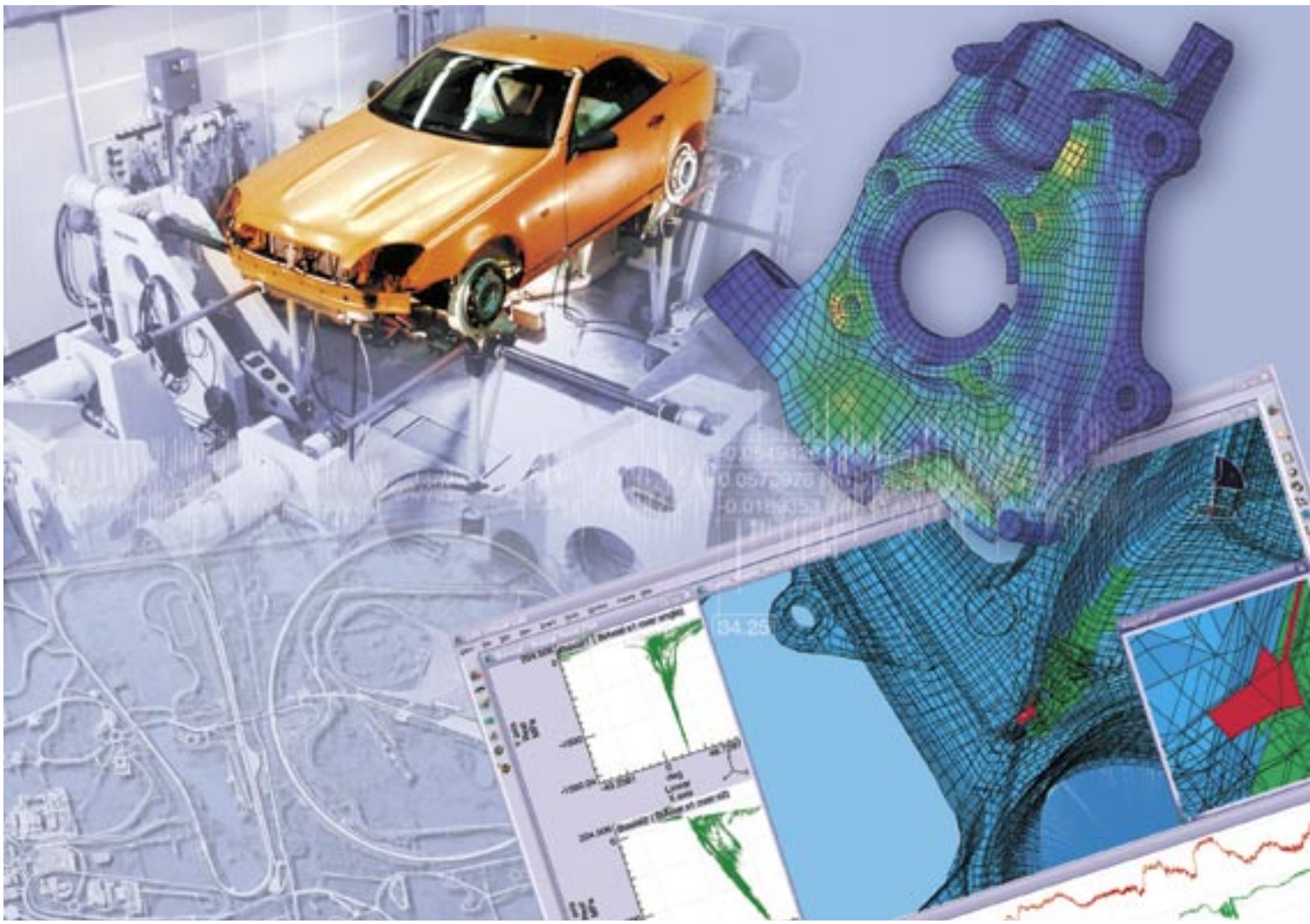
LMS Virtual.Lab Durability

Better Engineering Decisions Earlier in the Process



LMS Virtual.Lab™

LMS INTERNATIONAL

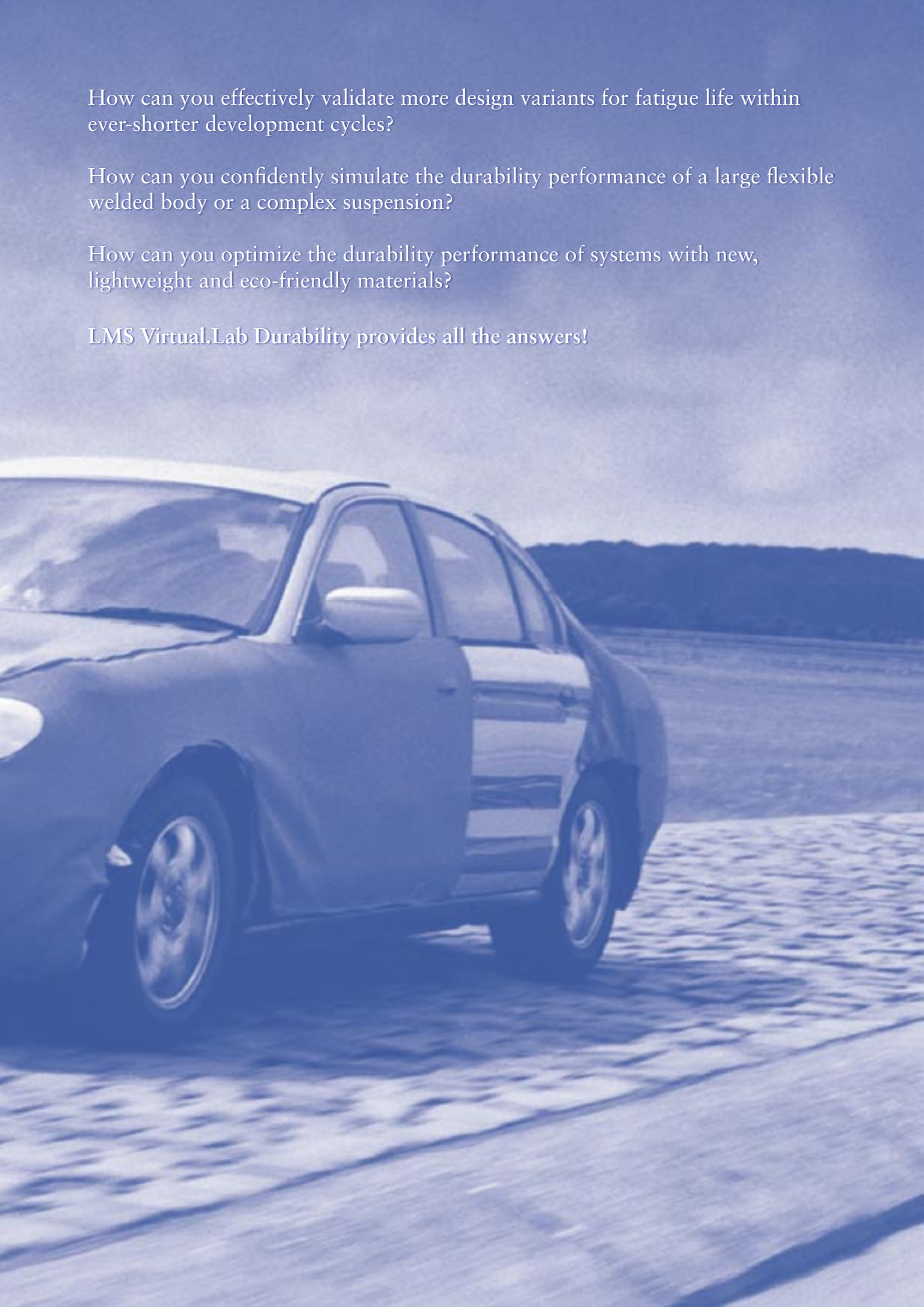
Empowering Engineering Innovation

How can you effectively validate more design variants for fatigue life within ever-shorter development cycles?

How can you confidently simulate the durability performance of a large flexible welded body or a complex suspension?

How can you optimize the durability performance of systems with new, lightweight and eco-friendly materials?

LMS Virtual.Lab Durability provides all the answers!



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 CAA V5 (Component Application Architecture), the open middleware for PLM (Product Lifecycle Management) from Dassault Systèmes.

