DASSAULT SYSTEMES

SIMULIA

3DEXPERIENCE®

SUSTAINABLE INNOVATION

BRING THE POWER OF THE SIMULIA PORTFOLIO TO LIFE

As an engineering professional, you are aware of the many benefits simulation can bring to product design and development.

But even if you're already using simulation, are you sure you've designed the best possible product from the least material at the lowest cost—ensuring both customer satisfaction and higher operating margins? Is your solution innovative enough to beat out the competition and sustain your business into the future?

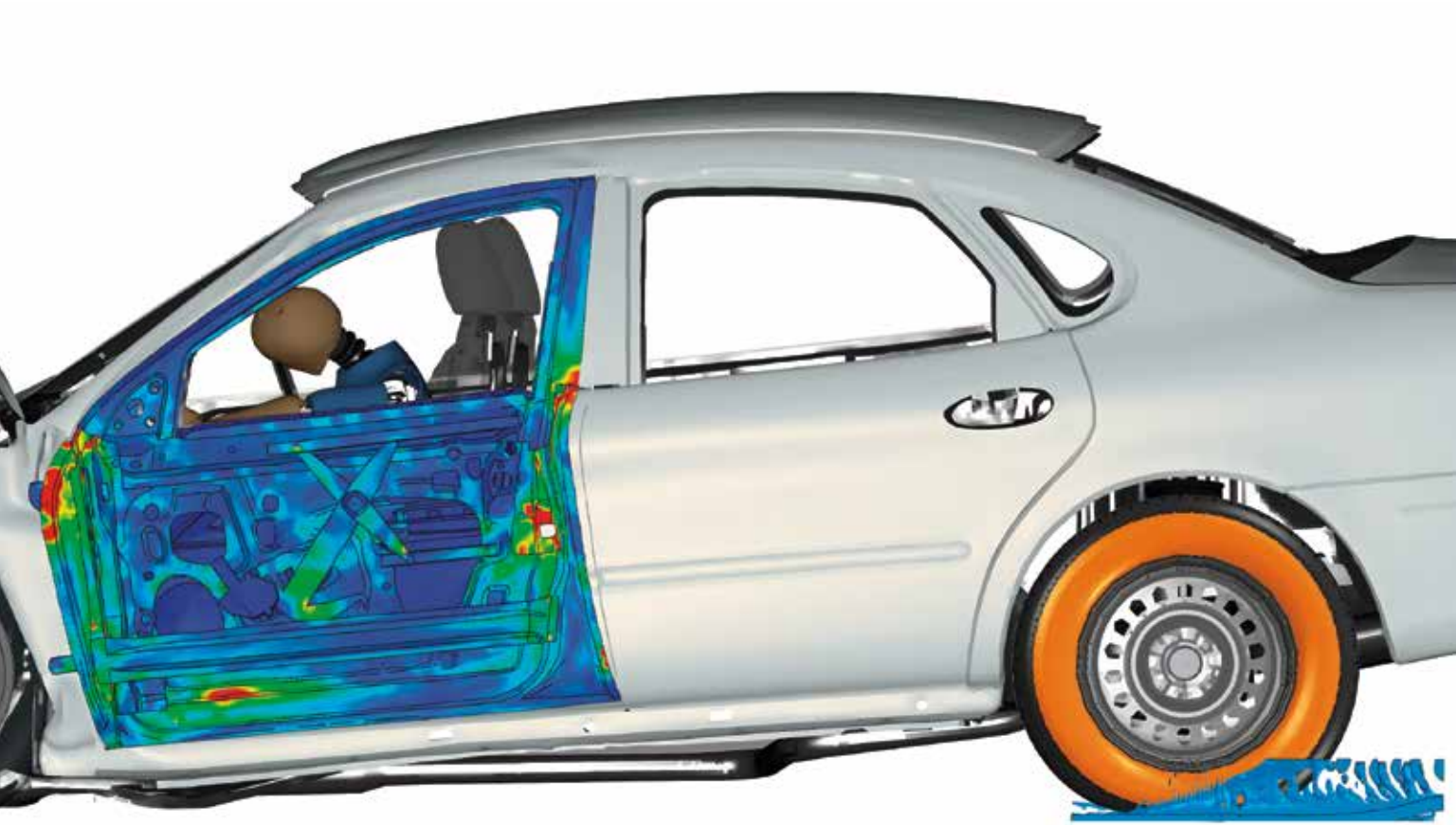
These are challenges that your company may still be struggling with. Leadership is looking to reduce risk and make innovation not just a shot in the dark, but a regular business process that ensures survival of the enterprise and ongoing market success. By taking risk out you make innovation sustainable. This is where simulation can help in ways you may not have even imagined yet.

Imagination is our specialty at SIMULIA, a Dassault Systèmes brand. We are engineers very much like you and we know that the science of design is continually evolving. So, for more than three decades, we've been striving to develop the finest-available simulation-based engineering tools—with ongoing input from our customers.

The result of this collaboration? The SIMULIA portfolio of powerful technologies described in the following pages. This is now the widest, deepest, best-in-class suite of simulation technologies for the specialist user available today.

The SIMULIA Portfolio offers technology in finite element analysis (**Abaqus**); topology, shape, bead, and sizing optimization (**Tosca Structure**); fluid-flow topology optimization (**Tosca Fluid**); durability and fatigue evaluation (**fe-safe**); and Design-of-Experiments, parameter optimization and process capture enabling the entire simulation sequence to be re-used (**Isight**).

Together, the portfolio provides SIMULIA users with expanded capabilities to simulate product performance as well as to improve and to virtually validate product designs so they are optimal and durable.



