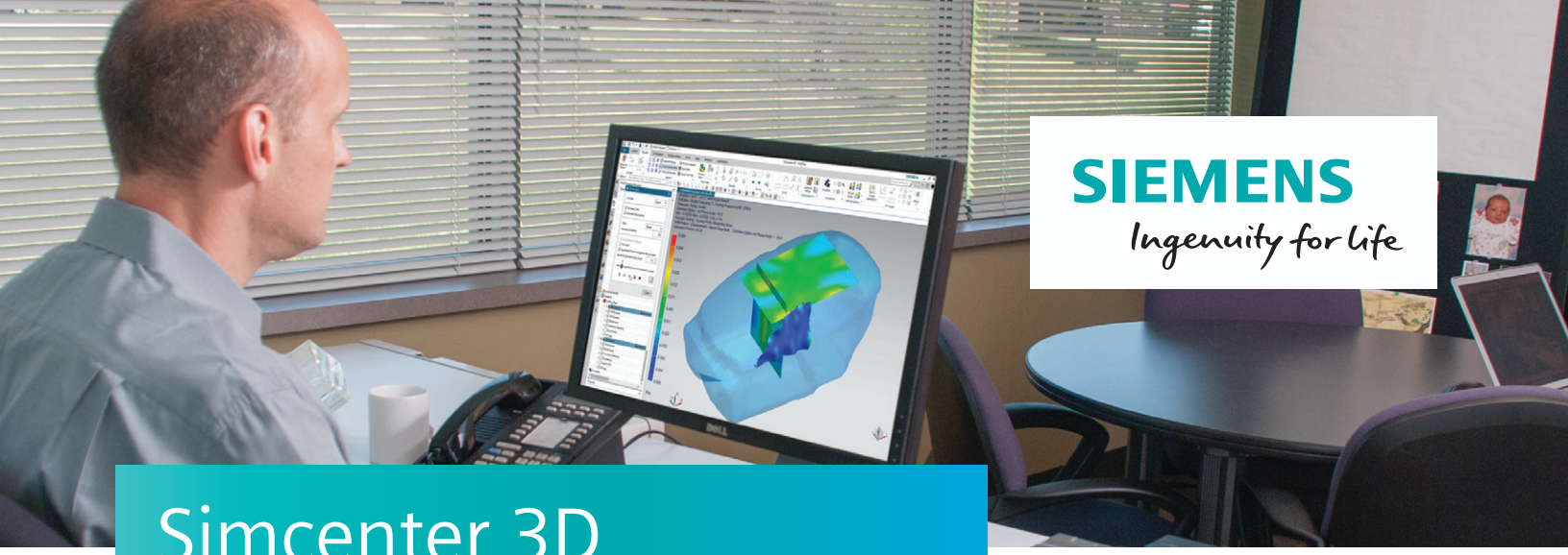

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Simcenter 3D Aero-Vibro-Acoustics

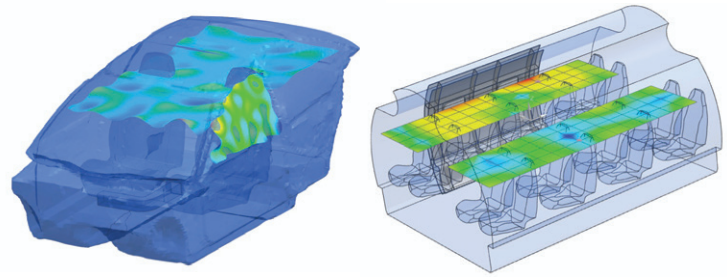
Facilitating the efficient prediction of flow-induced noise

Benefits

- Efficiently predict flow-induced noise
- Provide scalable and user-friendly load preparation for aero-vibro-acoustic wind noise simulations
- Deliver quick turbulent boundary layer loading generation via semi-empirical models
- Facilitate lean, surface pressure-based aero-acoustic source creation for stationary or rotating surfaces
- Import binary files with load data directly in Simcenter Nastran for response computation

Summary

Simcenter™ 3D Aero-Vibro-Acoustics delivers advanced modeling capabilities for simulating flow-induced noise. Two types of scenarios are supported. The first type involves preparing flow-induced pressure loads that apply to a structural model, ultimately resulting in vibrations and acoustic radiation. In this case we talk about aero-vibro-acoustics. Typical supported cases include wind noise in a car cabin, aircraft cabin noise due to turbulent boundary layer (TBL) loading on the fuselage exterior, or radiation from a pump housing structure due to interior fluid sloshing. The second type of scenario involves cases in which turbulence in the flow acts as a noise source that radiates acoustically in the same fluid environment as where it originated. This involves converting flow results from computational fluid dynamics (CFD) simulations to equivalent acoustic sources. To keep the required amount of flow results to a minimum, Simcenter 3D supports aero-acoustic analogies based on flow results at just the fluid boundary. These are converted into equivalent acoustic boundary conditions on the same surface in the acoustic model (mesh). The surfaces on which these sources are created can be stationary or rotating. A typical use case for stationary surface sources is predicting heating, ventilation and air conditioning (HVAC) noise. For rotating source surfaces, creating a fan source is supported for cooling fans, propellers for marine and aviation applications.