Integrating mission-critical applications

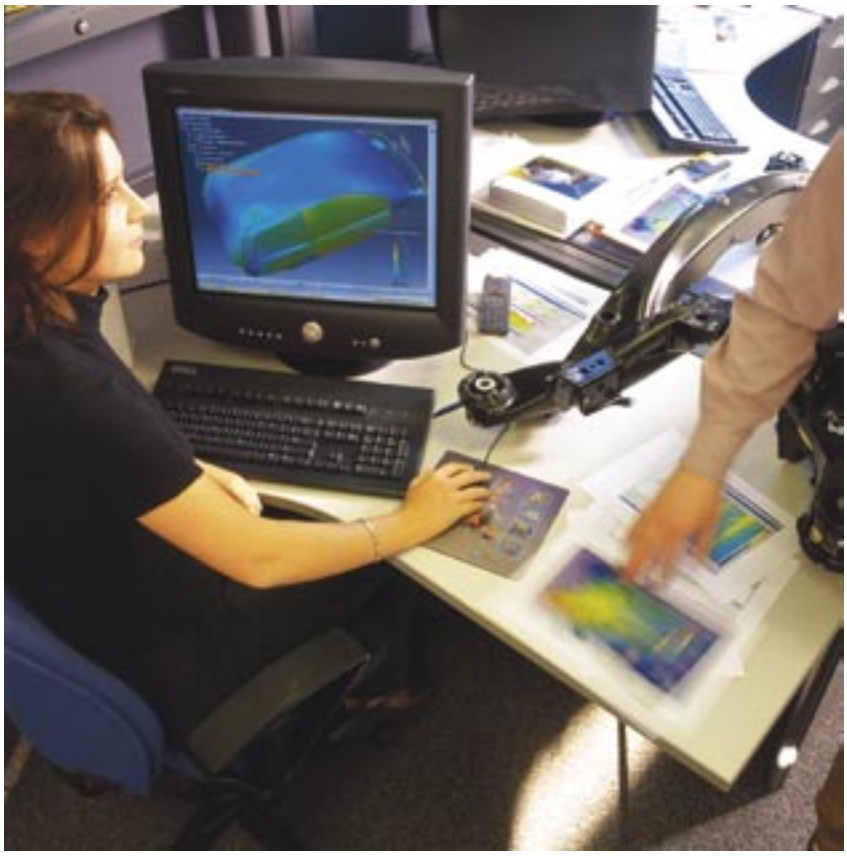
Being able to explore the design space for a given attribute already provides critical insights into the dynamics of an engineering problem. But Virtual.Lab can do more. It can intelligently find the optimum point in the design space, giving a leap forward in productivity. By a close integration of mission-critical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

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.

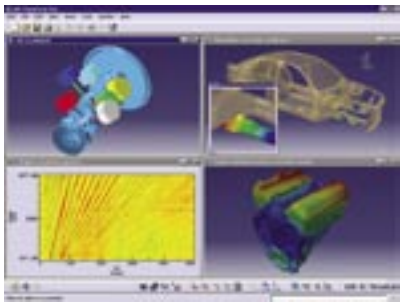
Delivering value-added engineering

LMS 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.



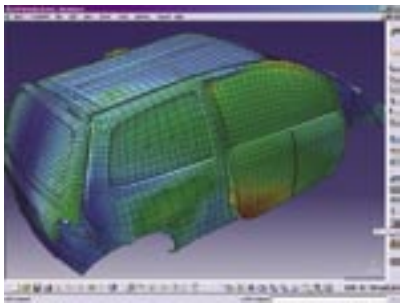
LMS Virtual.Lab Desktop

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.



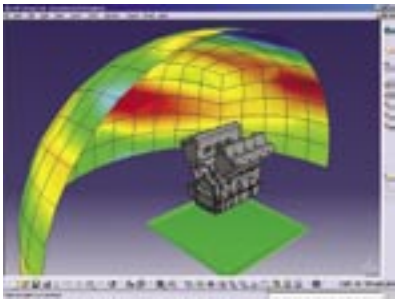
LMS Virtual.Lab Noise and Vibration

Virtual.Lab Noise and Vibration combines proven technologies with breakthrough techniques to create the world's first solution for N&V 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.



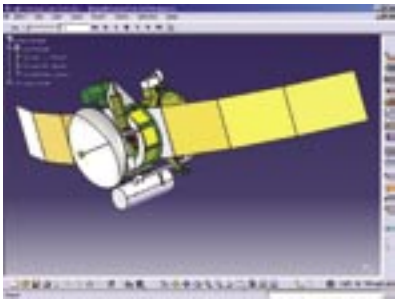
LMS Virtual.Lab Acoustics

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.



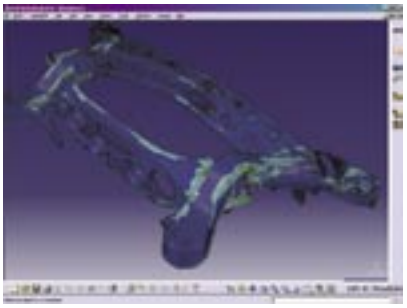
LMS Virtual.Lab Motion

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 allow you to predict fatigue-life performance in time to positively affect the design process. It predicts the durability performance of large flexible welded bodies subject to hundreds of loads from all directions. LMS Virtual.Lab Durability integrates Finite Element (FE) and MultiBody Simulation (MBS) with numerical fatigue-life predictions to provide the most advanced system-level durability solution.



Designing for Optimal Durability Performance

Undoubtedly the most challenging task for durability engineers is designing components and systems that are fail-safe – but not overdesigned. System parts with insufficient fatigue strength may cause permanent damage and potentially life-threatening situations. In addition, product recalls influence market perceptions negatively. Failing durability engineering also leads to parts that are too heavy and expensive to manufacture.

But this is not all! Today, development cycles have become dramatically shorter and more design variants are built upon the same platform. In response to highly innovative and compact design requirements, manufacturers are urged to evaluate and incorporate new lightweight and eco-friendly materials. And more distributed development responsibilities pressure OEMs and suppliers to more efficiently share requirements and analysis procedures.

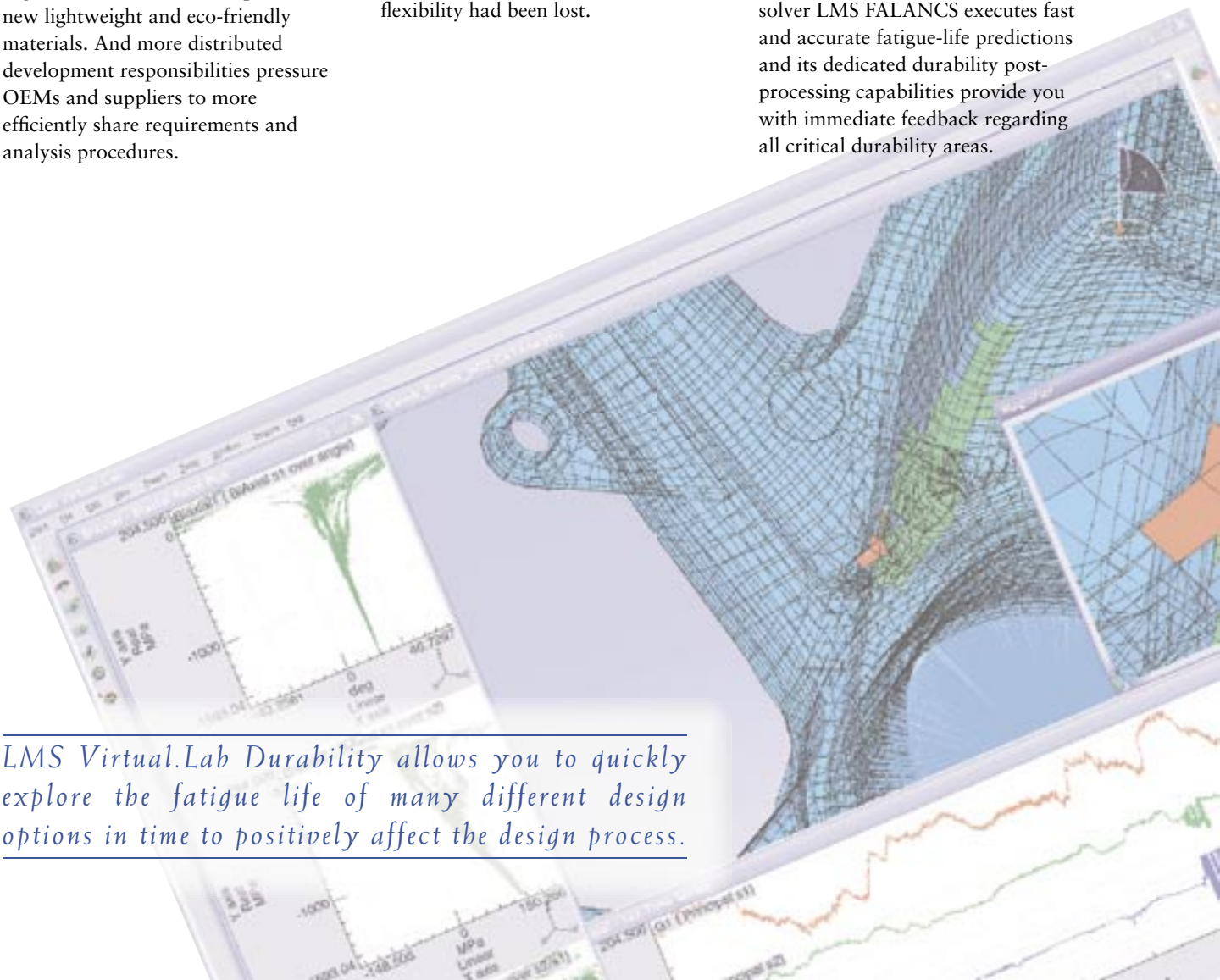
Turning durability challenges …

Shorter development cycles and increased quality requirements have stretched traditional test-based durability processes to the limit. Evaluating durability performance on a virtual prototype, before signing it off with a physical test – is the only valid alternative. Just a few years ago, predicting fatigue life on component level used to take weeks, while a system-level analysis used to take months – when possible at all. Exploring multiple options to optimize the durability of a design was simply not feasible given the time constraint. The only option was to use expensive treatments late in the development when all design flexibility had been lost.

