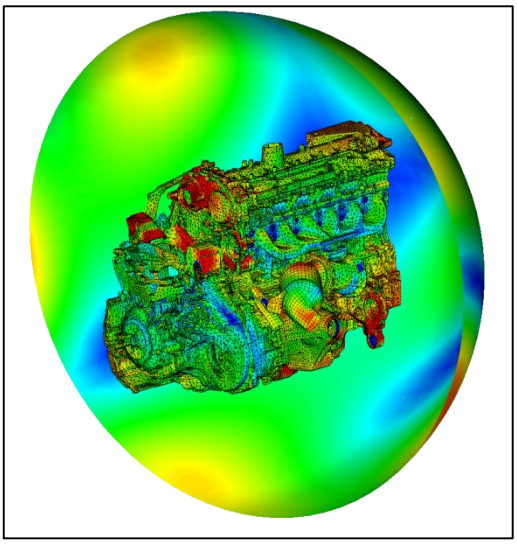
AVL EXCITE ACOUSTICS
AIRBORNE NOISE CALCULATION

EXCITE Acoustics is a tool for the calculation of sound radiation in free field from vibrating structures such as engines and power units using the Wave Based Technique (WBT). It seamlessly fits into the EXCITE structural dynamic analysis workflow as the final step of acoustic analysis, using the FE mesh of the structure and the surface velocity results as input. With interfaces to common FE tools for the import of the vibrating structure geometry and the surface velocity boundary condition, EXCITE Acoustics can also be used as a standalone EXCITE tool.

Highly Efficient Sound Radiation Calculation

Although the evaluation of structure-borne noise (surface velocities) as result of an engine or power unit flexible multi-body dynamic analysis already is a good basis for improving design, excitation mechanisms and transfer paths, the direct evaluation of airborne noise allows assessing and improving the design on basis of real “sound” quantities.

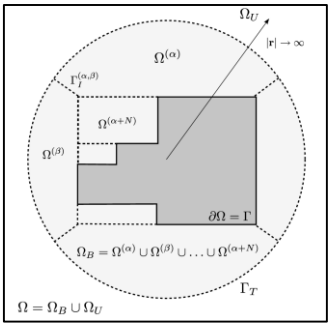
Using previously calculated surface velocities as input EXCITE Acoustics efficiently calculates the sound radiation in free field and provides airborne noise results which are directly comparable with measured acoustic data and legal noise limits.



Sound pressure on a spherical field point mesh around a 6 cylinder engine

The Wave Based Technique

The Wave Based Technique (WBT) is based on an indirect Trefftz approach whereby the dynamic response variables are described using wave functions, which exactly satisfies the homogenous Helmholtz equation. As a result no approximation error is made inside the domain, only at the boundary, as the wave functions may violate the associated boundary conditions. A weighted residual formulation is used to enforce the residuals at the boundaries to be zero in an integral sense.



Unbounded problem definition

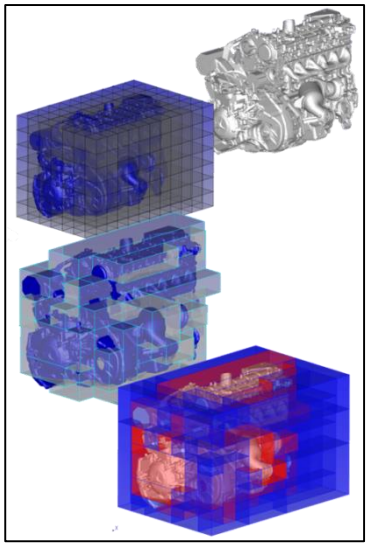
Compared to conventional element based methods, like the finite element method (FEM) and the boundary element method (BEM), which make use of approximating shape functions to describe the dynamic response variables, the resulting WBT models are small. This results in an enhanced computational efficiency of the WBT as compared to the conventional element

AVL – Advanced Simulation Technologies 2015
AVL List GmbH Hans-List-Platz 1, A-8020 Graz, Austria
E-mail: ast@avl.com, http://www.avl.com/ast

based techniques. Furthermore the WBT acoustic model is not frequency dependent.

To extend the method from radiation problems to unbounded problems (free field) an artificial spherical truncation boundary is introduced. It divides the problem into a bounded and an unbounded domain. The dynamic field in the unbounded domain is expressed by radiation functions, consisting of linear combinations of spherical harmonics and Hankel functions, while the bounded domain uses the wave functions.

Automated WBT Model Generation



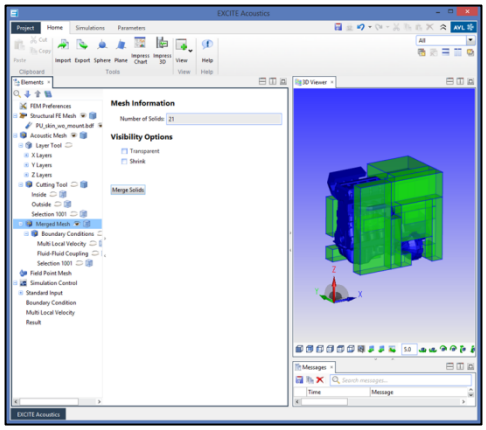
Steps of automated meshing procedure

For a smooth, fast and easy to use workflow an automated patented meshing procedure enables the acoustic WBT mesh to be generated with minimal effort.

