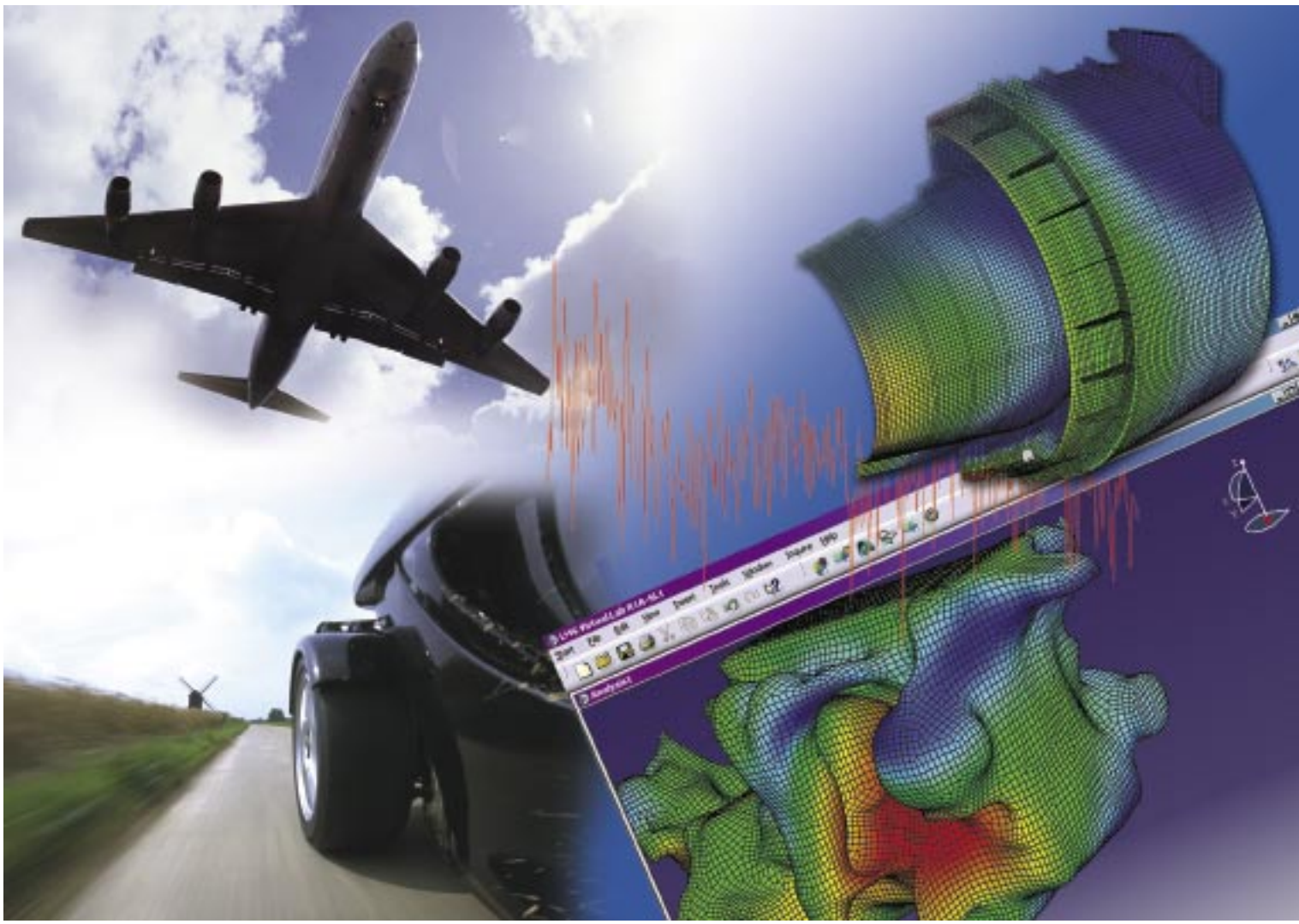
LMS Virtual.Lab Acoustics

Make Sound Engineering Decisions Faster



LMS Virtual.Lab™

LMS INTERNATIONAL

Empowering Engineering Innovation

LMS Virtual.Lab, the Integrated Environment for Functional Performance Engineering

LMS Virtual.Lab is the world's first integrated software environment for the functional performance engineering of critical design attributes such as noise and vibration, ride and handling, comfort, safety, crash, durability, and others. An open environment with seamless links to the CAD, CAE and Test worlds, LMS Virtual.Lab provides everything the multidisciplinary engineering team needs to get better products to market faster than before. It doubles the time available for value-added engineering and reduces the overall engineering process time by 30 to 50%.

LMS Virtual.Lab is based on the CAA V5 (Component Application Architecture), the open middleware for PLM from Dassault Systèmes.

Enabling hybrid engineering

LMS Virtual.Lab implements a unique "hybrid simulation" approach. By combining the best of the physical test and virtual simulation disciplines, the new engineering process is not only faster, but also more accurate and robust, as test-based validation is built in. The return on investment can therefore be measured not only in terms of faster time to market and reduced development cost, but also in terms of improved product quality and a reduction in the number of expensive product recalls.

Delivering value-added engineering

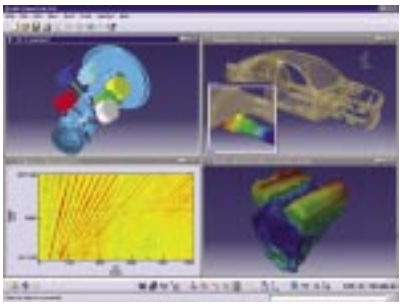
Virtual.Lab automatically links to leading CAD, CAE and Test tools and, by eliminating unnecessary file transfers and data redundancies, doubles the time available for value-added engineering. Virtual.Lab captures and automates the process flow to provide a very efficient parametric analysis capability. With Virtual.Lab any design change can be rippled through the analysis sequence in minutes. Such speed breakthroughs will allow companies to take weeks off the product development process, to reduce uncertainty and minimize the reliance on physical prototypes.

