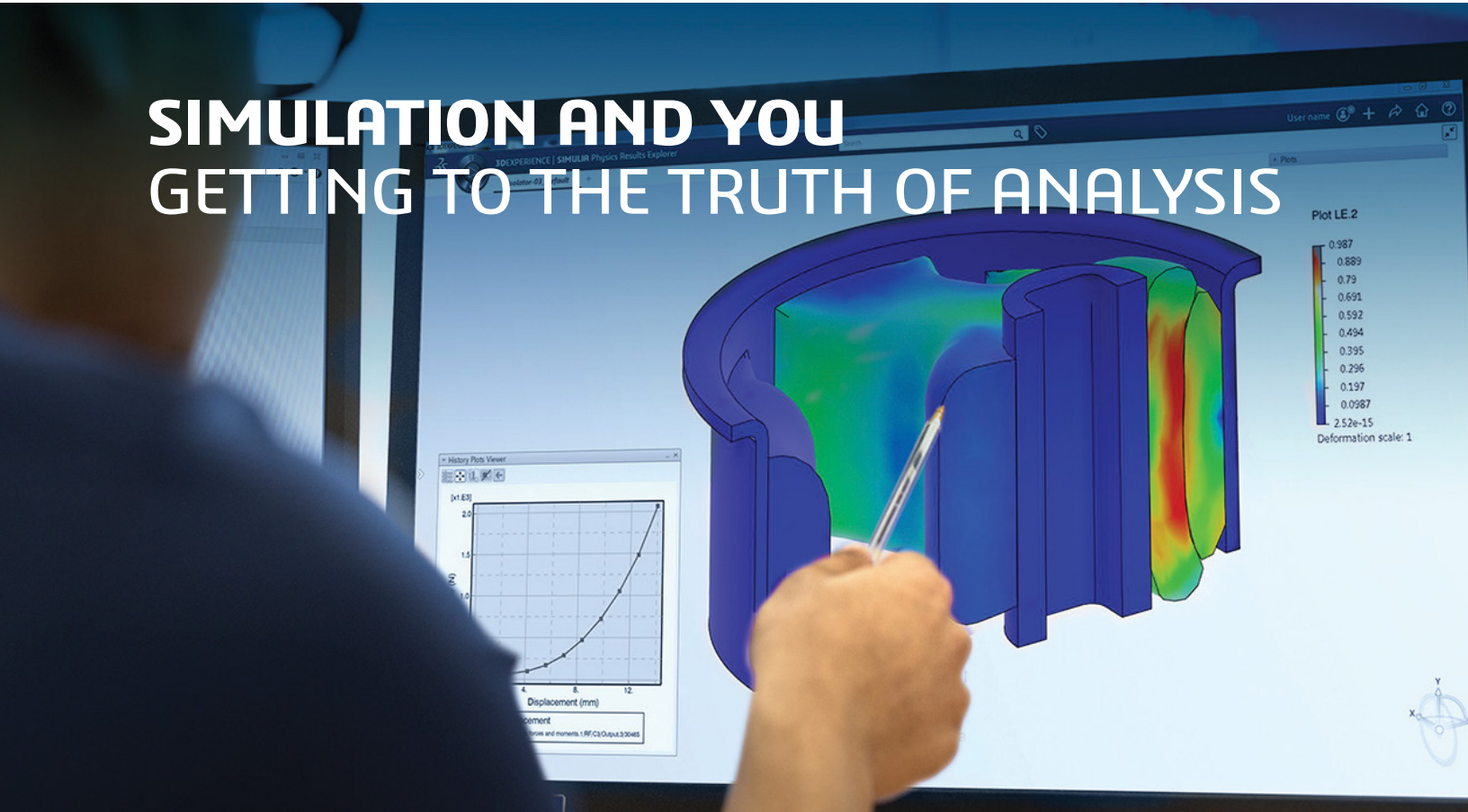**3S SOLID**WORKS

3DEXPERIENCE®

SIMULATION AND YOU
GETTING TO THE TRUTH OF ANALYSIS

THE TRUTH OF ANALYSIS

There's no doubt about it: Simulation has come a long way since its inception.

For decades, analysis was the exclusive domain of expert analysts. They would develop carefully crafted mesh models to assess only the most critical applications, such as automotive crash tests or the tension in a threaded connector. The stakes were immense. Accuracy was paramount. The significant effort invested in those simulations was worth it.

Fast forward to today, and many things have changed with simulation. Automated meshers can produce robust, high-quality simulation models. Cloud-based solvers can yield results in minutes. Easier-to-use interfaces make analysis available to practically anyone. And while that technological progress is irrefutable, many companies labor to figure out how to incorporate analysis into their development processes.

SIMTEK
Real Time. Real Results.

3S DASSAULT SYSTEMES

MANY QUESTIONS FOR SIMULATION

Today, there are many outstanding questions:

- How accurate do analyses need to be? Should they always be as precise as possible?
- What effect does simulation have on prototyping? Does it eliminate it? Decrease it?
- Do analysis results take the place of experience in decision-making?
- Where else in development can simulation be used? Is it for verification and validation only?

The intent of this white paper is to answer these questions and more. Along the way, we also provide details on how SOLIDWORKS® Simulation tools support these efforts.

The role of analysis in development has changed and expanded. Analysis can provide value in whole new parts of the development process. Read on to learn more.

NEED FOR SIMULATION ACCURACY VARIES

How accurate does a simulation need to be?

