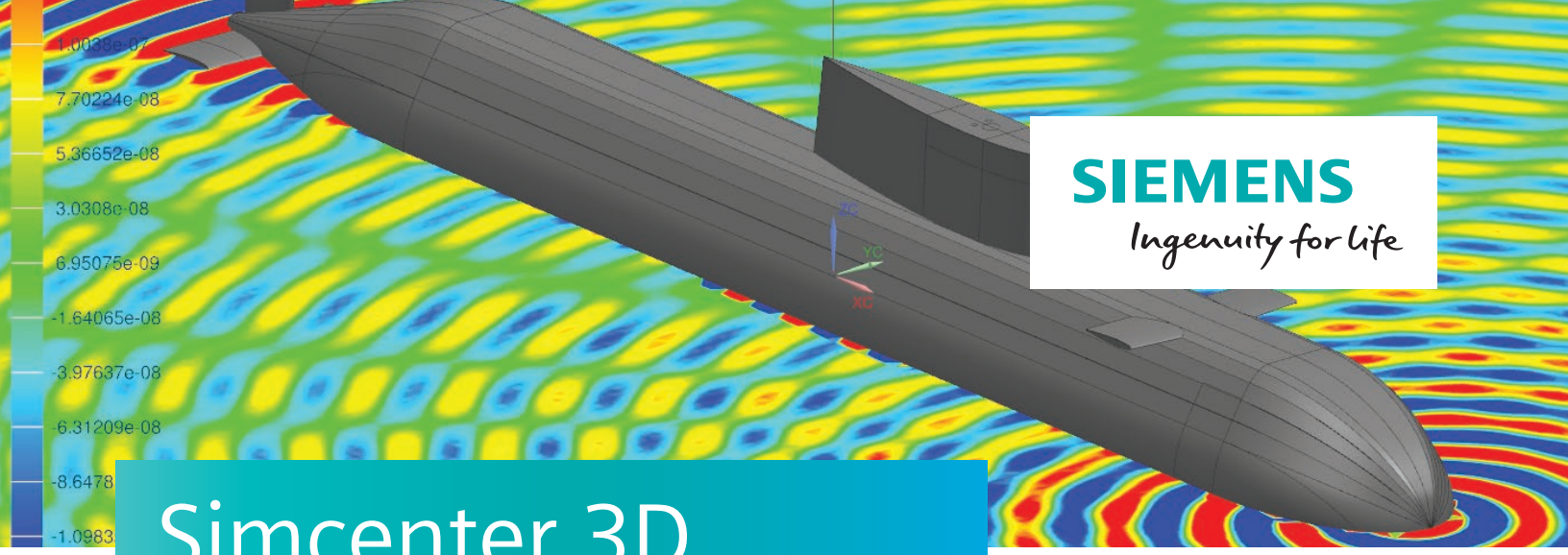


Simcenter 3D Acoustics Accelerated BEM solvers

Using accelerated boundary element method solvers to address larger acoustics problems

Benefits

H-Matrix BEM solver

- Deliver faster computations using advanced solver technology
- Become more efficient by lowering memory requirements with hierarchical matrix storage and compression
- Enhance scalability by using the direct solver approach to efficiently handle multiload cases

Fast multipole BEM solver

- Handles large BEM models (millions of BEM nodes)
- Requires lower system memory than standard BEM
- Reduces computational complexity through state-of-the-art iterative algorithm

Summary

Typically, six boundary elements per wavelength are required for a correct representation of the propagation of acoustic waves in a boundary element model (BEM). Therefore, the model size rapidly increases with the system frequency. Using standard BEM techniques limits either the upper frequency or geometric size of the analysis. The Simcenter™ 3D Acoustics Accelerated Boundary Element Method (ABEM) software provides a hierarchical matrix BEM (H-Matrix BEM) solver and fast-multipole BEM solver to extend the computational limits of standard BEM solvers.