Integrating mission-critical applications

Being able to explore the design space for a given attribute already provides critical insights into the dynamics of an engineering problem. But Virtual.Lab can do more. It can intelligently find the optimum point in the design space, giving a leap forward in productivity. By a close integration of mission-critical applications, engineers will also be able to trade off multiple and possibly conflicting attributes to balance the overall design.

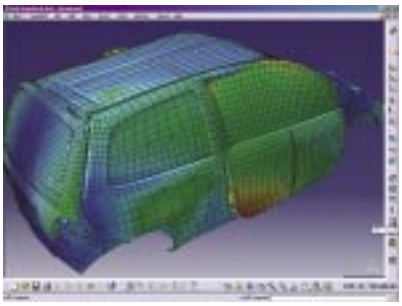
LMS Virtual.Lab Desktop

The Virtual.Lab Desktop provides a common environment for functional performance engineering. Through the Virtual.Lab Desktop, the user has seamless access to models and data of leading CAD and CAE codes, and to Test data. The Virtual.Lab Desktop provides a complete visualization environment for part and assembly geometry, functional performance engineering data, time and frequency functions and much more.



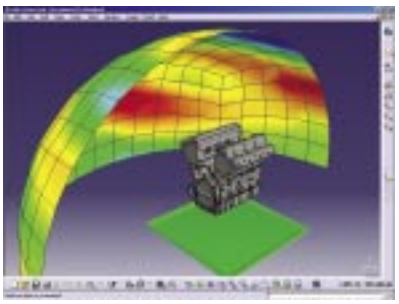
LMS Virtual.Lab Noise and Vibration

Virtual.Lab Noise and Vibration combines proven technologies with breakthrough techniques to create the world's first solution for modeling and refinement at the system level. With Virtual.Lab, system-level models can be assembled quickly, reliably, and in time to benefit the ongoing development process.



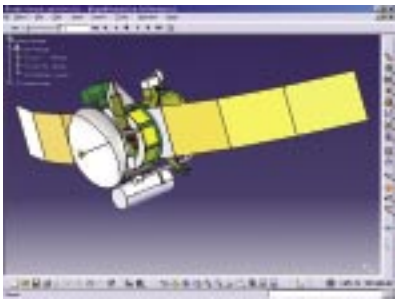
LMS Virtual.Lab Acoustics

Imagine that acoustic meshing could be performed in a couple of hours, that an engine run-up could be predicted within a day, and that any design change could be remodeled in minutes. With the breakthroughs embedded in Virtual.Lab Acoustics it has become reality.



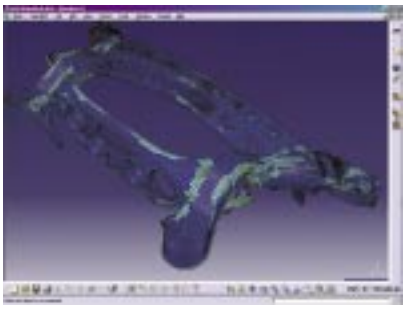
LMS Virtual.Lab Motion

How do you guarantee your mechanical design performs as expected, before signing off to a physical test? How do you make sure that the numerous components interact and move as planned? Will certain parts break under peak loads? Virtual.Lab Motion enables you to quickly analyze and optimize the real-world behavior of your mechanical design.



LMS Virtual.Lab Durability

LMS Virtual.Lab Durability will help you to predict fatigue-life performance in time to positively affect the design process. It predicts the durability performance of components subjected to a uni-axial load, and handles large flexible welded bodies or complex subassemblies subject to hundreds of loads from all directions.



Would you like to reduce noise levels and build-in desirable sound quality before expensive prototyping?

Do you need to minimize the cost and weight of the sound treatment - and eliminate the flawed concept altogether?

Would you like acoustic design to take part in the mainstream development process?

... LMS provides an integrated simulation environment that will dramatically improve the effectiveness of your acoustic design process

Designing for Optimal Acoustic Performance

Do your customers expect ever-quieter products? Are your competitors using sound quality as a differentiating advantage? Will ever-tighter noise emission legislation have an impact on your product sales?

Only a couple of years ago, predicting the sound fields of even the simplest product used to take weeks, while something like an engine run-up took months. Even for an expert, parametric analysis and design refinement was simply not feasible given the cost and time constraints - the only option was to use expensive treatments late in the development when all design flexibility had been lost.

From challenges…

Imagine that you are in the position of performing acoustic meshing in a couple of hours, predicting an engine run-up within a day, and remodeling design changes within minutes. With the breakthroughs embedded in our acoustic solutions, it's all possible. Imagine making well-informed decisions at the concept stage, and to systematically improving, refining, and optimizing your product's acoustic performance from the initial design to completion in a coherent way. Link design choices to measurable phenomena, and understand and simulate the effect of design alternatives at the virtual prototype level before committing to any expensive prototyping.