… into real differentiators

Based on its extensive history of cooperation with leading research institutes and key customers, LMS embedded its advanced numerical durability technology into LMS Virtual.Lab. This revolutionary process solution for durability performance engineering tightly integrates Finite Element (FE), MultiBody Simulation (MBS), Test and fatigue-life prediction.

LMS Virtual.Lab Durability allows you to quickly explore the fatigue life of many different design options on component and system assembly level, in time to positively affect the design process. Its industry-standard solver LMS FALANCS executes fast and accurate fatigue-life predictions and its dedicated durability post-processing capabilities provide you with immediate feedback regarding all critical durability areas.



LMS Virtual.Lab Durability allows you to quickly explore the fatigue life of many different design options in time to positively affect the design process.

A Process Approach to Component Durability Prediction

Tracking the fatigue-life performance of components through static stress simulations does not deliver trustable results. Stress simulations, gained from FE analyses, completely neglect the effects of multiple load combinations and load alternations over time. This leads to the fact that critical durability areas remain undiscovered during the development stage, yielding enormous risks during the subsequent stages.

LMS Virtual.Lab Durability goes way beyond static stress investigations. It is capable of assessing the durability performance of individual parts in an accurate and effective way. From within a single integrated environment, you can efficiently work with large industry-sized FE models and extensive material property sets.

Quick and easy setups

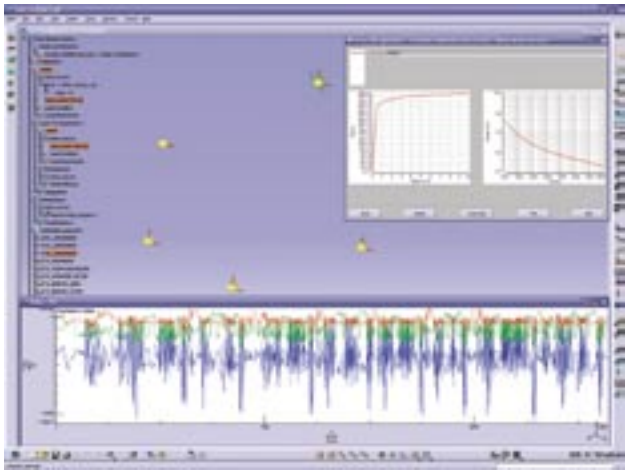
Setting up fatigue-life predictions in LMS Virtual.Lab is very straightforward. A clear built-in workflow and a template-based analysis setup accelerate user operation. Any FE solver of choice can be automatically launched and driven, eliminating all concerns about data handling and file transfer. After only a few minutes, engineers are ready to launch the fatigue analysis.

- Seamless access to structural FE meshes and stresses from CATIA V5 CAE, MSC.Nastran, I-DEAS, ANSYS, PERMAS and ABAQUS
- Automatic driving of MSC.Nastran and ANSYS
- Direct import of component loads from prototype measurements or multibody simulations from LMS TDF, IST RS, MTS RPC, nCode dac and ASCII file formats.

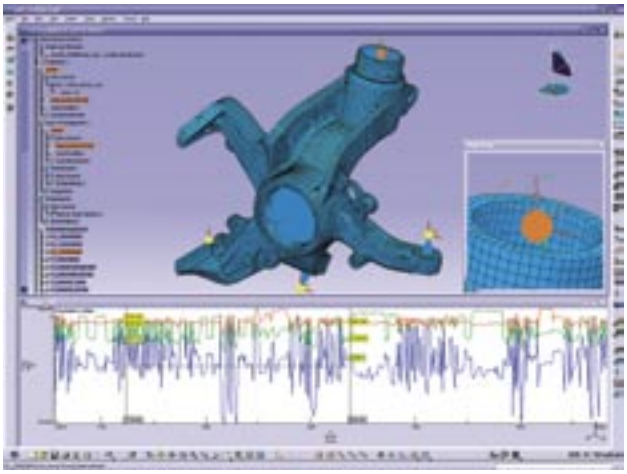
A wide range of analysis methods

Fatigue-life analysis capabilities in LMS Virtual.Lab Durability are based on LMS FALANCS, the well-accepted solver for industrial-sized problems. Methods for the assessment of low-cycle fatigue (stress-life), high-cycle fatigue (strain-life) and infinite life (Dang Van) are included for analysis. Additional specific approaches are available for the analysis of seam and spot welds.

To ensure that your components are fail-safe – but not overdesigned – you can calculate load safety factors using either the well-proven Dang Van approach or critical plane-based methods. The combined events analysis case allows efficient setup of complete durability schedules and easy “what if” scenarios by changing repetition factors.



Start your component durability analysis by opening a template – including measured load cases, material and fatigue solution parameters.



Import your FE mesh. Interactively inspect the different loads acting on your component. There is no limit to the number of loads and their duration.

Delivering dedicated engineering insights

Clear durability results set the baseline for smart durability refinement. LMS Virtual.Lab comprises a wide range of dedicated durability visualization and post-processing tools. It is also easy to combine any graphic representation with simultaneously displayed load time signals. It even supports animated structural deformations to be displayed next to stress and/or damage results, as opposed to non-animated result plots from generic post-processing tools.

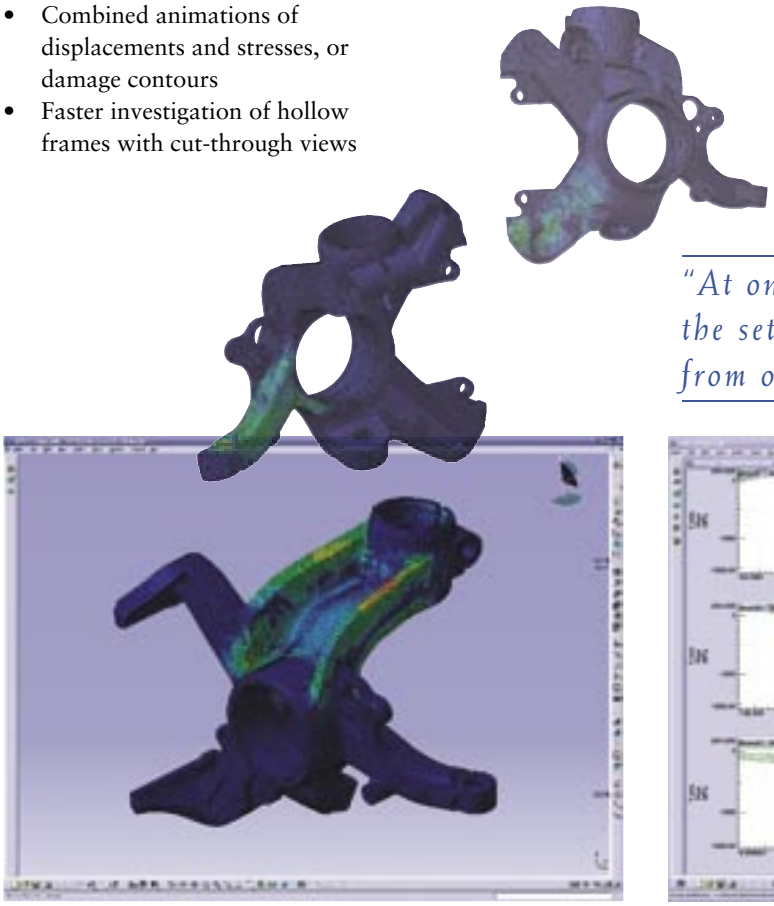
- Visualizations of damage, fatigue life, maximum stress amplitudes and safety factors
- Display of dedicated time series
- Combined animations of displacements and stresses, or damage contours
- Faster investigation of hollow frames with cut-through views

LMS Virtual.Lab Durability makes it very easy to assess the durability impact of a design modification, different loading conditions or an alternative material characteristic assignment. Various ways are offered to drill down and gain the insights you require to understand the root causes behind critical component locations. For each predicted hot spot, specific analysis tools enable you to easily retrieve the individual contributions of all participating loads.