H-Matrix BEM solver

The H-Matrix BEM solver allows you to solve acoustic radiation problems using a state-of-the-art tool. The H-Matrix BEM enables you to efficiently handle medium-to-large boundary element models that standard BEM solvers cannot solve practically. This technique can be applied to many applications such as the study of exterior acoustics of complete vehicles, large engines, pedestrian warning systems, enclosures, aircraft, ships and submarines, as well as high-frequency applications such as ultrasonic sensors.

Capabilities

Element properties

- Acoustic mesh containing linear triangular elements
- Acoustic fluid characterized by constant complex sound velocity and constant real fluid density

Acoustic boundary conditions

- Automatic creation of junction constraint conditions
- Automatic creation of free edges constraints
- Absorbent panels characterized by an impedance or admittance boundary condition on elements
  - Complex, constant or frequency-dependent values
  - Discontinuous impedance/admittance (each element side may be assigned a different value)
  - Rigid transfer admittance relations between element faces (complex and frequency-dependent values)

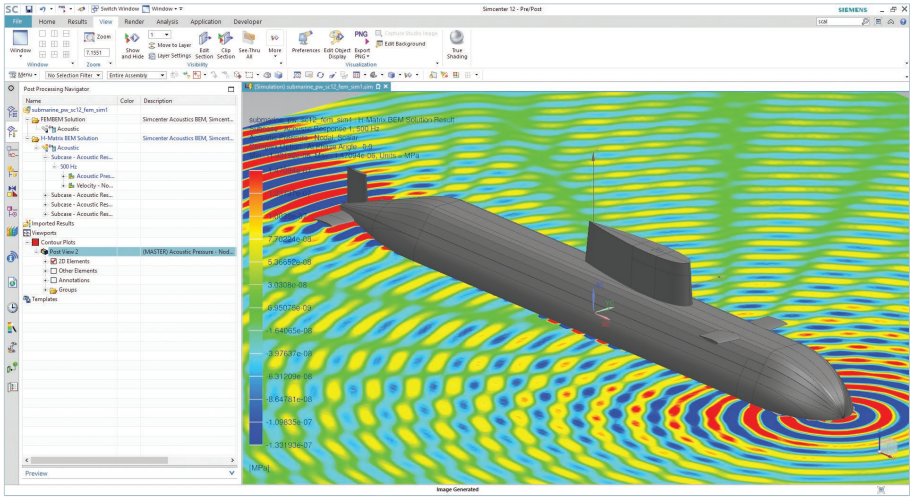
Simcenter 3D Acoustics Accelerated BEM solvers

Acoustic loads

- Acoustic monopole
- Plane wave sources
- Panel normal velocity
- Constant or frequency-dependent characteristics

Methods

- Boundary element formulation (indirect variational) with H-Matrix
- Forced frequency response
  - Single infinite plane (type: symmetry)
  - Storage of frequency response functions at all microphone nodes
- H-Matrix solver technology
  - Automatic hierarchical matrix storage and compression with in-core and out-of-core solver
  - Automatic optimal block-size selection for out-of-core solver
  - Load balancing for frequency level parallelization: frequencies are dynamically assigned to the running processes (instead of an upfront assignment)
  - Multithreading
  - Frequency-level parallelization (requires Simcenter 3D Acoustics HPC if more than four processes)
- Microphone results postprocessing
  - Postprocessing of acoustic field variables at any location in the boundary element domain
  - Evaluation of power radiated through a microphone mesh
  - Pressure evaluation
  - Scattered field evaluation



- Frequency selector
  - Single values
  - Frequency sweep
  - Octave band sweep
  - Linear or logarithmic step
  - Frequency interpolation
- Data storage
  - Optimized performance and storage through user input and output filters
  - Automatic solver log storage

Fast multipole BEM solver
Using a Fast Multipole BEM solver (FMBEM) allows you to solve acoustic radiation problems using a state-of-the-art fast multilevel multipole expansion BEM solver. FMBEM allows you to extend the upper frequency limit for large structures. You can handle big-to-huge boundary element models that standard BEM cannot tackle in a reasonable amount of time. The FMBEM technique opens a window for a new set of applications, such as the study of exterior acoustics for complete vehicles and large engines, including enclosures, aircraft, ships, submarines, as well as high-frequency applications such as ultrasonic sensors.