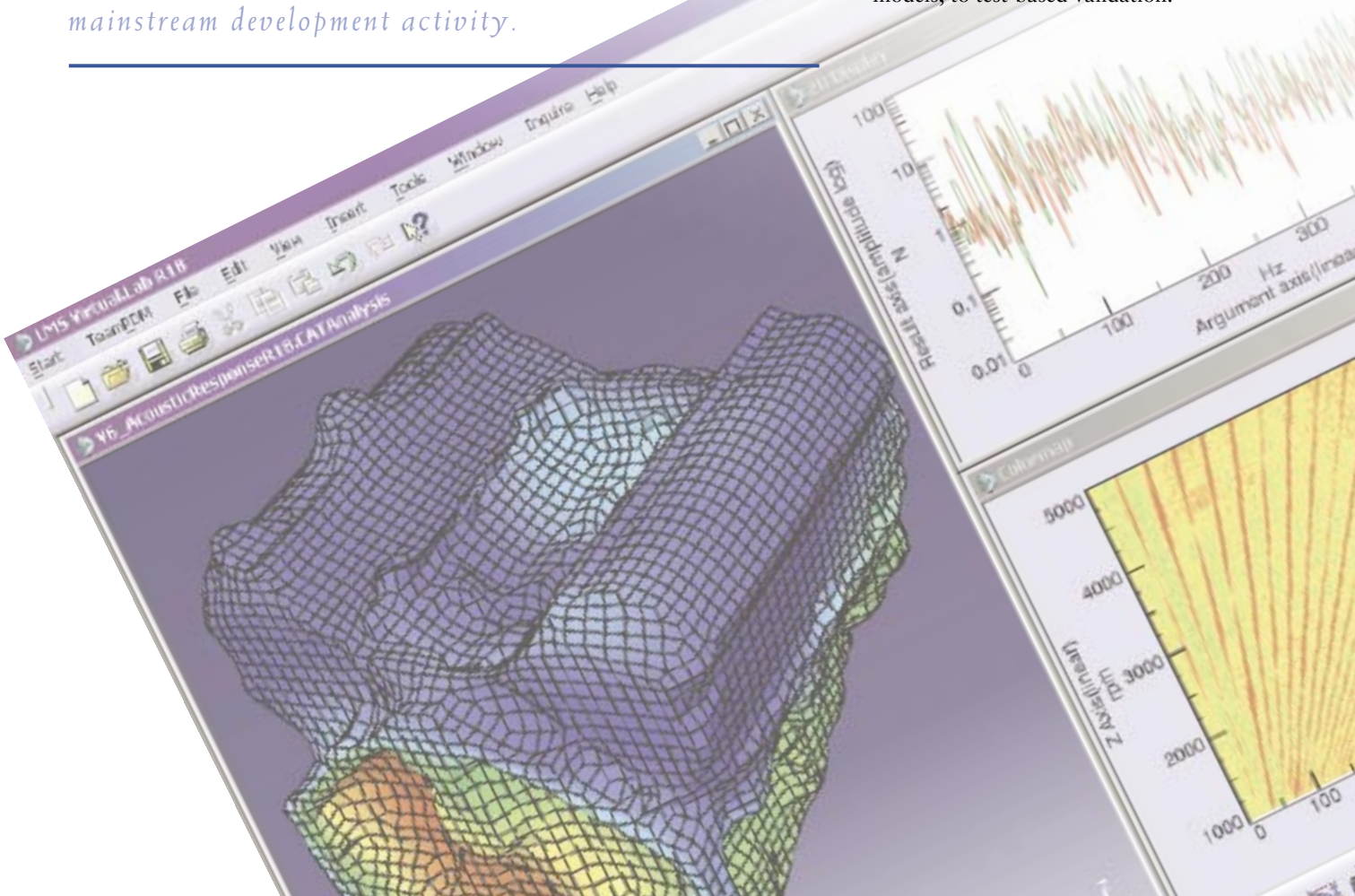
to real opportunities

From its pioneering application of acoustic FEM and BEM technologies over a decade ago, LMS SYSNOISE has been validated by thousands of users, spread over a wide range of industries. Recent technology breakthroughs made SYSNOISE faster than ever before – in many cases more than100 times faster!

The LMS acoustic solution covers routine applications, such as radiated sound and cavity field simulations, and addresses specific acoustic engineering issues, such as engine run-ups, wind-generated noise, or panel contribution analysis.

By integrating SYSNOISE into LMS Virtual.Lab, LMS created the world's first end-to-end environment for acoustic performance engineering, from concept development, through design refinement using virtual models, to test-based validation.

LMS turned acoustic prediction into a regular mainstream development activity.



Acoustic Simulation: an Integral Part of the Mainstream Engineering Process

Re-use CAD and CAE models

To facilitate an easy start in the acoustic engineering process, LMS Virtual.Lab has seamless links to leading CAD and CAE tools, and even to the Test world. No more time lost in recreating models, re-meshing for different applications, or endlessly converting between different file formats. You can use your preferred Finite Element (FE) solver for structural analysis and have it even run in the background of the LMS Virtual.Lab environment.

Create the acoustic mesh

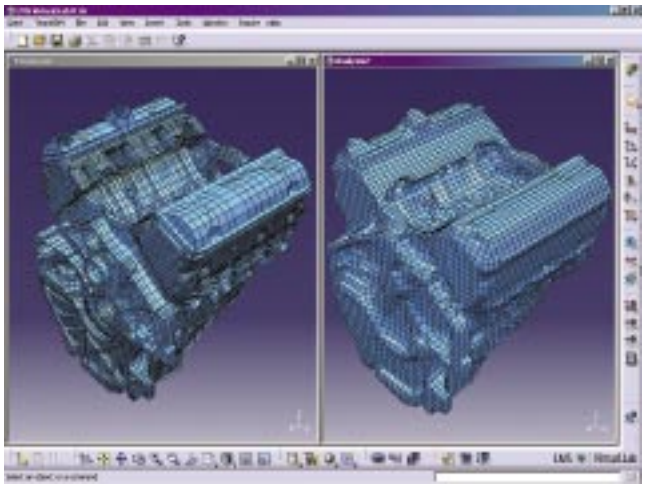
LMS has dramatically accelerated both the cavity and exterior acoustic meshing process. For exterior meshing, the unique approach can be compared to wrapping the structure with a rubber sheet: small surface features are therefore smoothed, but the features responsible for the acoustic response remain in place. Acoustic meshes are validated automatically, free edges and 'junctions' are detected to ensure proper boundary conditions – and any potential problems are flagged to prevent errors rippling through the process.