- Topological detection of critical regions restricts further analysis exclusively on critical regions
- Detailed analysis of stress tensor histories can easily occur at hot spots

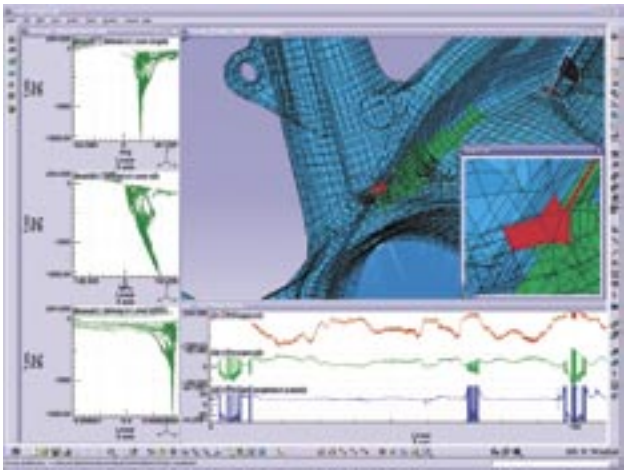
Exploring multiple designs

LMS Virtual.Lab's tight and seamless integration with Test, CAD and CAE solvers literally cuts weeks out of the durability engineering process. LMS Virtual.Lab Durability is capable of automatically executing consecutive analyses, during which different design variations and/or load cases seamlessly flow through the complete fatigue-life simulation process. With these parametric analyses, you can efficiently explore the design space and identify the most innovative design solutions, before starting physical prototyping. While optimizing designs for durability, LMS Virtual.Lab also permits you to keep a close eye on other functional performance attributes, such as ride and handling, noise and vibration, or crash.



The FE stress analysis is automatically launched, eliminating data transfers and management worries.

"At one automaker, Virtual.Lab reduced the setup time for durability predictions from one week to one hour!"



Launch the fatigue-life prediction. Zoom in on critical component hot spots and derive suggestions for design improvements.

Delivering Technology Breakthroughs on Component Level

Efficient seam and spot weld assessments

Hundreds of spot welds and long runs of seam welds may be part of sheet structures, as used in vehicle body and suspension systems. For spot welds, LMS Virtual.Lab supports the Rupp/LBF approach, CDH and a special JSAE model.

LMS Virtual.Lab Durability automates the durability assessment of seam welds and spares engineers the trouble of tediously adapting the FE-mesh according to seam weld meshing guidelines. All that needs to be done is defining manufacturing details of the welded zone. LMS Virtual.Lab identifies the local stress concentrations, based on all possible combinations of (local) load conditions of the welded detail.

- Sheet connections are automatically detected and classified (element groups or predefined groups)
- Connection types are automatically classified (e.g. butt welds, overlap joints, T-joints)

Outstanding accuracy through in-depth investigations

Assessing the effects of loads can be challenging, in particular when they consist of multiple independent inputs. Such forces generate local multiaxial stress states. Outstanding accuracy is achieved by treating these cases based on the critical plane approach, which accounts for the anisotropy caused by microscopically small cracks.

Fatigue-life solver fit for rigid and flexible bodies

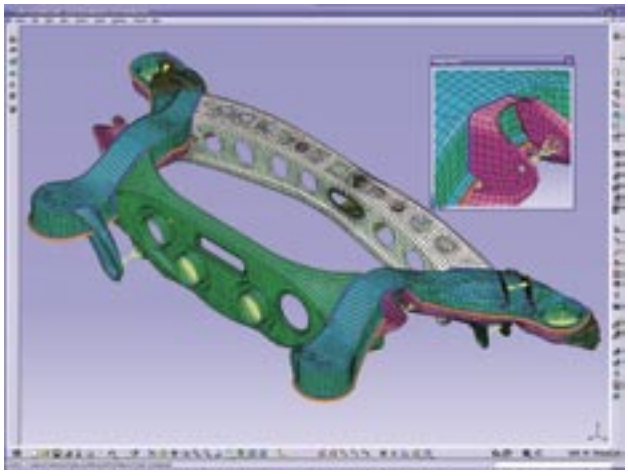
While components such as knuckles are never excited close to their natural frequencies, other parts such as suspension subframes, truck chassis, or exhaust systems may be. To accurately and efficiently tackle any situation, the solver of LMS Virtual.Lab Durability supports different approaches for predicting stresses, based on quasi-static, inertial relief and on modal superposition techniques.

Top analysis speed with smart data reductions

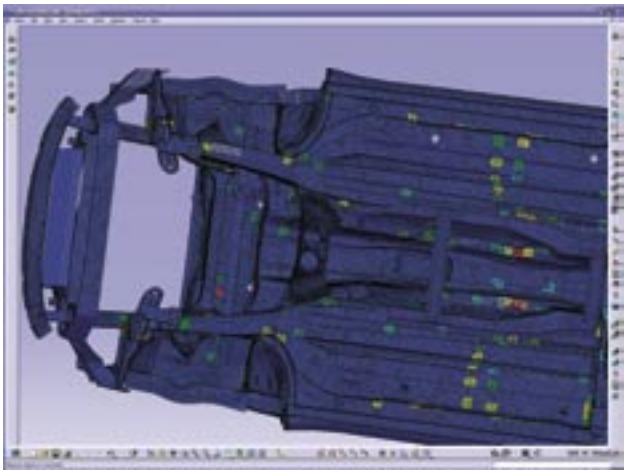
To facilitate the computation of real-life industrial size models, LMS Virtual.Lab Durability intelligently reduces the amount of data to be handled with a fully automatic process, through node elimination and RP filtering. No need to guess where the critical locations might be – all locations are found automatically. The analysis of a complex car body model, with hundreds of spot and seam welds and over 350,000 elements, is completed in just a few hours!

Insights on damage impact of individual loads

Specific capabilities that analyze local load contributions enable durability engineers to easily derive those design modifications that minimize the damage at hot spots. The assessment is based on changes in maximum stress or damage when leaving out one of the loads.



LMS Virtual.Lab predicts the fatigue lifetime of seam welds, which it automatically detects and classifies without any manual interaction.



In durability assessments of a body-in-white, LMS Virtual.Lab Durability is capable of automatically integrating hundreds of spot welds.

Understanding the Loading

A critical factor in successful durability design is gaining a precise understanding of the loads that your product will undergo during its lifetime. The use of unreliable load scenarios inherently implies invalid fatigue-life predictions, regardless of the durability prediction solution that was used. With LMS TecWare, you design load scenarios that accurately represent real-life circumstances and customer usage, both in amplitudes and variations, which form the foundation of trustable durability simulation of system parts. Systematically applying this approach minimizes product overdesign and therefore allows significant weight and cost savings in the final product.

Gathering real-life load data

LMS Virtual.Lab offers all the standards, hooks and connections needed to gather real-life load data from any source: field data from a test track, laboratory benchmarks, synthesized data from multibody simulations – or even your own archived records and drive files. There is no need at all to convert between different formats.

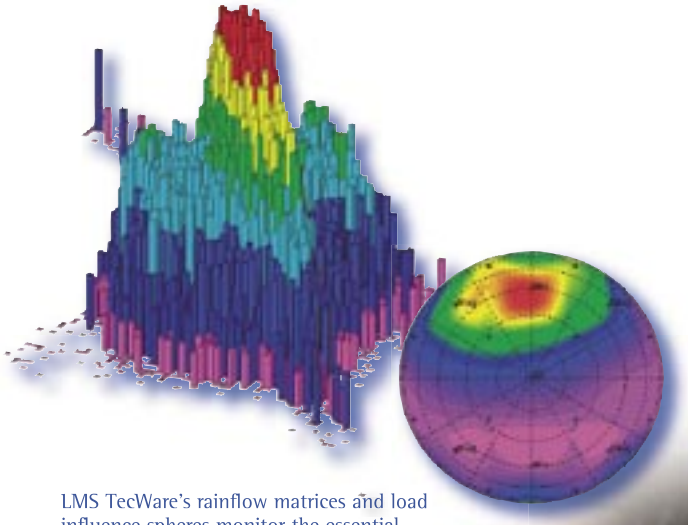
In addition, LMS Virtual.Lab is capable of transparently and simultaneously dealing with multiple data types, including LMS TDF, IST RS, MTS RPC, nCode dac and ASCII.

Analyzing and correlating load data

Dedicated state-of-the-art techniques, such as rainflow counting, help to monitor and compare the essential durability-specific aspects of dynamic load data. Starting from a rainflow counting algorithm, all one-dimensional methods such as range-pair, level crossing, and peak counting can be instantaneously derived in LMS TecWare.

In real life, of course, multiple independent loads will interact in multiple axes and result in significantly different failure locations. In response to this, LMS provides rainflow methods for the analysis of multiaxial, non-proportional loading histories.

LMS Virtual.Lab makes sure that virtual prototypes are driven by loads that match reality, delivering accurate durability simulation results.



LMS TecWare's rainflow matrices and load influence spheres monitor the essential durability-specific aspects of dynamic load data.

In LMS Virtual.Lab, you can easily integrate load data gained from test laboratory benchmarks, field measurements or multibody simulations.

From Component-level to System-level Durability Prediction

System-level durability prediction

Design problems at the full-assembly level, for example a complete suspension system or a full vehicle, are too often discovered late in the development process. Therefore, the ambition of durability engineers is to optimize subsystems or systems as a whole. This is exactly what LMS Virtual.Lab has to offer. It tightly integrates multibody simulations with flexible-body analyses and fatigue-life predictions. The durability performance of any particular system part can be effectively and accurately traced. LMS Virtual.Lab's proven solver technology and real-life modeling capabilities guarantee top-class prediction accuracy.