Abaqus – THE FOUNDATION

If you are already an Abaqus user, you are empowered by the world's technology-leading suite of finite element analysis (FEA) software for modeling, visualization and best-in-class implicit and explicit dynamics. SIMULIA's common-model data structure and integrated solver technology help you zero in on the problems you want to solve, quickly and accurately.

If you are thinking about trying Abaqus for the first time, you can have confidence that you are looking at the most powerful, complete solutions available for both routine and sophisticated engineering problems across the full spectrum of industrial applications.

Developed over 30 years, and always in close cooperation with our customers, the Abaqus Unified FEA Suite of scalable analysis products—Abaqus/Standard, Abaqus/Explicit and Abaqus/CAE—allows all users, regardless of simulation expertise or domain focus, to collaborate and seamlessly share data and methodologies while preserving information fidelity.

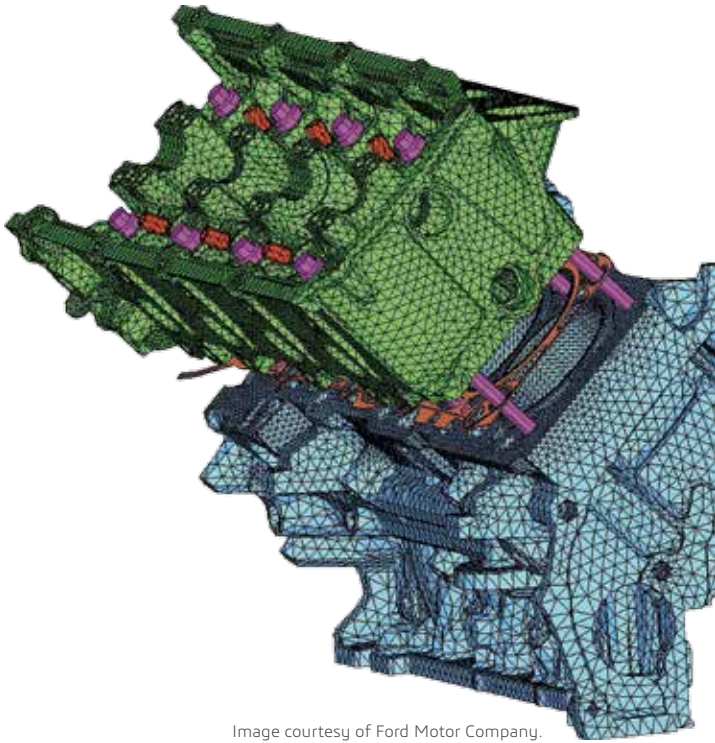


Image courtesy of Ford Motor Company.

Abaqus for Transportation & Mobility

Multibody systems

Nonlinear static loads

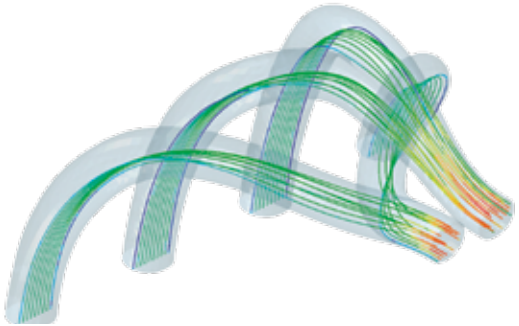
Full vehicle loads

Dynamic vibration

Impact/crash

Thermal coupling

Acoustic-structural coupling



Leading companies take advantage of Abaqus Unified FEA to:

- Consolidate processes and tools
- Reduce costs and inefficiencies
- Decrease FEA toolset and training expenses
- Achieve greater efficiency in model generation
- Improve correlation between test and analysis results
- Facilitate data transfer between simulations
- Build a more flexible workforce with greater bandwidth for innovation

Abaqus for Life Sciences

Turbulence

Cyclic loading

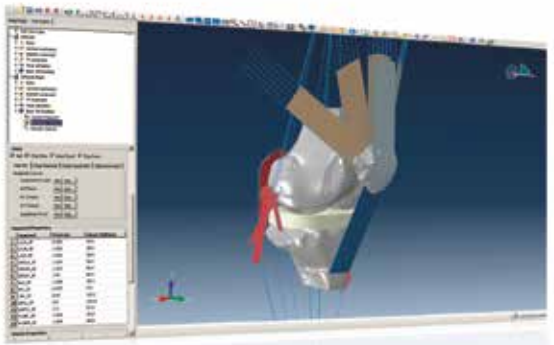
Fluid-structure interaction

Hyper-elastic material behavior

Temperature dependency

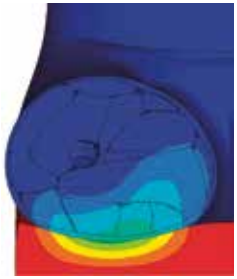
Self-contact

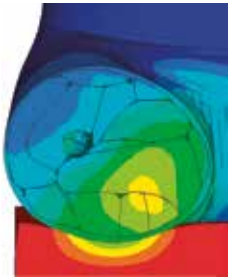
Creep



"Simulating comfort using FEA greatly simplifies the design process. It's objective, reproducible and cost-effective."