Complete the model

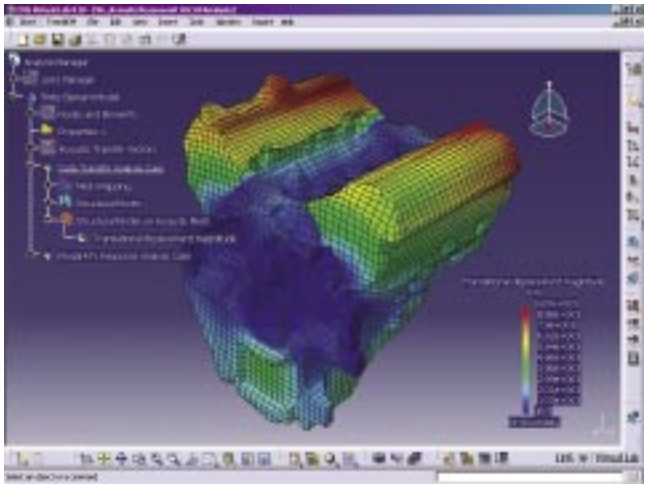
Even from incompatible structural models, it's easy to create structural vibration loads and apply as input for the acoustic calculation. Quickly build-in acoustic properties, such as frequency-dependent absorbent surfaces, add complexity for more detailed studies, automatically generate ISO field-point meshes and make the model associative with geometry, so you can even track any geometrical design change. Acoustic source definitions range from simple point sources to sophisticated distributed sources such as random pressures, diffuse fields, and even flow induced noise.

In case your design is subjected to internal forces generated by moving parts, you can perform a system-level mechanical simulation using Virtual.Lab Motion, to accurately predict these forces and the resulting structural vibrations. This approach delivers more accurate results and provides significantly more insight in the cause of acoustic problems.

"Imagine that acoustic meshing could be performed in a couple of hours, and that an engine run-up could be predicted within a day. With LMS Virtual.Lab Acoustics it has become reality".



Virtual.Lab easily transforms a structural mesh (left side) into an acoustic mesh (right side). Holes are filled, ribs are removed and a new frequency-dependent mesh is wrapped around the structure.



You can use your preferred FE solver to calculate the engine modes. In Virtual.Lab, modes are mapped onto the acoustic mesh to serve as vibration input for the acoustics calculations.

Solve tough acoustic problems

Robustness and speed of calculation are two of the critical attributes when it comes to applying acoustic simulation successfully in mainstream product development. Results are needed in time to feed back into the design. A week's calculation should be reduced to an overnight calculation or even further down to a one hour calculation.

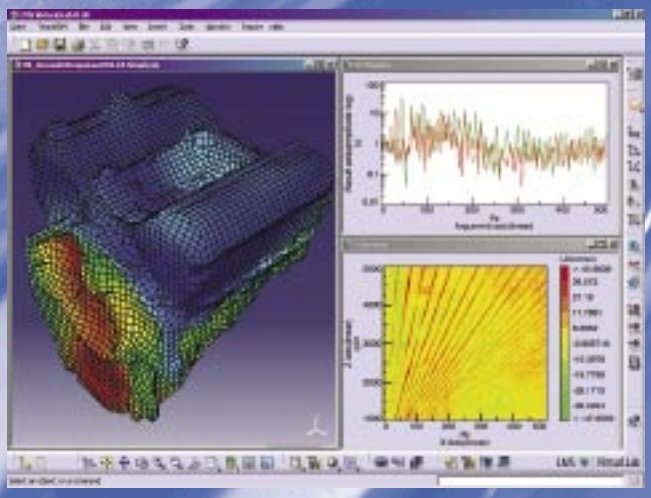
The LMS SYSNOISE solver technologies have been recognized particularly for speed and robustness. Solvers are available in the frequency domain for stationary problems and in the time domain for transient calculations. Modal solvers, direct solvers, high-speed iterative multi-domain solvers, Acoustic Transfer Vector (ATV) solvers and more provide the speed and robustness tuned to each particular application.

Visualize and interpret results

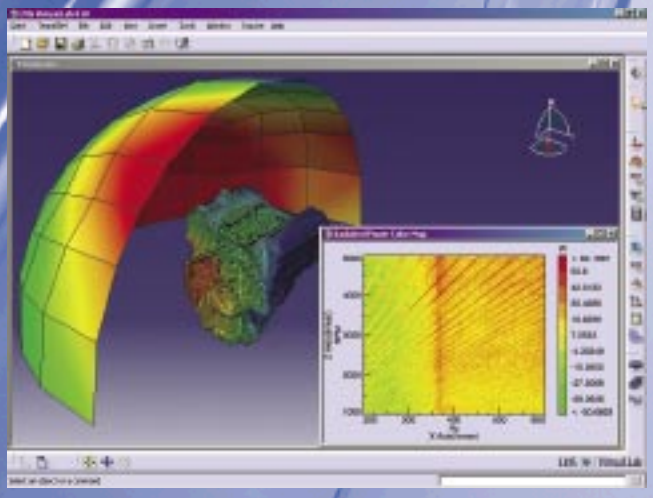
Engineers need to verify acoustic performance, identify existing acoustic problems and have to come up with qualitative solutions. They need a wide range of specialized post-processing tools to manipulate, visualize and interpret their data. LMS has it all. From the initial avalanche of results, you'll be able to grasp the most significant information, post-process, identify design trends, and create graphical acoustic data representations. Stunning visual animations permit you to inspect structural vibration and acoustic patterns - and provide deeper insight as to what is really happening. A summary report is generated and delivered on the spot!