Early system load simulations

Long before vehicle prototypes become available, LMS Virtual.Lab is capable of generating system loads. LMS Virtual.Lab can start from virtual driver sessions, or from road tests executed on a previously released vehicle.

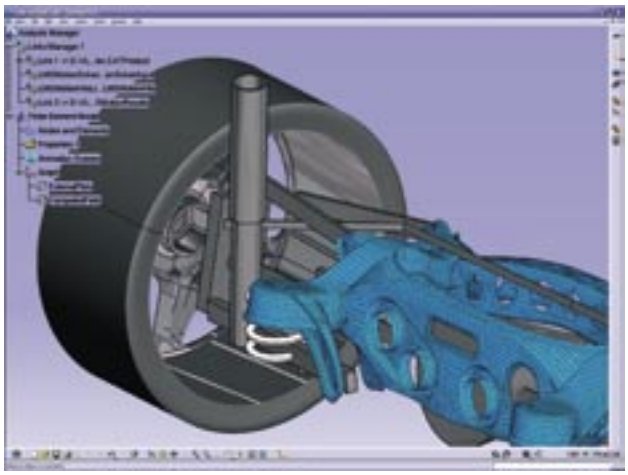
The Digital Test Track approach predicts spindle loads through realistically simulated driver sessions. A virtual vehicle is equipped with virtual tires to allow it to "ride" over digitized test tracks.

For tracks and public roads that are too complex or expensive to be digitized, LMS Virtual.Lab offers a valid alternative. The Hybrid Road approach incorporates test-based system loads of a predecessor vehicle in order to generate loads that can be confidently applied to the new design.

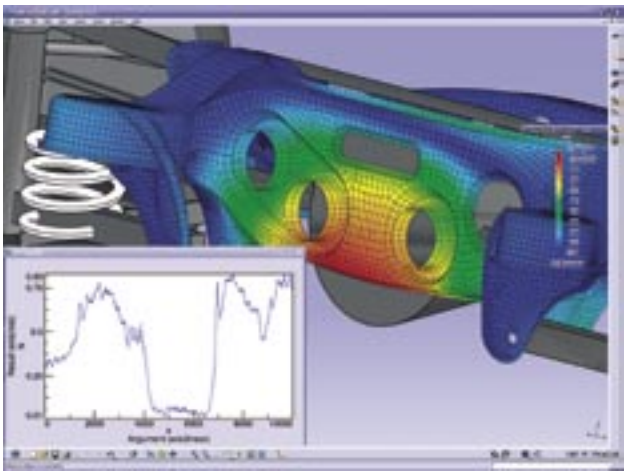
Easy to create and reuse models

Setting up multibody models in LMS Virtual.Lab Motion is very easy, for any type of user. Novices will like the way its built-in workflow, custom templates and wizard applications speed up the creation process. Experts will appreciate all available specialized features and capabilities. Existing multibody models, such as rigid-body models from LMS DADS and MSC.ADAMS, are easily importable and effectively reusable.

Scalable modeling makes it possible to refine or coarsen models at any time. Engineers can quickly set up a base model to effectively assess handling performance at high computing speed. Plugging in a flexible body is an example of refining the model for comfort and durability analyses. When finished, the handling performance of the design can be checked again by downscaling to the base model.



The automatic incorporation of flexible bodies into a multibody model eliminates the need for user interaction.



LMS Virtual.Lab Motion cascades road profiles down to load responses on component level, both for rigid and flexible bodies.

Tune your models for durability

LMS Virtual.Lab offers everything engineers need to bring models up to speed for virtual durability assessments. It makes sure that the models used for durability predictions precisely reflect non-linear stiffness and damping. It also allows taking into account flexible structures through FE modeling.

In LMS Virtual.Lab, the previously lengthy and error-prone job of integrating a flexible body only takes a few mouse clicks. All you need to do is pick up the FE mesh and drag it into the graphic display of your system model. All body connections are automatically established, based on the detected attachment nodes and degrees of freedom. Any required FE analysis is automatically driven, based on automatically generated Craig-Bampton cases and identified connection definitions.

From system to component loads

LMS Virtual.Lab Motion cascades road profiles down to load responses on the component level. The multibody model is put on a virtual test rig and the appropriate boundary conditions for applying the road profile are automatically set. Extensive experience in multiaxis actuator control have led to specific algorithms that prevent numerical drift, rotation, and rollover of the vehicle.

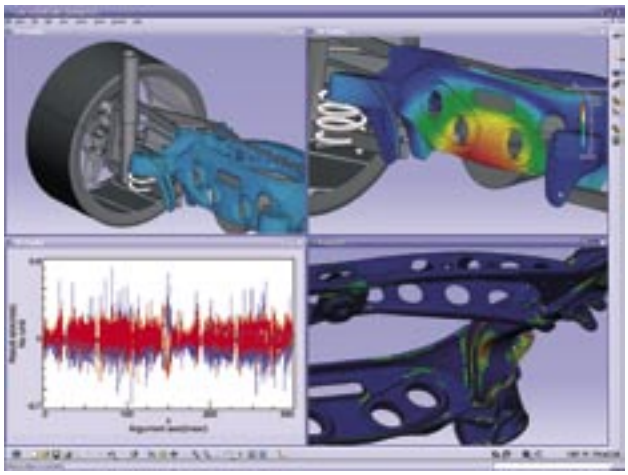
For each individual system part, predicted information concerning dynamic load cases, modal participation factors, locations of excitations and local axes, configurations are kept together. The transfer of load responses to fatigue-life solver occurs fully automatically.

Gaining fatigue-life insights

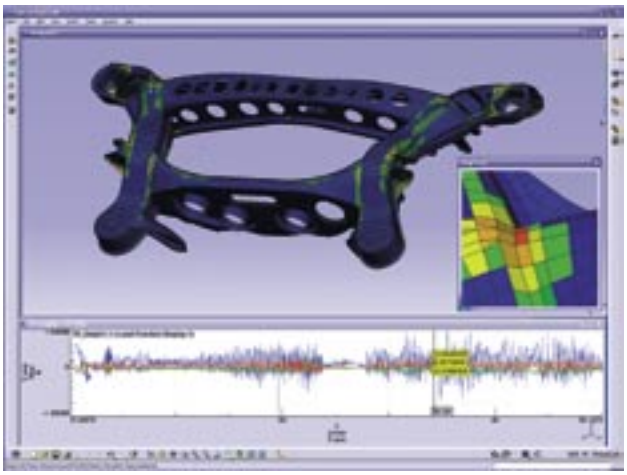
Turning dynamic system simulations into reliable fatigue-life predictions is what LMS Virtual.Lab Durability is all about. Predicted load responses and relevant material characteristics together with the FE model seamlessly flow into the integrated fatigue-life solver.

Numerous dedicated durability post-processing features allow you to quickly gain critical insights regarding fatigue life of any individual component of interest. Reach maximum productivity by quickly investigating hot spot areas and efficiently re-running analyses for many different design variants on the system level.

"In customer trials, a design modification that previously would have required 28 days of rework to estimate the impact of fatigue life - was completed in less than two days!"



Modal participation factors for deformation and stresses, gained from LMS Virtual.Lab Motion, are displayed in function of time.



While post-processing the durability results, such as fatigue damage or hot spots, LMS Virtual.Lab Durability automatically locates major fatigue-damage areas.

Realistic System and Component Load Predictions

With LMS Virtual.Lab, system loads can be generated through dynamic simulation, even before they can be measured on a physical prototype. Virtual driver sessions and road tests performed on a previously released vehicle form the basis of two distinctive simulation approaches.

Digital test track

During realistically simulated driver sessions, a virtual vehicle equipped with virtual tires, drives around over digital test tracks. Its tire models are capable of calculating the dynamic forces and moments acting on the spindles of the vehicle. LMS CDTire (Comfort – Durability) is a tire model that consists of physical entities such as masses, springs, dampers and sensor points. To keep processing times acceptable, the virtual tire is subdivided on macroscopic level, rather than with finite elements.

LMS CDTire supports:

- 2D tire models with stiff ring (CDT20) or flexible ring (CDT30)
- Complex full 3D tire model (CDT40) with a multiple flexible ring, suitable for any type of road surface.

Hybrid road

An alternative solution, pioneered by LMS, draws on a hybrid approach, which combines test-based loads with virtual simulations. It applies a new transformation methodology to accurately determine system loads, before they can be gained through measurement. It starts from wheel spindle loads measured on a previous model vehicle and converts these into wheel spindle displacements. The breakthrough of this approach is that these displacements are much less vehicle-dependent, since they are based on road surfaces, rather than on vehicle characteristics.