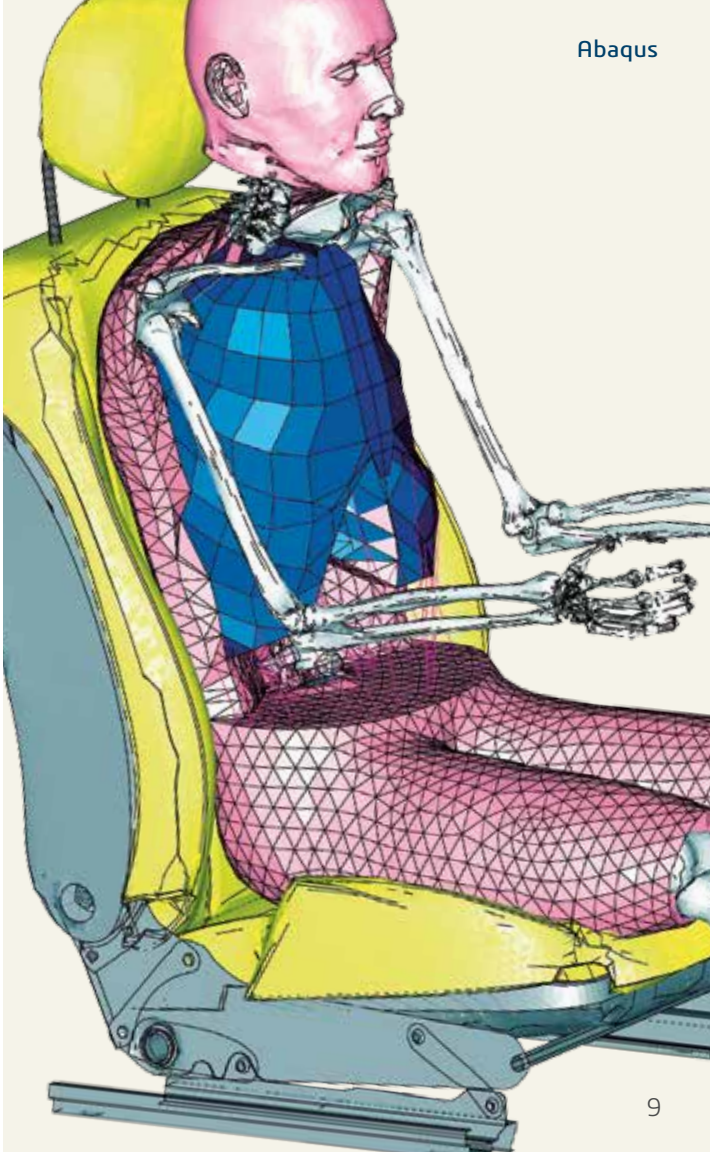
–Alexander Siefert, Wölfel Group





Images courtesy of Wölfel Group.

For a complete list of
Abaqus capabilities and applications, please go to:
www.3ds.com/products-services/simulia/products/abaqus



Tosca – THE NONPARAMETRIC STRUCTURAL AND FLUID-FLOW OPTIMIZER

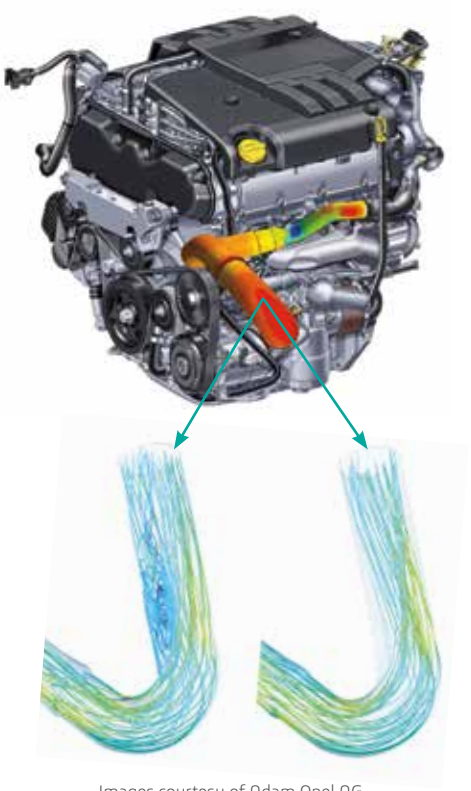
If your industry is one of the many that are increasingly focused on lightweighting through material reduction, Tosca Structure software's structural optimization capabilities may be exactly what you are looking for. Tosca Fluid is the answer if your interest lies in optimizing fluid flow.

These two are available in SIMULIA's Tosca Optimization Suite to provide fast and powerful nonparametric structural and flow optimization solutions based on FEA and CFD simulations. When you query your designs with Tosca, you arrive at the best-possible, manufacturing-oriented results that promote efficient production.

Tosca Structure is a one-of-a-kind design-flexibility tool. During early-stage product development, Tosca will reveal a variety of design concepts—some of which you may never even have considered—that reduce the material weight of your product while maintaining, or even improving, its rigidity and durability. Alternatively, if you are working at a later design stage, where changes to a component are limited but you still need improvements in durability, Tosca will let you investigate stress-reducing alternatives that don't require major geometry changes.

Tosca Fluid helps you develop topology-optimization driven design concepts for fluid-flow systems and components. Use its capabilities to create innovative design ideas automatically for a defined flow task and available design space. Tosca Fluid's unique technology helps you achieve the highest flow performance, quality and eco-efficiency.

Optimized product performance



Images courtesy of Adam Opel AG.

The benefits of using Tosca Structure and/or Tosca Fluid are many:

- Accelerate conceptual design and reduce time-to-market
- Support ready-to-manufacture product design
- Save weight and ensure the highest result quality for reliable components
- Avoid error-prone, time-consuming model simplification
- Apply realistic simulation and handle nonlinearities directly within the optimization
- Define optimization tasks interactively in intuitive graphic user interfaces
- Create fluid-flow devices with reduced pressure drop and improved flow uniformity

Tosca for Consumer Goods & Retail

Automatically optimize component weight and shape

Improve load capacity without increased costs

Identify optimal geometry within manufacturing constraints

Use FEA to ensure strength and durability targets are met

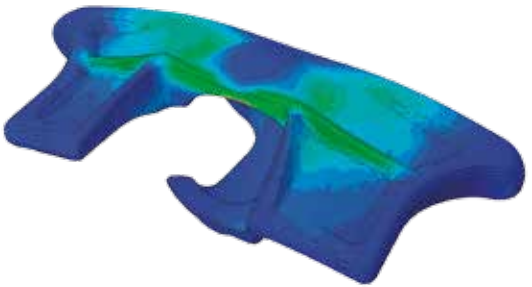


Image courtesy of Matrix Applied Computing.