Refine and optimize your design

Take full advantage of LMS acoustic solutions to predict the effect of any design change fast. A very effective parametric analysis capability permits you to automate the process workflow. For example, it enables you to apply new engine run-up excitation data to an existing acoustic model of an engine and, on top of this, it is possible to compare all previous results with the new results and with target values. By using Design Of Experiments (DOE), you can automatically explore the design space and find the design parameters for the optimal acoustic performance against non-acoustic constraints such as weight or durability performance.



Test-based excitation data, such as order or multi-rpm frequency spectra, are applied to the engine. Results showing the vibration of the engine in operation are plotted on the acoustic mesh.



The total radiated acoustic power from the engine is plotted on easy-to-interpret colormaps, taking into account multi-rpm engine load conditions. Pressure plots for critical engine speeds or frequencies are projected onto a hemisphere around the engine.

A Process Approach to Interior Acoustics

How can you apply structural damping, absorption or insulation to tune the sound of vehicle interiors in the most efficient way? Is adding a mass to the firewall the preferred option, or stiffening the roof, or perhaps changing the trim thickness of a panel? How can you reduce the noise in ducts and other enclosed spaces - or improve the efficiency of a muffler? LMS provides a complete process solution that enables you to engineer the sound inside cavities: making a FE mesh; creating the model, setting up boundary conditions and excitations, accounting for fluid coupling and structural responses; managing the solution; post-processing, visualizing, interpreting and refining.

Modeling interior acoustics

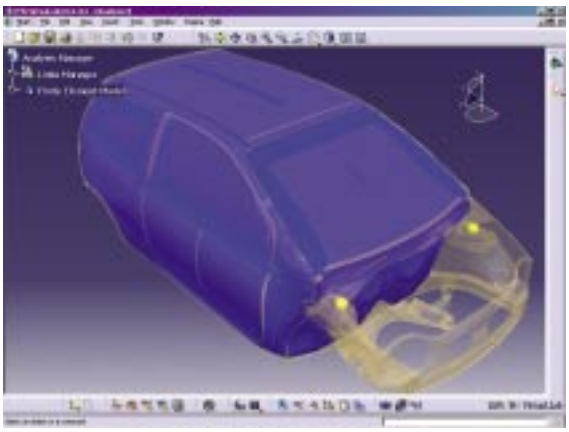
You can use the FEM methodology to model the fluid, including absorbent liners, perforated or permeable walls and porous material, and as a result, predict the corresponding vibro-acoustic modes and responses. The advanced tools offer efficient panel contribution displays, predict coupled modes, sound transmission coefficients and insertion losses.

And what's the result? In a flexible fashion you are able to manage the modeling of a body, sub-frames, assembly, force inputs … to predict system-level transfer functions; account for the contribution of individual panels to the overall sound field; include volumetric absorption from vehicle seats, surface absorption from acoustic treatments, and structural damping from the trim in the model.

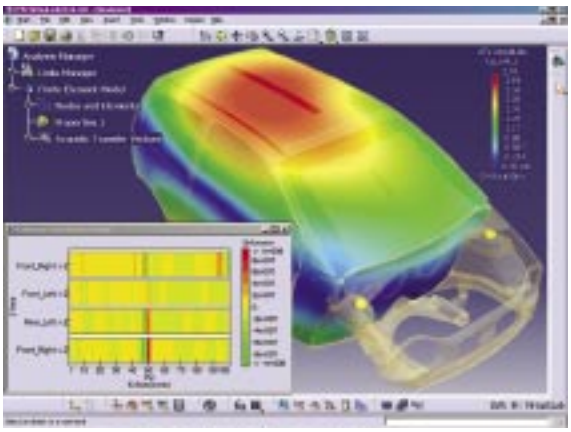
Advanced tools

Even the effect of temperature variations and wind flow can be simulated. It's that comprehensive! LMS also provides time domain models to solve transients, such as bump events and door slams. Local models of sound transmission through an individual panel or a sub-system can be used (with multiple layers, partial holes, etc.) in order to simulate transmission tests and to investigate the behavior in the higher frequency ranges, to optimize local as well as global behavior and isolation.

- Cavity meshing
- Multi fluids
- FEM and BEM methods
- Fluid-structure coupling
- Surface and volume absorbers
- Sound treatment
- Iterative solvers
- Panel contribution analysis



The structural finite element mesh is overlaid with the acoustic cavity mesh, a hexa-dominant volume mesh that is developed directly from the structural finite element mesh of the car body and closures.



Built from predicted interior sound pressure levels and vehicle noise transfer functions, contribution diagrams enable the NVH engineer to focus on the acoustic troublemakers and get to system improvements.

A Process Approach to Exterior Acoustics and Sound Radiation

What is the best way to minimize radiated sound? Do you need to consider internal structural stiffening? Where may damping be added? Is encapsulation an option? LMS provides all the tools and the technology breakthroughs needed to dramatically accelerate the solution process, ranging from building an acoustic radiation mesh to a new Acoustic Transfer Vector (ATV) approach for performing multi-regime acoustic calculations. This benefit is further leveraged through the integration with other technologies of the engineering process (structural models, multibody dynamics, etc.)