Aero-vibro-acoustics: flow-induced force loads

Unsteady turbulent flow in fluids near flexible structural panels can lead to structural vibrations and vibro-acoustic radiation. For instance, in a car moving at high speed, the side windows are exposed to fluctuating pressure loads by the wind flowing over the side mirrors. This will result in side-window vibrations and radiated noise inside the car cabin. Also, the flow on the underbody of the car can create similar effects by exciting the floor plate. This type of loading and noise can also be observed in trains and aircraft since they travel at high speed, so flow-related noise can be rather dominant. In addition to the transportation industry, flow-induced noise from pumps can be evaluated using the same methodologies. Once the loads for the use cases are created in Simcenter 3D, they can be used in Simcenter Nastran® software for random forced-response analysis, meaning that all typical struc-

Simcenter 3D Aero-Vibro-Acoustics

tural and acoustic results are supported as outputs for postprocessing.

Key features and functionalities:

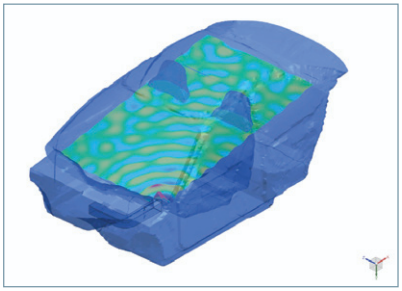
- Flow results can be read from CFD General Notation System (CGNS) formatted results; for instance, from Simcenter STAR-CCM+™ software or from other CFD vendor solutions. For Simcenter STAR-CCM+ based results, both aerodynamic and aero-acoustic pressure loads (for instance, from Simcenter STAR-CCM+ acoustic perturbation equations solver) can be applied
- Conservative mapping of pressure results from CFD to a structural mesh, including filtering options on both source and target surfaces
- Digital signal processing (DSP) functionality supporting time segmentation (delayed averaging) technique for handling stochastic pressure loading from unsteady turbulent flows
- Pressure to force conversion and transfer to Simcenter Nastran for vibro-acoustic response analysis (SOL108 / SOL111) via lean HDF5 based binary files. The vibro-acoustic model can be represented by a finite element method (FEM) model or by a vibro-acoustic transfer vector (VATV) representation, to speed up forced response computation for multiple load cases
- Multiple semi-empirical TBL models are supported, including Robert (Corcos), Efimtsov, Goody and Chase-Howe. These provide representative loads on smooth surfaces without the need for costly (unsteady) CFD analysis
- The TBL loading can be generated with physical coordinates or in a wavenumber domain
- Cholesky decomposition of TBL power spectral density (PSD) loading and random sampling is supported with a reduced, yet well approximated version of the stochastic loads

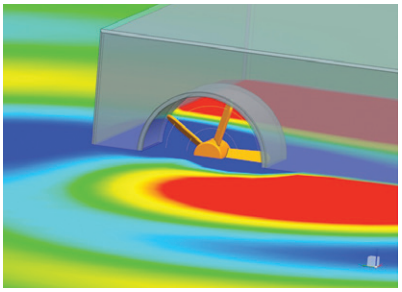
Aero-acoustics: surface dipole sources and fan sources

Simcenter 3D Aero-Vibro-Acoustics supports creating aero-acoustic sources, from rotating surfaces in a fluid and from stationary obstacles such as vanes, diaphragms and side mirrors. It facilitates computing the aero-acoustic or aero-vibro-acoustics response in an exterior or interior environment, including all installation effects relevant for acoustics: complex surface scattering in a large domain (typically much larger than the domain in which the sources are located), frequency-dependent porous materials and surface impedances, etc. One example is noise originating from HVAC or environmental control system (ECS) components in ducts and propagation of the noise into car/train/aircraft cabins. Other noise applications, which are more related to exterior propagation, include pass-by noise due to flow around train boogies and pantographs, and noise heard due to cooling fans, ship and aircraft propellers.

Key features and functionalities:

- Flow results can be read from CGNS formatted CFD results, for instance from Simcenter STAR-CCM+ or other CFD vendor solutions
- Conservative mapping of pressure results from CFD to a structural mesh, including filtering options on both source and target surfaces
- DSP functionality supporting time segmentation (delayed averaging) technique for handling stochastic character of the noise source
- For stationary surfaces, equivalent surface dipole sources can be created based on both compressible as well as incompressible CFD results
- Fan sources are created based on Ffowcs-Williams and Hawkings (FWH) analogy. Equivalent rotating acoustic dipoles sources are created at specific blade segment centers. Both tonal and broadband noise components are supported
- The surface dipoles and fan noise sources are exported to specific Nastran cards, which include references to lean HDF5 based binary files containing the aero-acoustic source data. The sources are then picked up by Simcenter Nastran for vibro-acoustic response analysis (SOL108/ SOL111) to compute interior or exterior noise radiation





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