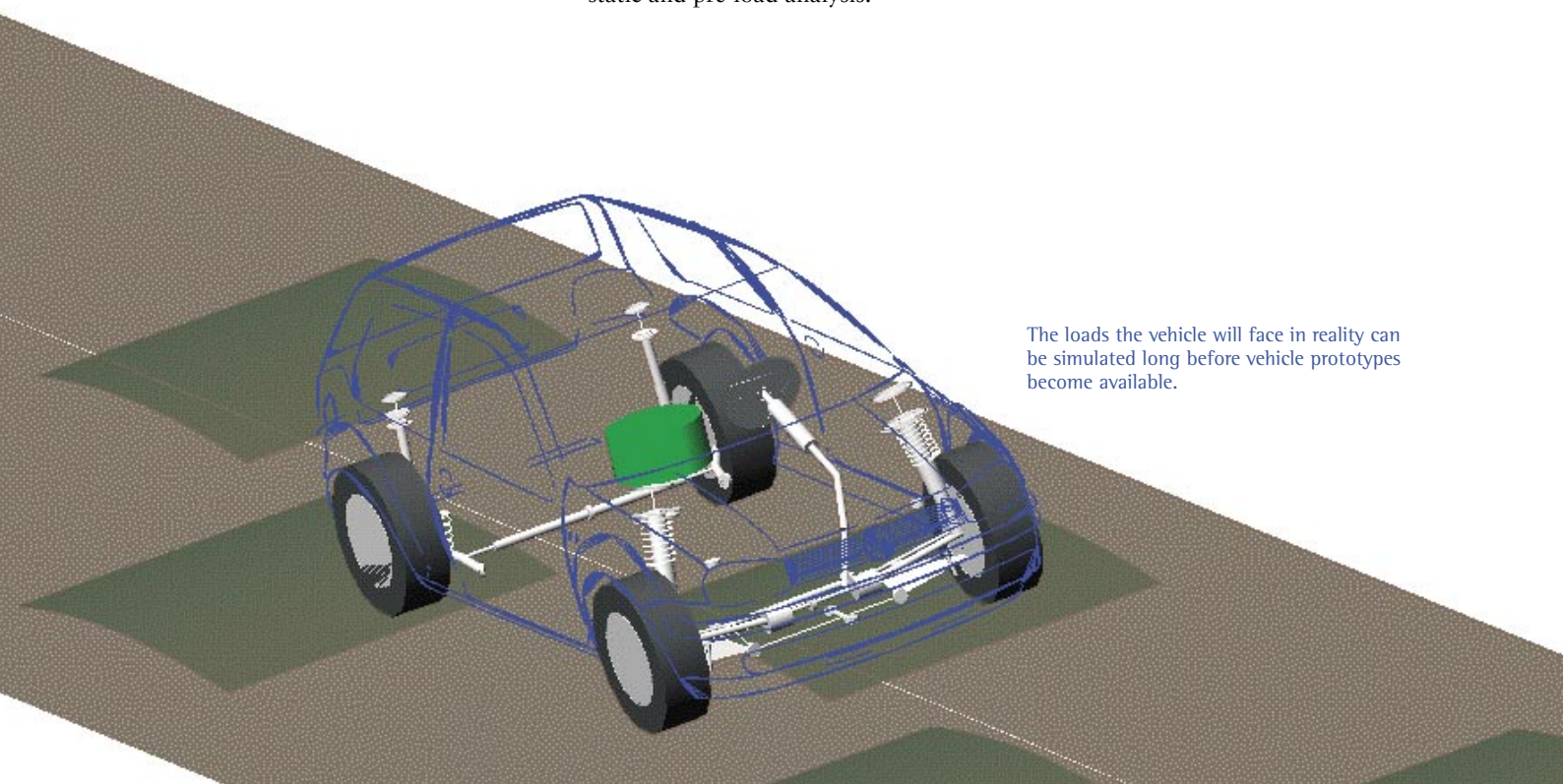
Accurately gaining dynamic component forces

The LMS Virtual.Lab Motion solver evolved from LMS DADS, which is widely renowned for its accuracy and inherent robustness and stability. It offers a vast choice of high-performance time-domain solvers for kinematic, transient dynamic, quasi-static and pre-load analysis.

LMS Virtual.Lab Motion is capable of predicting true dynamic stresses and deformations by accurately taking mass effects and vibrations into account. Automatically generated Craig-Bampton cases enable FE analyses to be automatically driven. Top-speed is achieved by state-of-the-art reduction techniques. Modal participation factors are automatically made available to the downstream fatigue-life prediction analysis.

Delivering loads for early durability testing

Component loads retrieved from LMS Virtual.Lab Motion are not only used as input for virtual fatigue-life predictions, they are also very useful for driving physical durability tests. Realistic component loading and pre-information on critical locations significantly improves the accuracy and efficiency of component durability tests.



The loads the vehicle will face in reality can be simulated long before vehicle prototypes become available.

Effective Load Case Comparisons

Correlating models with reality

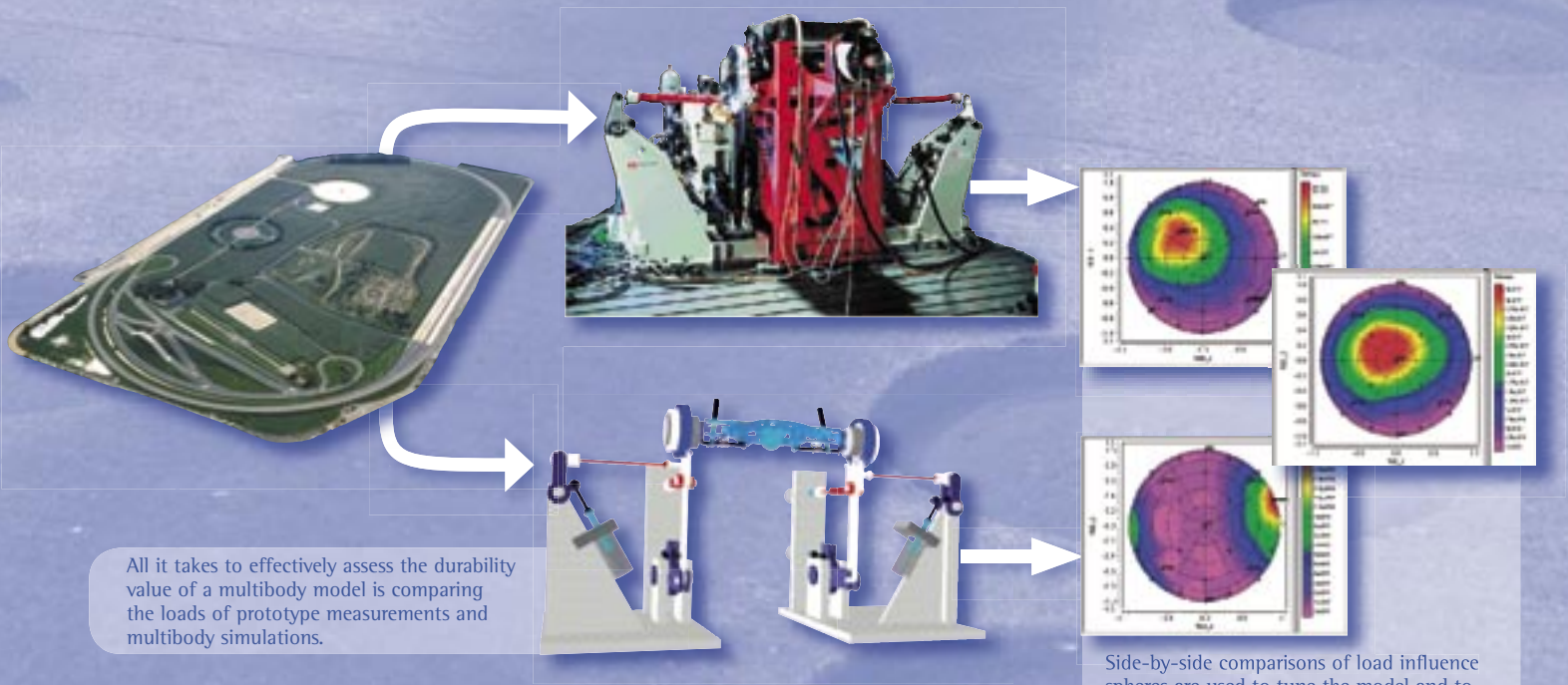
When setting up numerical durability predictions, you may want to start from an existing multibody model that has previously been used for ride & handling assessments. But the question is to what extent these models are suitable for use as a basis for durability predictions. Especially since structural flexibility and non-linear stiffness and damping are often inaccurately modeled. Prototype measurements help to assess the durability value of a multibody model. All it takes is a quick comparison between the measured component loads and the predicted loads received from the multibody simulations.

LMS TecWare includes state-of-the-art tools for monitoring the essential aspects of component loadings from a durability perspective. As an example, multiaxial rainflow counting takes into account the correlation between multiple load inputs and instantaneously indicates how well the multibody model is in tune with reality. The outcome is highly suitable to modify the model and to increase the utility of its load prediction capabilities as part of accurate durability investigations.