Modeling exterior acoustics

The modeling process features the automatic generation of field point meshes, symmetry planes, and sources for acoustic scattering problems. You can implement a fully-coupled fluid-structure solution based on structural FE models, taking into account the compliance of light/flexible structures, the influence of dense fluid, the effect of narrow fluid regions between flexible parts … and at the same time, providing structural as well as acoustic responses for a wide variety of applications, such as interior/exterior transmission, loudspeakers and hull-water interaction.

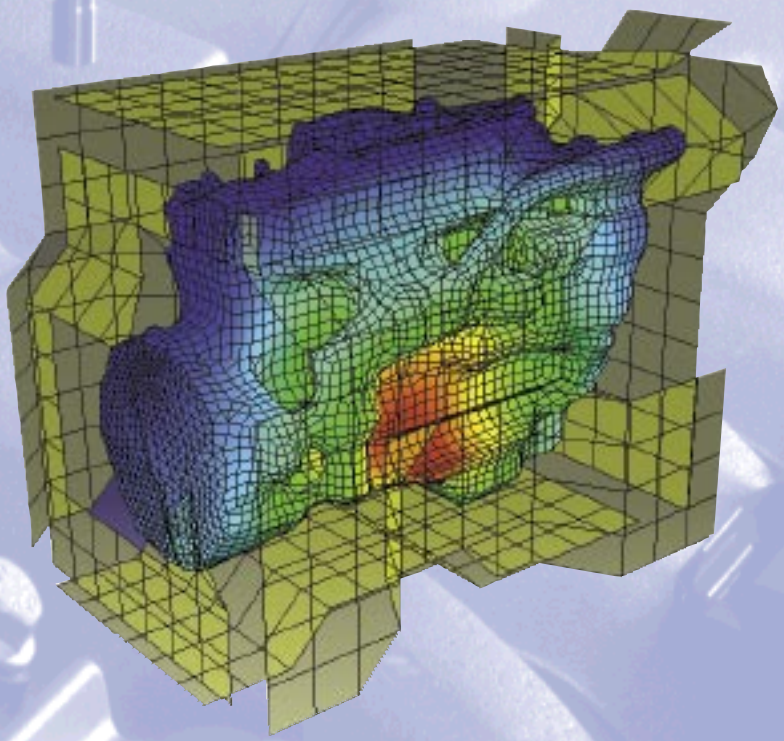
Advanced tools

For time domain solutions, and in general cases where FE acoustics features are needed, acoustic FEM models can be extended with Infinite Elements using a choice of state-of-the-art formulations.

Key Methods:

- Envelope meshing
- BEM and IFEM methods
- Highly efficient ATV-based solver for multiple load cases
- Field point meshing

LMS provides an integrated solution for performing multi-regime acoustic calculations



Delivering Technological Breakthroughs

From advanced FEM and BEM modules for routine applications, to state-of-the-art solvers for specific applications, LMS solutions strongly increase the efficiency and capability of the acoustics engineer.

Finite Element and Boundary Element Modeling

Over the years, the LMS FEM, infinite FEM, BEM solutions have been tuned for speed and flexibility. Acoustic engineering can now become part of the mainstream development activity because algorithm calculations are far more time efficient and can, by taking advantage of parallel computer networks, be completed in one hour instead of the usual 100 or more. Both time and frequency solvers are supported.

Acoustic Transfer Vectors (ATV)

Using traditional FE approaches, a full engine run-up analysis easily takes over a month to complete. With the LMS patented Acoustic Transfer Vector technology (ATV), an acoustic mapping to ISO3744 can be completed in less than a day.

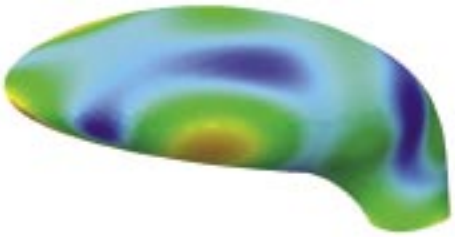
Any subsequent runs for other loads or design iterations typically take minutes. ATVs can be combined with BEM for acoustic radiation and with FEM for cavity models, both providing super-fast panel contribution calculations.

Flow induced noise

Flow-induced noise is often a major contributor to the overall sound field, but its effect has traditionally been difficult to simulate. In a unique extension to the LMS acoustic solution, the results of industry-standard CFD codes, such as StarCD, CFX and Fluent, can be used to model aero-acoustic noise. The sources can be surface-distributed dipoles (surface pressure noise), volume-distributed quadrupoles (wake noise), and fan noise.

Random vibro-acoustics

Random Vibro-Acoustics uses a fully coupled model of vibro-acoustic interaction to solve the response to pure random excitations. Also multiple excitations with complete or partial incoherence between them, diffuse fields, spatially distributed random pressure loads, such as jet engine shock cell noise, are handled.