Image courtesy of Springfree Trampoline.

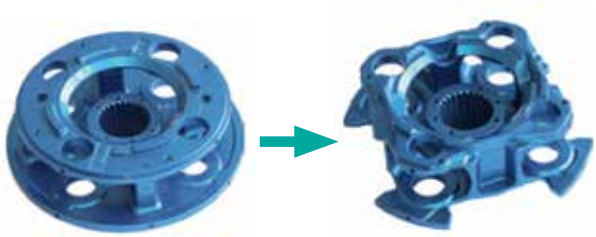
Tosca for Transportation & Mobility

Maximize performance

Shorten development cycles

Minimize material and weight

Design lightweight, stiff, durable parts and assemblies



Images courtesy of Voith.

For a complete list of
Tosca capabilities and applications, please go to:
www.3ds.com/products-services/simulia/products/tosca

fe-safe® – THE FATIGUE LIFE EVALUATOR

So you have your design optimized for geometry, weight and performance. But there's still one important question you may want to ask: "How long will it last?" Your customers are increasingly demanding this answer as they make purchasing decisions based not just on initial quality but on lifespan as well.

SIMULIA's fe-safe is a powerful, comprehensive, easy-to-use suite of fatigue analysis software for finite-element models. It can be used alongside Abaqus and within Tosca—or any commercial FEA software—to calculate where fatigue cracks will occur and when they will initiate, the factors of safety on working stresses, the probability of survival at different service lives (the "warranty claim" curve) and whether cracks will propagate. Typical fe-safe applications include the analysis of machined, forged and cast components in steel, aluminum and cast iron, high-temperature components, welded fabrications (structural, seam and spot welds) and press-formed parts.

By adding fe-safe to your simulation toolkit, you will be able to increase the fatigue life of safety-critical components and reduce product recalls and warranty costs for your organization. You'll have increased confidence that your product designs will pass their test schedules as "right-first time."

Critical plane multiaxial stress-life and strain life methods

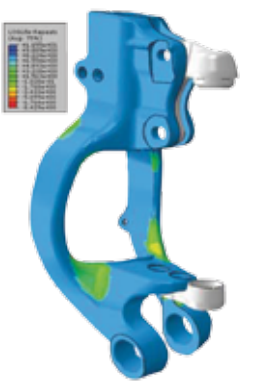
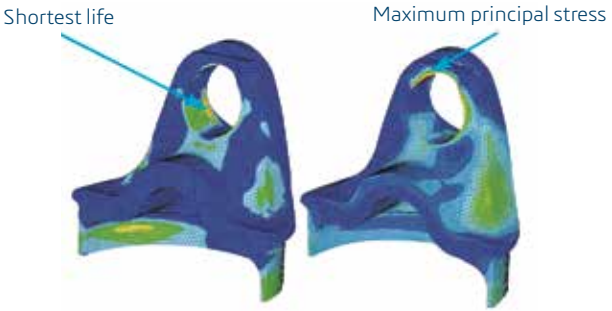


Image courtesy of Raufoss Technology.

Cracks may not occur at the locations of maximum stress

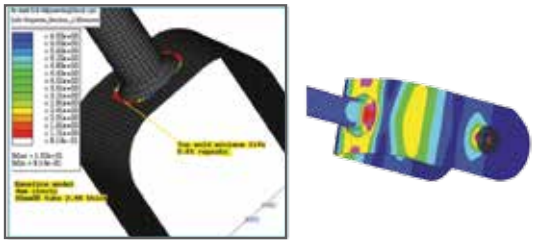


Images courtesy of Dana Automotive Systems Group, LLC.

fe-safe provides many benefits to users:

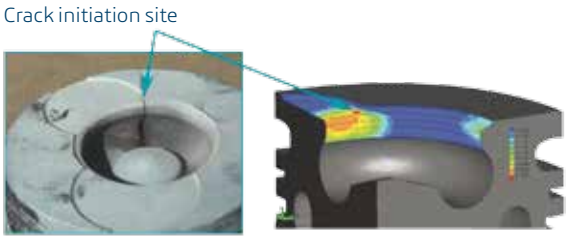
- Accurate analysis of structural welds, seam welds and spot welds
- Vibration fatigue evaluation of damage that identifies which parts of the duty cycle contribute the most fatigue damage
- Results reading from forming or assembly processes to estimate residual stresses for rapid sensitivity analysis
- A mesh-insensitive structural stress method predicts failure locations and calculates fatigue life for welded joints and structures
- A material database providing a comprehensive library of fatigue properties for commonly used materials

Durability by design using advanced multiaxial algorithms



Images courtesy of Ford Motor Company.