- Rainflow-based analysis (uni and multiaxial rainflow counting)
- Frequency-based analysis
- Statistics
- Automated reporting

Supporting decisions in late design stages

Although late design changes after the durability sign-off of the prototype should be avoided altogether, small design changes regularly occur, due to unpredictable NVH or handling issues. For each of these late design changes, durability engineers must decide whether their final durability assessment and "go-ahead" is still valid. Omitting a renewed virtual durability validation could be very unsafe and creates a huge risk of expensive product recalls. But repeating a virtual simulation loop, or an extra physical prototype test, would potentially delay the launch of a new vehicle. Side-by-side comparisons obtained from multi-axial rainflow counting show at a glance whether the durability loading has changed its damage content significantly enough to re-do parts of the durability validation process.



All it takes to effectively assess the durability value of a multibody model is comparing the loads of prototype measurements and multibody simulations.

Side-by-side comparisons of load influence spheres are used to tune the model and to increase its loads prediction capabilities.

LMS, a Key Player in Durability Engineering for Automotive Applications

For over a decade, LMS delivers advanced simulation and test solutions to the majority of automotive OEMs and an extensive list of other manufacturing companies, active in many different markets around the world. All along, LMS has been working with leading research institutes and key customers to ensure that the most advanced techniques fit into industrial fatigue design processes – and to validate the analysis capabilities by rigorous comparison with tests. Moreover, hundreds of international consulting projects performed on real-life assemblies and complex products help LMS to stay in touch with the typical durability challenges companies are facing today.

Breakthrough technologies …

LMS customers execute numerous analyses on vehicle bodies, space frames, subframes, knuckles, control arms, brake components, including a variety of different seam and spot weld configurations. Not only steel parts were subjected to investigations, also aluminum components were analyzed successfully. LMS technologies not only indicated the crack-initiation locations automatically – without forcing the user to guess which areas on the component might be critical – they also provided excellent fatigue-life estimates.

… applied at key customers

Among its key automotive OEM customers, LMS counts Audi, BMW, DaimlerChrysler, Fiat, GM, Honda, Jaguar, Landrover, Mazda, Nissan, Renault and VW.

Many world-class suppliers are served by LMS, including key customers such as ACI, Arvin, Behr, Bosch, Delphi, Donaldson, Johnson Controls, Freudenberg, Karmann, Knorr Bremse, Matra, Pankl, Thyssen-Krupp, TRW, ZF and many others.

Among its key durability customers in truck, bus and off-highway, LMS counts Daewoo, DaimlerChrysler, FORD, MAN, Mitsubishi, PACCAR, and Volvo.

"Having used LMS durability technologies for load data analysis and numerical fatigue life prediction for several years we are able to improve our durability engineering process substantially, and to reduce the time and costs of the development process"

Dr. Martin Brune, Manager Predevelopment, Methods, Calculation, BMW Group

Chassis and suspension

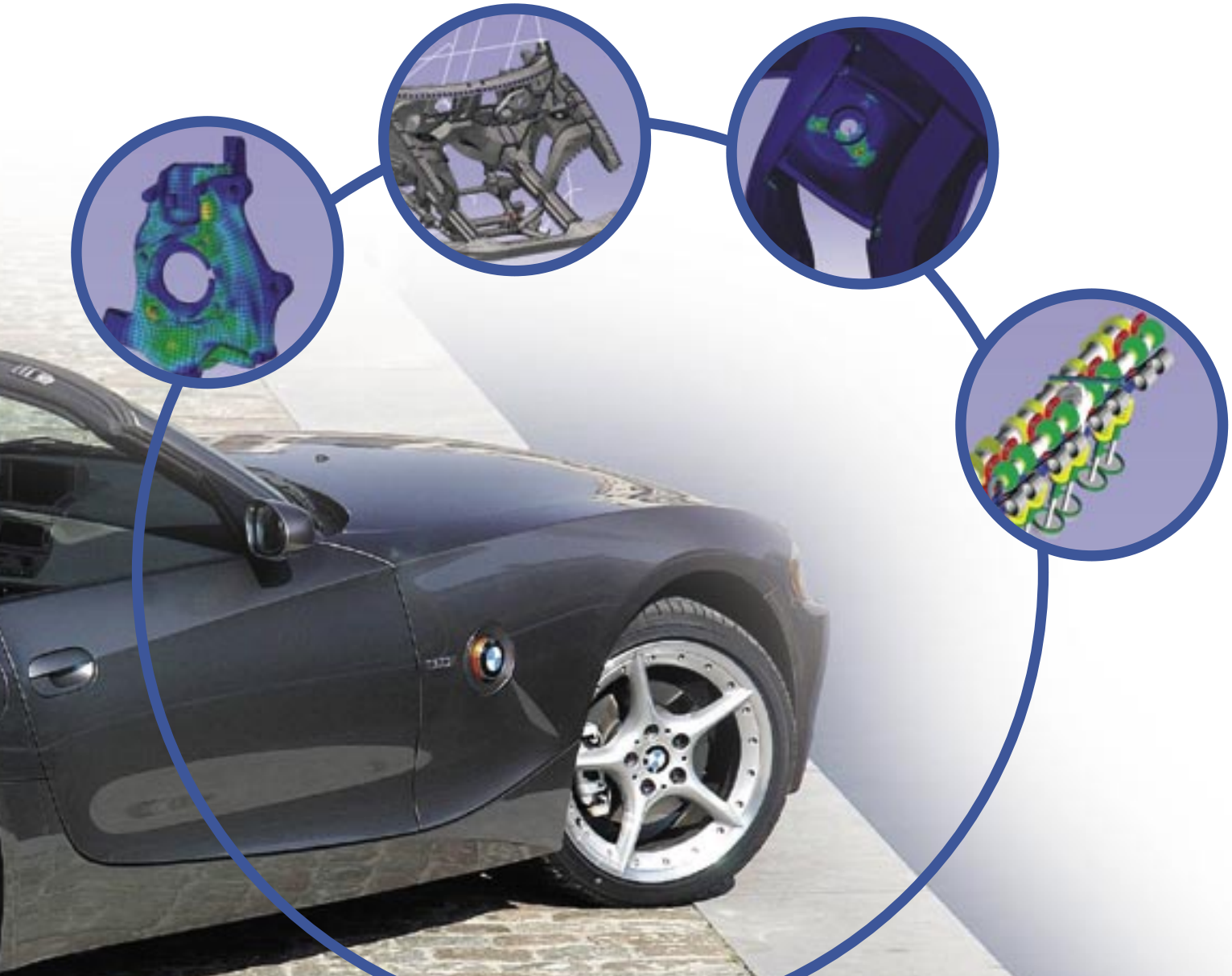
Whether the focus is on suspension knuckles, control arms and auxiliaries, or on brake calipers or steering system parts, LMS Virtual.Lab Durability accurately traces the fatigue performance of each involved component. Its effective and robust processes are easily controllable, yield powerful seam weld capabilities and provide access to all simulation parameters.

Body

It is quite striking how fast LMS Virtual.Lab Durability executes fatigue-life assessments on frames, panels, cross-members and door systems as well as on sunroofs, latches and locking systems. Specific analyses of spot welds occur in a highly accurate fashion. Template-based analysis setups and built-in workflows accelerate user operations, without the need for specific durability models.

Engine and powertrain

Advanced numerical durability predictions can be applied to specific engines and powertrain parts. Engine brackets, gear box chainwheels and exhaust lines are typical examples of components that can be effectively optimized with LMS Virtual.Lab Durability.



Durability Engineering Solutions Applied in Many Markets

Aerospace

A major challenge facing engineers designing aerospace mechanical systems is to increase functionality while reducing weight and improving reliability. The interaction between control systems and mechanical assemblies needs to ensure safety, durability and stability. Loads at the component and system level need to be accurately calculated long before the prototype phase, while taking into account the flexibility of the structures involved. In order to improve reliability and safety, the number of load cases that need to be considered in the design process is steadily rising.