Unsteady pressure loading on a side car mirror generating noise

Unsteady forces on fan blades generating noise

Noise from a strut present in a turbulent subsonic jet

Inverse numerical Acoustics

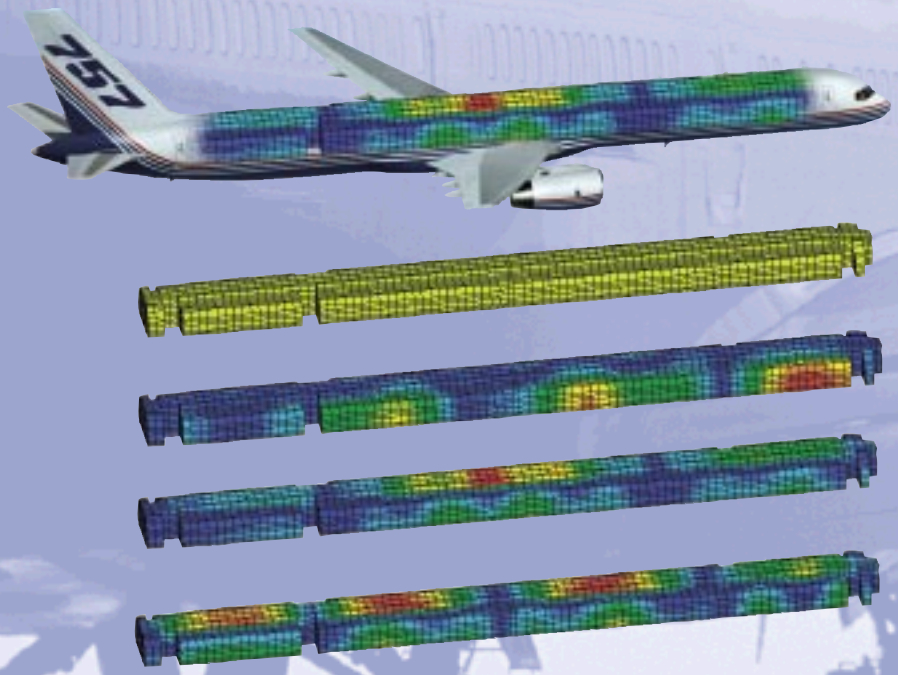
Inverse Numerical Acoustics determines the operating vibration patterns on noise-radiating surfaces, starting from measured sound fields. In particular when the vibration cannot be measured directly, this powerful tool solves noise source identification and quantification problems very efficiently.

Multi-layer sound insulation

Through developments in conjunction with specialists in the acoustic materials business, LMS provides special methods to model multi-layered acoustic treatments and assemblies. Design engineers are not limited as to the number of layers, which can include solid materials (such as structural shells and damping treatments), as well as air gaps and poro-elastic layers (such as foam, fiber matting and inter-laminar glue.)

Panel contribution analysis

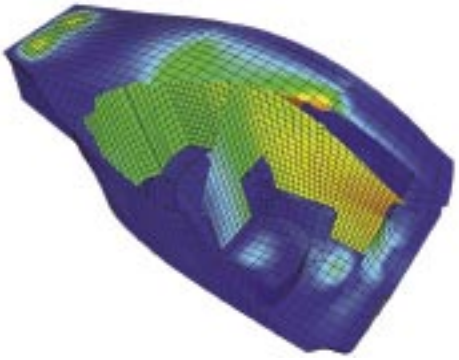
With this module it's easy for example, to rank the contribution from the firewall, doors, windows, roof to the passenger cabin interior noise. It all operates in a highly interactive fashion and is extremely fast. Just click on the panels and get an almost-instant diagnosis. Select the appropriate assessment criterion and you will learn what is causing the overall noise and, at the same time, be able to identify modifications that improve noise characteristics.



Acoustic Simulation for a Broad Range of Applications

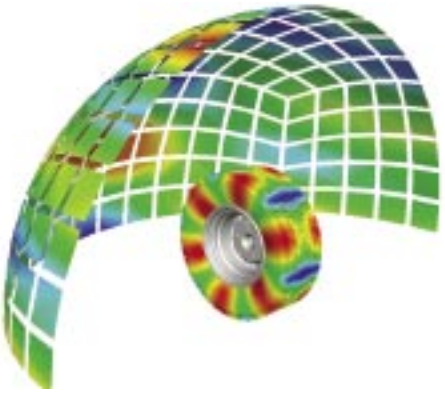
Automotive and Ground Vehicles

LMS Virtual.Lab Acoustics empowered by the technologies of LMS SYSNOISE provides everything one needs to model, analyze and refine the quality of the interior sound of passenger cars, trucks, buses and trains.



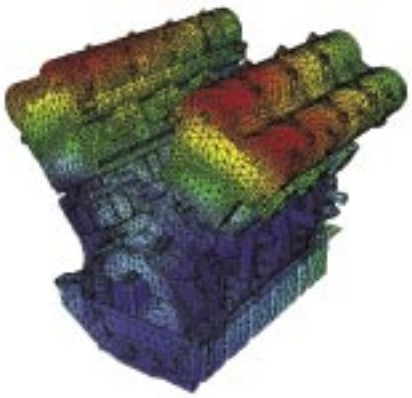
Tires

Tires represent a significant contributor to the noise generated by ground vehicles including interior acoustic comfort as well as pass-by noise. Acoustic modes can be excited inside the tire and therefore can amplify the sound radiated to the outside. Comprehensive noise modeling for tires typically includes several techniques such as FEM, I-FEM, BEM, frequency and time domain techniques all of which are part of the LMS Acoustics portfolio.



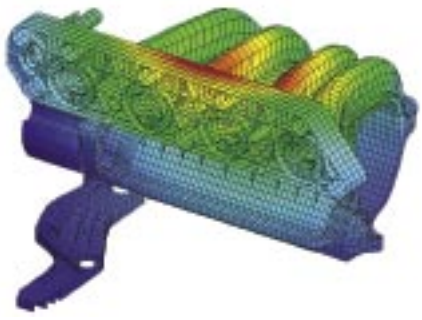
Combustion engines

With Virtual.Lab Engine Acoustics, engineers solve complete acoustic radiation problems even starting from the design stage. Load identification based on experimental techniques or on multibody analyses provides the accurate inputs for any operating condition of the engine.