Different parts of an assembly may need different design stress margins

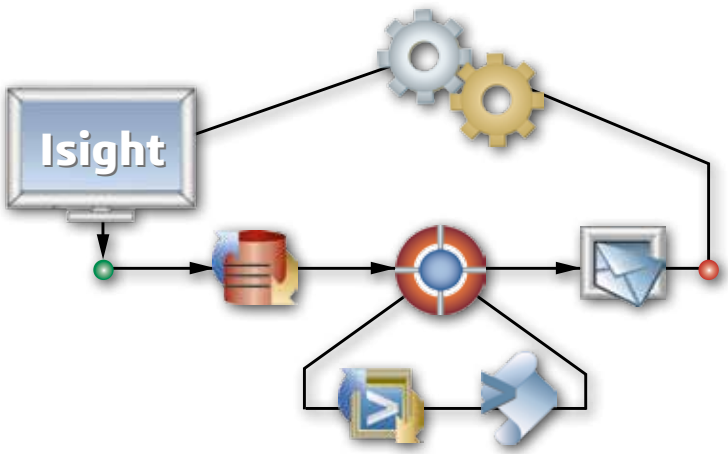


Images courtesy of Federal Mogul Technology.

For more fe-safe capabilities and applications, please go to: www.3ds.com/products-services/simulia/products/fe-safe

Isight – THE WORKFLOW ACCELERATOR AND PARAMETRIC OPTIMIZER

Today's high-performance computing resources are both a blessing and a burden. You have a continuously growing mountain of information to process and analyze in order to deliver critical results that can make or break your latest product development project. You may need to query your data across multiple domains and against strict parameters.



Isight, SIMULIA's industry-leading process automation and optimization software tool, helps you stay on top of the data-deluge, target the problems you need to concentrate on and find the best solutions much more efficiently.

The power of Isight can extend beyond your desktop to enable workgroups to collaborate from anywhere in the world. Used in conjunction with the SIMULIA Execution Engine (SEE), Isight lets your team build a secure, web-based framework for distributing the execution of simulation processes and optimizing computing resources across your entire enterprise.

Isight for Industrial Equipment

Material trade-off studies

Automated stress analysis

Multidisciplinary simulation

Material creep and lifetime wear assessment

Design exploration with DOE or Monte Carlo methods

Vibration and resonance behavior study

Tolerance reviews

Isight makes your job easier:

- Easily automate simulation process flow
- Leverage advanced techniques such as design of experiments (DOE), design for Six Sigma
- Optimize your designs for cost, weight, materials and more
- Engage your hardware and computing resources at optimum levels
- Integrate seamlessly with your enterprise Web application servers and databases
- Shorten design and delivery cycles

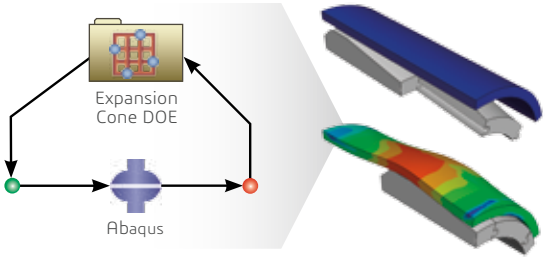
Isight for Energy, Process & Utilities

Identification of best performing designs that are least expensive to manufacture

Avoidance of time-consuming manual iteration

Allowances for tight manufacturing tolerances and small operating clearances

Fine-tuned product configurations for more rapid, precise customization



Images courtesy of Baker Hughes.

Isight for Consumer Packaged Goods & Retail

Automatic evaluation of loading scenarios

Automated simulation process flows

Optimized geometry

Reduced product weight

For a complete list of Isight capabilities and applications, please go to:
www.3ds.com/products-services/simulia/products/isight-simulia-execution-engine

Images courtesy of Saint-Gobain.

ALSO FROM SIMULIA

SIMPACK

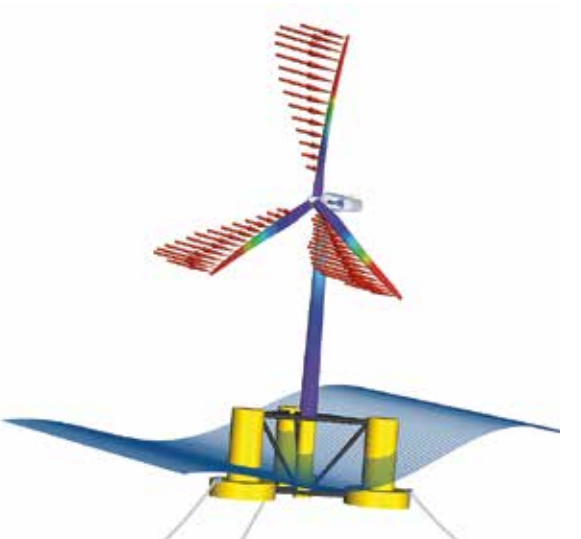
This leading technology expands the SIMULIA realistic multiphysics simulation portfolio to include multibody mechatronic systems, from virtual concept validation to accurate, real-time experience and control. The result is accelerated end-to-end development of advanced systems in transportation & mobility, aerospace & defense, and other industries.

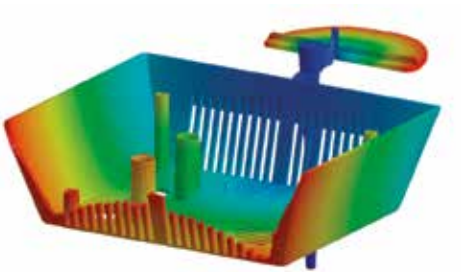
Simpoe-Mold

For companies that design plastic parts or injection molds or manufacture plastic parts, Simpoe-Mold helps users predict and avoid manufacturing defects during the earliest stages of part and mold design, eliminating costly mold rework, improving part quality, decreasing time to market and optimizing production cycle times.

SLM

SIMULIA has harnessed the proven collaboration technology from ENOVIA and combined it with our 30+ years of simulation expertise to offer this breakthrough, economically deployable solution for capturing, managing and securing your valuable simulation intellectual property in any industry.