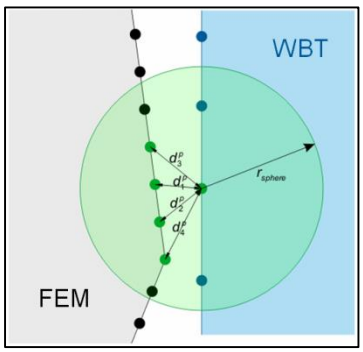
The automated process starts with the import of FE structural mesh which has been used for flexible multi-body dynamic analysis to calculate the structural vibrations. Based on internal evaluated optimal layer distances depending on the structure aspect ratio a regular mesh using equally spaced layers is generated for the complete analysis domain. To detect whether an element is inside or outside the structural mesh and to get an acoustic mesh close to the structural mesh, those elements intersected by the outer skin of the structural mesh are further refined.

Finally all outside elements representing the acoustic WBT fluid mesh are merged to reduce the number of elements and surfaces and that way optimize the computational performance.

A 3D viewer allows to check each step of the meshing process and optionally adjust e.g. the generated layer positions according to specific structure locations or to define acoustic boundary conditions like impedance for selected parts of the structural surface.



Merged acoustic mesh of the bounded region

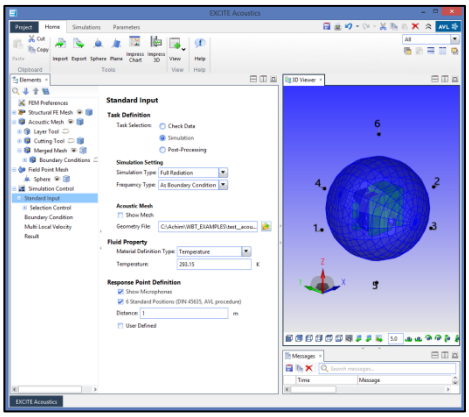


A multi local velocity (MLV) mapping approach with an inverse distance weighting (IDW), which is fast and element independent, is applied in order to ensure an accurate transfer of the structure-borne noise boundary condition from the skin of the FE structural mesh to the acoustic WBT mesh.

MLV mapping - search for the m closest FE nodes to a given Gauss point

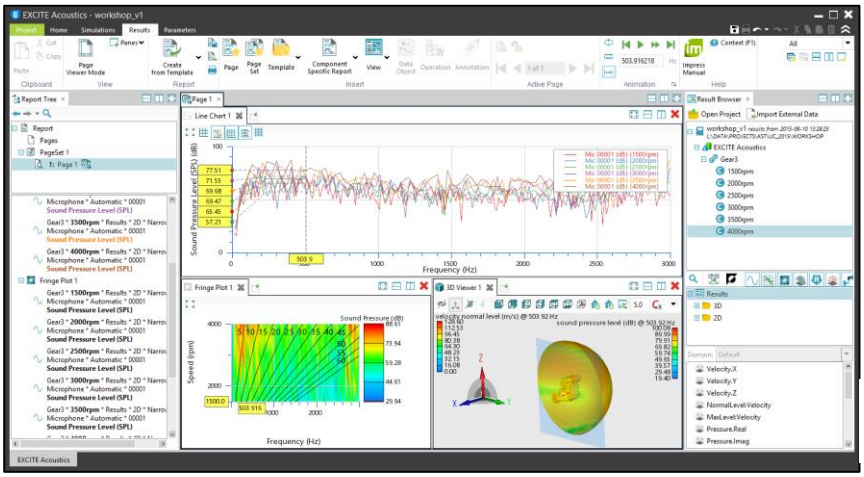
Capabilities and Features

EXCITE Acoustics is a complete package including all necessary pre and 2D/3D post-processing tools:



Final acoustic mesh with microphone positions

- meshing tool for automated generation of the acoustic WBT mesh
- 3D pre-processing viewer for visualization of the acoustic meshing step results with interactive capabilities for optional mesh modifications
- various interfaces to import geometry and surface velocity boundary conditions of the vibrating structure
  - geometry: EXCITE (.meg), Abaqus® (.inp), ANSYS (.rst), MSC Nastran® / NX Nastran® (.bdf, . op2)
  - surface velocities: EXCITE (.mer), Abaqus® (.odb), ANSYS (.rst), MSC Nastran®/ NX Nastran® (.pch, .op2)
- optional constant or frequency dependent boundary conditions on selected structure parts (pressure, velocity or impedance)
- dynamic and fully automated mapping of structure boundary conditions and velocities on the acoustic mesh
- OpenMP parallelized solver for use of multiple CPU's for each frequency step
- default standard and user definable microphone positions
- field point mesh generator for 3D post-processing (plane and sphere)



Integrated and connected 2D / 3D post-processing

- integrated, interactive and connected 2D / 3D result evaluation of
  - active and reactive output power (on skin and/or arbitrary field point meshes)
  - radiation efficiency
  - sound pressure levels at microphones and on field point meshes (single freq., third octave /octave bands or user defined freq. bands)
- pre-defined and customizable templates for reporting
- animation versus frequency of surface velocities on structure with sound pressure levels on field point meshes
- export of sound pressure at microphone positions as audible files (*.wav)

Your Benefits

- meshing of the acoustic model starts from unmodified FE mesh used for the structural vibration analysis – no need to close smaller openings, to change element types …
- fully automated generation of the acoustic mesh with interactive 3D viewer – easy and fast preparation of the calculation model with a few clicks
- acoustic mesh is not frequency dependent – accurate results with one model for the whole frequency range, high computational performance due to small acoustic models
- fast and flexible post-processing – microphone positions and field point meshes can be added or modified without recalculation of the sound radiation

Export of sound pressure at microphone positions as audible files

- audible results - direct assessment of noise characteristics by hearing comparisons
- short analysis lead times from model preparation till result evaluation