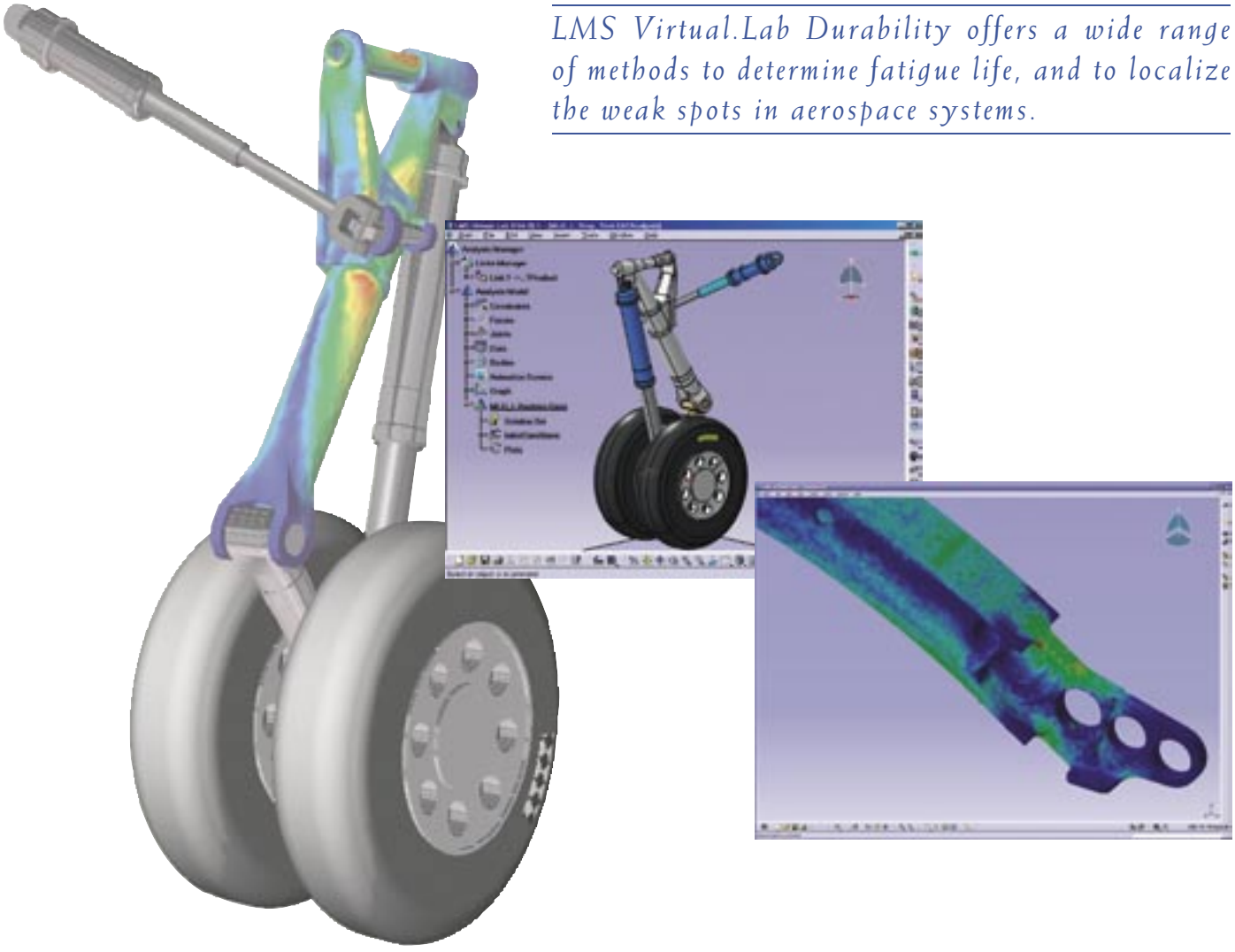
Mechanical systems simulation

LMS Virtual.Lab Motion provides dynamic and kinematic simulation solutions that can evaluate the behavior of mechanical systems such as landing gear, control surfaces, slat tracks and other critical assemblies prior to the availability of a physical prototype. Loads on components, assemblies and complete aircraft can be accurately calculated under a wide range of conditions, for example towing, taxying, symmetric and asymmetric braking, takeoff and landing.

Fatigue-life prediction

These loads then are used by LMS Virtual.Lab Durability to generate fatigue life predictions. Local stress concentrations are identified based on all possible combinations of local load conditions, making it possible to address durability problems long before prototypes are built. A wide range of methods is offered to determine fatigue life, and to localize the weak spots. Dedicated durability post-processing tools provide you with immediate feedback regarding all critical durability areas.

LMS Virtual.Lab Durability offers a wide range of methods to determine fatigue life, and to localize the weak spots in aerospace systems.



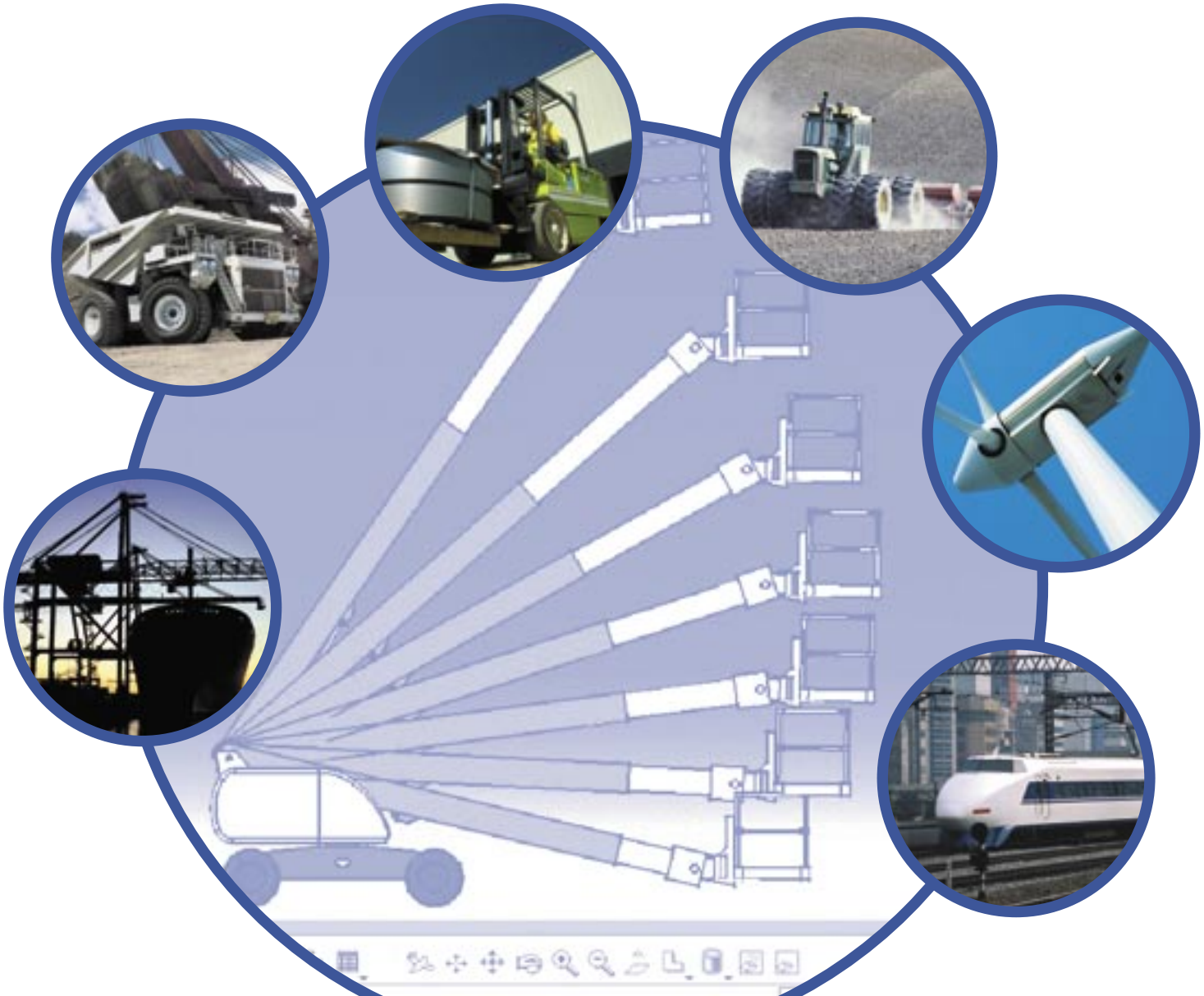
Other ground vehicles

As extreme operating conditions and low-volume production series are common for other ground vehicles, successive prototype testing is not an option. LMS Virtual.Lab reliably simulates all real-life circumstances on the level of the full vehicle and vigorously assesses the durability performance of individual system components, prior to physical prototyping.

Using more accurate component loads, gained through flexible body modeling in LMS Virtual.Lab Motion, can easily uplift the accuracy of durability predictions. The same FE results data can be automatically re-used in durability simulations. Test measurements as well as simulation results can be systematically incorporated for model correlation and refinement.

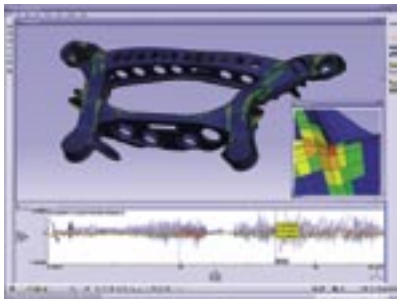
Industrial machinery

In industrial applications, economic efficiency depends on critical parts that are typically subjected to large dynamic multiaxial load cases. LMS Virtual.Lab is capable of accurately determining the fatigue life of rotor bases used in large wind mills, or crane parts that are integrated in industrial-sized trucks. Guaranteeing secure operation also supports the safety of industrial workers.



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.



LMS Virtual.Lab

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, handling, comfort, safety and durability.

LMS Test.Lab

LMS provides the most complete portfolio of applications for test-based durability engineering. It comprises LMS TecWare used for durability based load data analysis and synthesis, LMS TWR for multi-axial measurement and test rig control and LMS FALANCS for experimental fatigue life predictions.

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.

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The Durability Alliance
ACCELERATING THE DEVELOPMENT PROCESS

DASSAULT SYSTEMES GOLD SOFTWARE PARTNER