LEVERAGING THE PORTFOLIO

We are certain that your team will benefit by taking advantage of the power of the SIMULIA portfolio to fuel your own imagination and sustain innovation. But don't just take our word for it. See some real-life examples and listen to the voices of some of our enthusiastic customers from various industries...

Courtesy of Dana Automotive Systems Group, LLC.

EXAMPLE: AUTOMOTIVE TRANSMISSION FLEXPLATE

A flexplate is a thin metal plate that transfers engine torque to the automatic transmission. It must be light and highly flexible yet strong enough to carry the high loads needed to propel vehicles forward. Lightening holes are used to achieve this balance of flexibility, weight and strength. But how can the shapes and sizes of these holes be determined? How can you know if you have the best design for the application? You can easily see that physically testing each possible hole pattern is impossible.

At the 2013 SIMULIA Community Conference, Diwakar Krishnaiah* presented a paper showing the use of Abaqus and Tosca together to automatically identify improved hole patterns to reduce the weight while increasing the safety factor. This example illustrates that the Power of the Portfolio is much more than just stress analysis—it's innovation!

*D. Krishnaiah, S. Patil, M. Friedrich, "The Use of Optimization Software Tosca in a Standard Flexplate Design Process," 2013 SCC. Read the full manuscript at: www.3ds.com/products-services/simulia/resources.

Used with permission of GM Powertrain.

Abaqus + Tosca

- Stress analysis and shape & topology optimization
- Strength factor improvement
- Design innovation
- New shapes
- Mass reduction
- Efficient optimization process

CASE STUDY: USPTU

Pumping equipment is used in oil refining plants to pump oil distillation products. The equipment has to withstand heavy combined hydrodynamic and thermal loading, and had been reported to fail due to fatigue damage. IE-UPSTU (Sergey Tropkin) used SIMULIA solutions **Abaqus** and **fe-safe** to analyze the stress on key components, correctly predict the site of crack initiation and identify proper maintenance cycle timelines.*

*S. Tropkin, A. Winkler, A, Devyatov, M. Zakirnichanya, R. Tlyasheva, "Fatigue Analysis of Centrifugal Pumping Equipment Impeller with fe-safe and Abaqus," 2014 SCC. Read the full manuscript at: www.3ds.com/products-services/simulia/resources.

Abaqus + fe-safe

- Stress and fatigue
- Analysis and prediction
- Durability assessment
- Component lifespan assessment
- Accuracy
- Crack initiation site identification
- Maintenance cycle improvement

"fe-safe correctly predicted the crack initiation sites and also achieved correlation with the lower end of test results in the statistical fracture range."

–Sergey Tropkin, UFA State Petroleum Technological University

CASE STUDY: BAKER HUGHES

The use of expandable tubulars has emerged as a popular technology for drilling and completing oil & gas wells; design decisions are critical for achieving reliable function in harsh downhole environments. Baker Hughes employed Abaqus to simulate expansion of threaded connections in their latest designs.* **Abaqus** was also used in conjunction with **Isight** to optimize the geometry of the next generation of expandable cones for downhole tubulars.

Project	Build and Test Two Manual Iterations	Design and Test Using One Seat of Isight With Abaqus CAE Plug-In
Expandable cone	**20 Months**	**2 Weeks**

*Baker Hughes Refines Expandable Tubular Technology with Abaqus and Isight, 2011, www.3ds.com/customer-stories.

Abaqus + Isight

- Stress and design optimization
- Ability to run Abaqus/CAE from Isight
- Streamlined, efficient setup
- Design of Experiments
- Identification of novel geometries
- Keeping an open mind
- Thinking outside the box
- HPC cluster potential

"Isight took us down a path we had not foreseen and gave us the confidence to keep an open mind about design. If we hadn't been using the software, the most effective cone geometry would have never been considered."