Capabilities

Element properties

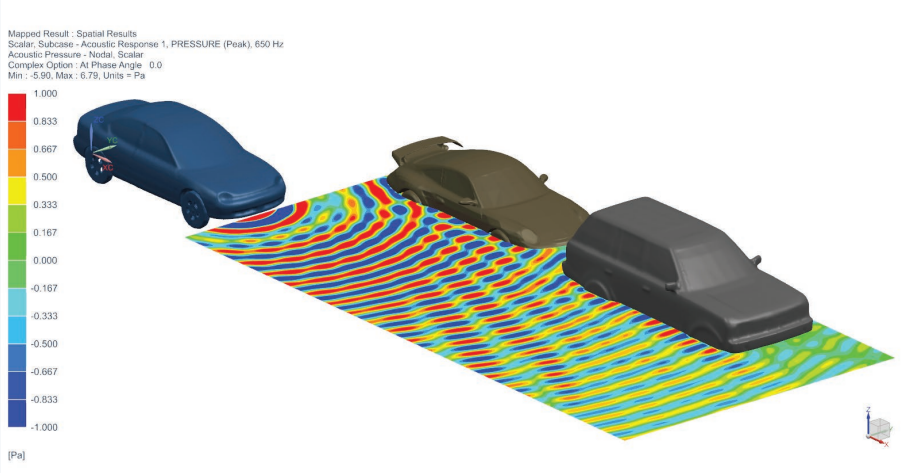
- Acoustic mesh containing linear triangular elements
- Acoustic fluid characterized by constant complex sound velocity and constant real fluid density

Acoustic boundary conditions

- Automatic creation of junction constraint conditions
- Automatic creation of free edges constraints
- Absorbent panels characterized by an impedance or admittance boundary condition on elements
  - Complex, constant or frequency-dependent values
  - Discontinuous impedance/admittance (each element side may be assigned a different value)
- Rigid transfer admittance relations between element faces (complex and frequency-dependent values)

Acoustic loads

- Acoustic monopole
- Plane wave sources
- Panel normal velocity
- Constant or frequency-dependent characteristics



Methods

- Boundary element formulation (indirect variational) with multipole expansion
- Forced frequency response:
  - Single infinite plane (type: symmetry)
  - Storage of frequency response functions at all microphone nodes
  - Uncoupled solver
- Fast solver technology
  - Element integration quadrature automatically optimized by solver
  - Out-of-core iterative solver with optimized preconditioning
  - User-selectable convergence criterion
  - Optimal handling of multiload conditions with the singular value decomposition (SVD) technique
  - Frequency-level parallelization
- Microphone results postprocessing
  - Postprocessing of acoustic field variables at any location in the BE domain
  - Evaluation of power radiated through a microphone mesh
  - Pressure evaluation
  - Scattered field evaluation
  - Faster postprocessing via the Kirchhoff-Helmholtz integral theorem using multipole expansion
- Frequency selection
  - Single values
  - Frequency sweep
  - Octave band sweep
  - Linear or logarithmic step
  - Frequency interpolation
- Data storage
  - Optimized performance and storage through user input and output filters
  - Automatic solver log storage

Postprocessing

Postprocessing is fully supported in the Simcenter 3D environment for BEM acoustics

- Contour plot
  - Boundary conditions (velocity and admittance or impedance)
  - Acoustic pressure on microphone meshes (total field or scattered field only)
  - Particle velocity vector on microphone meshes
- Function displays
  - Acoustic pressure at nodes of microphone meshes (total field or scattered field only)
  - Particle velocity vector at nodes of microphone meshes
  - Power through a microphone point mesh

Parallelization

- ABEM solvers give you access to solve problems using up to four parallel processes
- When combined with Simcenter 3D acoustics high-performance computing (HPC) software, the user can obtain full scalability running on multiple (more than four) central processing units (CPUs), systems or clusters

Recommended

- Simcenter 3D environment for BEM acoustics is recommended for pre- and postprocessing
- Simcenter 3D Acoustics HPC is recommended for full scalability running on multiple CPUs, systems or clusters

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