Intakes and mufflers

Orifice noise and shell noise, due to mechanical and acoustic loadings and including the fluid-structure coupling of light-weight components can be solved, as well as transmission loss of mufflers and complete systems.



Aircraft and aerospace

Accurate prediction of the acoustics of an aircraft interior requires accurate modeling of the different transmission paths of noise: structureborne and airborne. The random acoustics technologies of SYSNOISE make it possible to calculate the structural behavior of the fuselage due to a random pressure field acting on its surface. Multi-layer trim transmission combined with an interior acoustic model then provide accurate interior noise levels of the aircraft. The aero-acoustics capabilities tackle noise generation from landing gear and flaps.

Aircraft engine

Aircraft engine manufacturers face continuous challenges to reduce the noise emitted by the engine to comply with ever-more stringent government regulations and to increase passenger comfort. Near-field noise in open ducts with non-uniform flow, as well as far-field noise radiation and scattering, can be modeled.

Industrial machinery

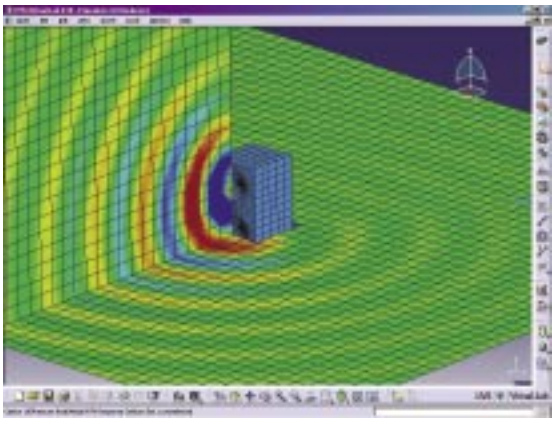
Workplace noise levels are of general concern, and government regulations are put in place to limit workers' exposure. Noise generated from machinery becomes a critical factor in the design process of systems ranging from compressors and pumps to electrical transformers and more.

Consumer goods

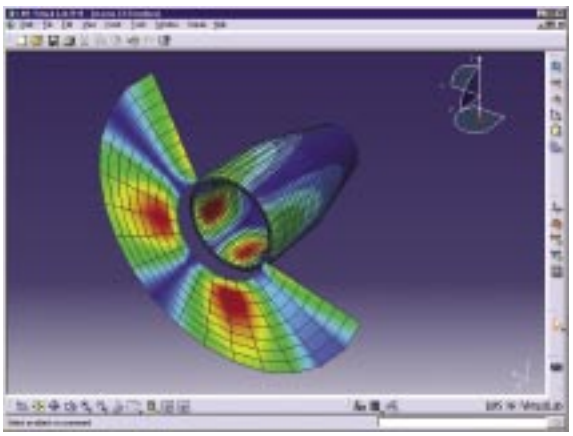
Acceptable noise levels of consumer goods have become a critical factor for acceptance by the customer, for items like dishwashers, washing machines, microwave ovens or drills. For other consumer goods, high quality acoustic performance should be obtained for example for items like mobile phones and loudspeakers.

Underwater acoustics

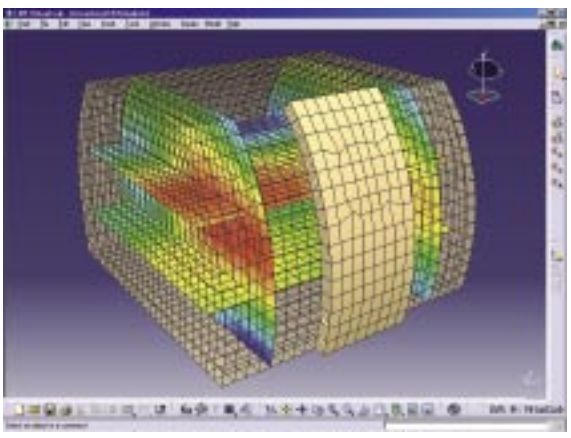
Applications include the analysis and refinement of sonar systems including interactions of multiple tranducers in an array, and underwater radiation from ships and submarine hulls.



Acoustic prediction helps improving loudspeaker characteristics



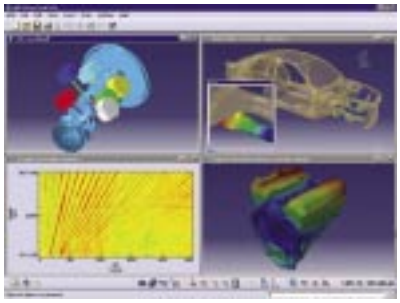
LMS Acoustics solutions help aircraft engine manufacturers to reduce engine emitted noise



Aircraft manufacturers investigate noise control strategies to reduce cabin noise

LMS International,
Empowering Engineering Innovation

LMS enables customers to engineer functional performance targets into their products, creating and maintaining distinctive brand values. LMS' unmatched understanding of the product development process is captured through a unique combination of products and services supporting physical and virtual product development: Test systems, CAE software products and engineering services. Critical attributes such as noise and vibration, ride, handling, motion, acoustics and fatigue are turned into a competitive advantage.



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LMS Test.Lab

LMS Test.Lab provides the most complete portfolio of applications for test-based noise and vibration engineering. It comprises modules for structural, rotating machinery and acoustic testing and analysis, environmental testing, reporting and data sharing.

LMS Engineering Services

Through its Engineering Services Division, LMS provides vehicle development support from overload contracting and troubleshooting, technology transfer, up to co-development projects.

Image courtesy Boeing, David Noels, TWR

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