–Jeff Williams, Baker Hughes

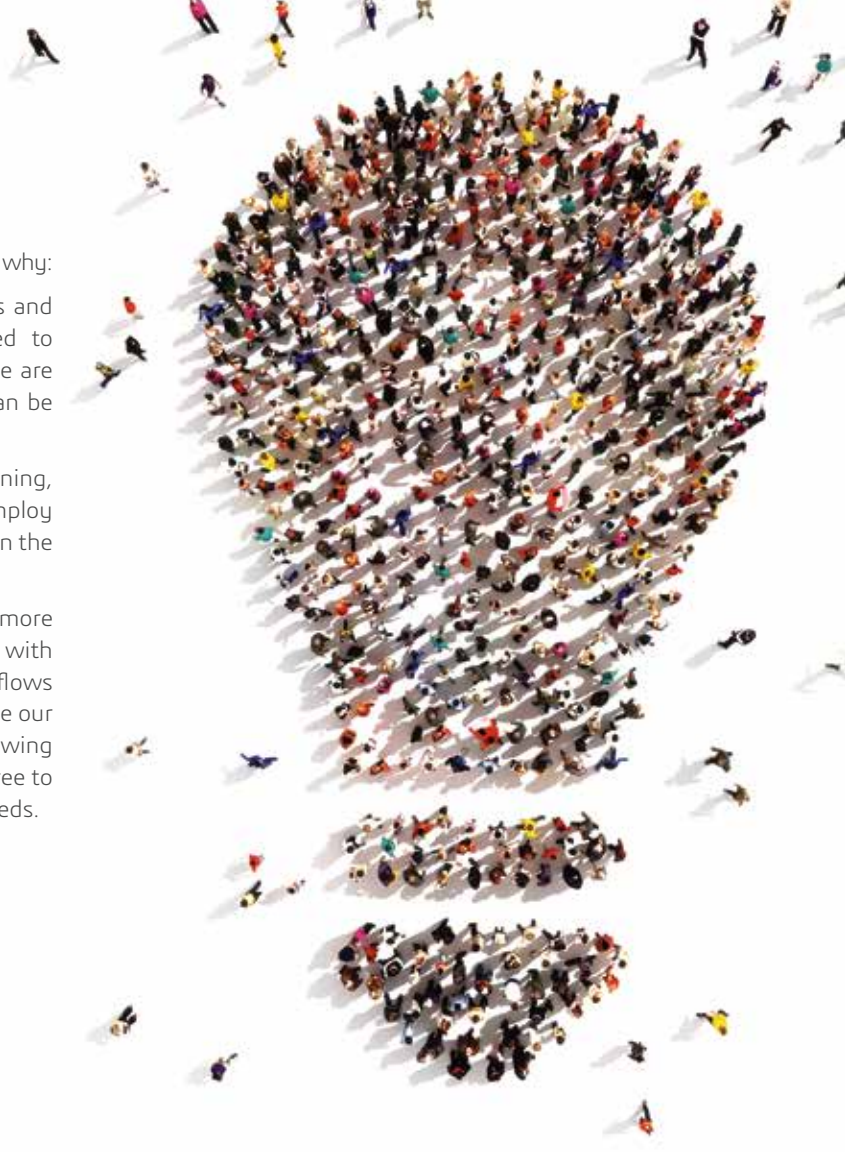
IMAGINATION IN ACTION

At SIMULIA, we are often our own best customers. Here's why:

Because we work so closely with leading companies and academic researchers—in almost every field related to product design, development and manufacturing—we are intimately familiar with the many challenges that can be addressed with our technologies.

We encourage our software engineers to keep imagining, and then creating, new ways to strengthen and employ Abaqus, Tosca, fe-safe, Isight and our other products in the always-evolving search for solutions.

As we anticipate our customers' demands for even more sophisticated software tools, we charge ourselves with producing innovative product development workflows focused on specific industrial problems. Then we share our results openly with our users. Take a look at the following examples of SIMULA imagination at work. And feel free to challenge us to help you tailor a workflow to your needs.



Quadcopter flight plan: from concept to airborne

To demonstrate how the power of the SIMULIA portfolio can enhance a wider, group effort in product development, our engineers carried out a transformative design project using simulation on the Dassault Systèmes **3D**EXPERIENCE® platform to solve a real problem in the developing world.

Imagine that a flood endangers a remote village, swamping roads and cutting off all emergency access. From concept (how to get medical supplies to inaccessible areas), to design (optimize an unmanned aerial system for low cost, 3-minute flight time and manufacturability) to an actual flying quadcopter carrying a package, our team of SIMULIA analysts collaborated with each other on the **3D**EXPERIENCE platform.

Starting in conceptual design with mission optimization, they moved to detailed design to verify strength and durability during hard landings, and finished with manufacturing analysis to ensure the newly designed parts could be produced quickly without compromising stiffness. Using Abaqus/CAE, Abaqus/CFD, fe-safe, Tosca, Simpoe-Mold, Isight, CATIA, SOLIDWORKS and some traditional products, they were able to prove out a reliable, robust aerial vehicle.

The finished quadcopter was brought on stage during the 2014 SIMULIA Community Conference, took off, released the medical supplies and landed successfully in front of an audience of more than 700 attendees.

How can we help you bring your imagination into the real world? Just ask. www.3ds.com/simulia

Getting to the Heart of Coronary Stent Design

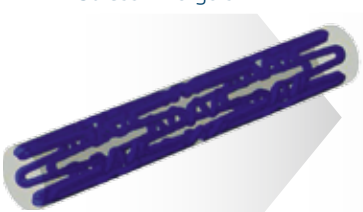
Deepen your knowledge about the geometry and physics of stents, expand your skillset and boost your ability to achieve optimum, verifiable results. Starting from a CAD model of your stent, perform stress analysis with Abaqus FEA, parametric optimization with Isight, and nonparametric shape optimization with Tosca. At any point along the workflow, you can also employ fatigue-life assessment using fe-safe as an adjunct for greater insight into durability.

Explore the full extent of SIMULIA's portfolio for stent design with our Extended Packaging program, which allows access to all of our solutions—Abaqus, Tosca, fe-safe and Isight—on a single token. You'll enjoy:

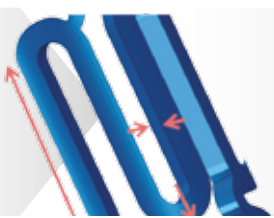
- Deeper understanding of effectiveness, robustness and loading conditions
- The ability to predict durability and reliability
- Mitigation of device failure, recalls and other uncertainties
- Powerful capabilities for design exploration of materials and geometries, parametric and shape optimization and manufacturing tolerances
- Insights into fatigue and failure through evaluation of stress concentration and cyclic loading
- Support of future patient-specific modeling with customized geometries and loading conditions

See www.3ds.com/products-services/simulia/solutions/life-sciences/stents for more details.

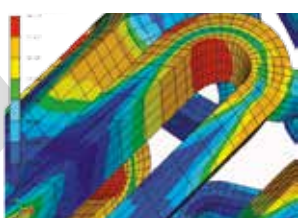
Stress Analysis



Parametric Design Optimization



Nonparametric Design Optimization

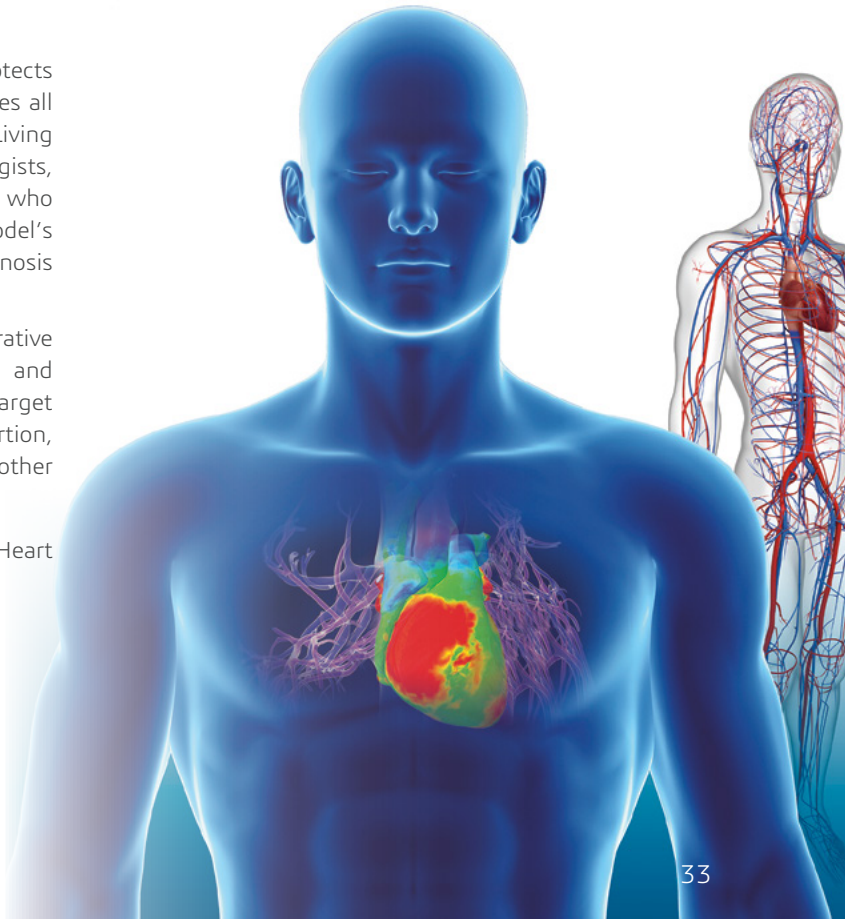


The Living Heart Project

Using a technology crowdsourcing model that protects the intellectual property of each member, yet enables all to share the outcome, SIMULIA is developing The Living Heart Project by working closely with leading cardiologists, medical device companies and academic researchers who participate in the evaluation of the simulated heart model's use in testing medical devices, improving clinical diagnosis and guiding pre-surgical planning.

Dassault Systèmes has signed a five-year collaborative research agreement with the United States' Food and Drug Administration (FDA), which will initially target the development of testing paradigms for the insertion, placement and performance of pacemaker leads and other cardiovascular devices used to treat heart disease.

Learn more about the Living Heart Project and Living Heart Human Model by visiting www.3ds.com/heart.



LET SIMULIA SUPPORT YOUR EFFORTS

One of the best things about being an engineer, or a manager of an engineering team, is that you get to keep learning throughout your career. But to truly thrive and move forward, you need to cultivate a mindset of openness for innovation. By building up your knowledge base and enhancing your expertise, you are able to keep pace with the latest technologies so you can adapt and respond to the ever-expanding demands placed on you and your team.

You are not alone! When you work with us at SIMULIA, you receive the degree of support you need to take advantage of the most comprehensive technology set available today for tackling your most difficult design problems.

We hope these pages have inspired you to think about new ways to apply our resources to your challenges. The power of the SIMULIA portfolio can lift your current skills to an even higher level of professionalism, making you more visible with greater impact on your organization.

Simulation Powers Innovation!

Continuous learning happens in so many ways these days—through your own efforts, through collaboration with colleagues and with the right degree of technical and strategic support. SIMULIA is dedicated to keep it all moving forward on every level.

Our active online Learning Community and regular Regional Users Meetings bring engineers together from all corners of the globe. And our annual SIMULIA Community Conference keeps growing every year in both attendee numbers and papers submitted for presentation.

- Join the SIMULIA Learning Community: www.3ds.com/slc
- Participate in a Regional User Meeting close to you: www.3ds.com/events/all-events/?brand/simulia
- Attend our annual SIMULIA Community Conference: www.3ds.com/scc
- Contact sales: www.3ds.com/how-to-buy/contact-sales

Using SIMULIA Tools for Your Industry

How can you use Abaqus, Tosca, fe-safe and Isight in your industry? Access in-depth information about SIMULIA applications within your field of expertise at www.3ds.com/products-services/simulia/products.

Extended Packaging

While Abaqus, Tosca, fe-safe and Isight are separate programs—and still available as such—SIMULIA has unified the licensing of all of them through our extended packaging offering. Now you can have interactive access to all of SIMULIA's model-building, visualization and pre- and post-solution processors through a single pool of Abaqus/CAE Extended Tokens.

More importantly, this also gives you the full-solution capability of all these programs (Abaqus, Tosca Structure, Tosca Fluid, fe-safe and Isight) even if only one product is purchased. The worth of your simulation investment is amplified through immediate access to every core technology in our portfolio.

Our **3D**EXPERIENCE® platform powers our brand applications, serving 12 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the **3D**EXPERIENCE® Company, provides business and people with virtual universes to imagine sustainable innovations. Its world-leading solutions transform the way products are designed, produced, and supported. Dassault Systèmes' collaborative solutions foster social innovation, expanding possibilities for the virtual world to improve the real world. The group brings value to over 190,000 customers of all sizes in all industries in more than 140 countries. For more information, visit **www.3ds.com**.

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