For many, answering this question is a scary and confusing proposition. If you make a decision based on an analysis that isn't accurate enough, you set yourself up for failure at some point in the development. As a result, many fall back to the most conservative position: Simulations must always be highly accurate. That creates an impossibly high bar for the use of analysis. For some, analysis solutions with any uncertainty are a risk. For others, assessing the accuracy of a solution is too burdensome and, as a result, they shun its use entirely. The truth is that the need for simulation accuracy varies from stage to stage during the development process.

Early in concept design, engineers use simulations to compare the performance of different design ideas, much like any trade study. These simulations are often highly simplified models under generic loads that don't resemble the design's detailed conditions. Why? The purpose is to uncover each concept's underlying behavior early, when the final details of operation may not even be known yet. Engineers use these analyses to gain insight into the feasibility and innovation potential for each idea, ultimately selecting one to take to detailed design. Keep in mind that this isn't some final check for the design; it is the first, simple assessment. Such designs will be refined and digitally tested to greater depth in detailed design and beyond. As a result, the cost of inaccuracy here is very low.


QUICK FACTS ON SIMULATION AND ACCURACY:

- The need for simulation accuracy varies by product development stage. Early, accuracy can be lax. Late, it must deliver high fidelity results.
- Simulation doesn't replace prototyping, yet it can reduce it. Simulation has a natural application in testing as well.
- Simulation doesn't replace experience; it augments it. Engineers can make better decisions with more information about a design's performance.

In detailed design, the needs of engineers change. They use simulations to contrast the impact of specific decisions in fine-tuning a design. This process includes selecting the right material grade, determining wall thicknesses, or selecting off-the-shelf components. These simulation models roughly represent the design's final operating environment. The purpose of these analyses is still directional; the results here are comparative and not absolute. More formal simulations and tests will catch design flaws later. The cost of inaccuracy here is low.

The need for simulation accuracy ramps up significantly in digital verification and validation. At this point in development, engineers and analysts perform a final and formal check of a design's performance before moving to prototyping and testing, where hard monies are spent to build something physical. The idea is to catch and address design issues here to avoid costly physical prototype failures. The cost of inaccuracy here is moderate.

The reality is that the need for analysis accuracy increases as you progress from concept design through digital verification and validation, corresponding to the risk of the task. It starts low. It ends high.
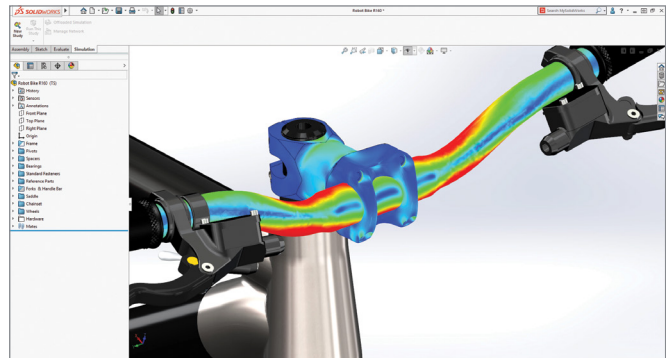
SIMULATION DOESN'T REPLACE PROTOTYPING

Can you replace prototyping with simulation?

No. To be perfectly clear, companies should not have any expectation that prototyping can be completely replaced with simulation. Every product should be physically tested to verify and validate the satisfaction of requirements, conformance to constraints, and performance against the engineer's intent. That does not change with simulation. Period.

Can simulation help reduce the number of prototypes built?

Yes. Absolutely. Using simulation in verification and validation allows engineers and analysts to digitally check performance before a prototype is built. These highly accurate simulations catch most design flaws before any money is spent on hardware. Furthermore, analyses can reveal secondary and tertiary failure modes. Engineers can mock up changes and rerun the analyses, verifying that their new designs do, in fact, pass the check. This stands in stark contrast to a testing-reliant approach that requires many prototype iterations to uncover a failure, perform a root-cause analysis of the issue causing the failure, make modifications to the design, and then build another physical prototype. The difference is quite simple: One relies on digital approaches while the other relies on physical approaches.

There are, however, significant implications of this difference for companies. The Cloud Adoption study (see page 4) conducted by Lifecycle Insights found that a single round of prototyping and testing costs $46,720, on average, and takes 30 days to complete. Findings from the study show that respondents averaged 2.6 rounds of prototyping and testing per project. That totals $121,472 and 78 days per project. Obviously, these metrics will vary from industry to industry and company to company. However, this is one area where simulation can have a significant impact, on both keeping projects on schedule and reducing project costs. The truth is that companies will not eliminate physical prototyping and testing with simulation. This is a key step in the development process. Companies can, however, dramatically reduce the amount of money and time spent on prototyping and testing through the use of simulation. Specifically, simulation calls for the application of highly accurate analysis in verification and validation, a step immediately before prototyping and testing.

SIMULATION DOESN'T REPLACE EXPERIENCE

### Can simulation replace experience in making design decisions?

No. This is another misconception about simulation. No company should use simulation results to overrule an engineer's experience in making a design decision. At the end of the day, engineers make design decisions. Simulation is no replacement for engineering experience. However, simulation can enable engineers to make better design decisions in a couple of ways.

First, analysis results augment an engineer's experience. During the development process, engineers use many different sources of information to make their decisions. That includes material specifications, industry standards, codes and regulations, reference works, periodicals, patents, and much more. Simulations only add to this set of information that engineers use to make their decisions. Armed with more insight, engineers make better decisions.

Second, simulation can validate and even extend an engineer's experience. Individuals often know not to design components with certain features or traits because they fail in prototyping and testing. However, they might not know why those parts fail. A simulation run before—or even after—prototyping and testing can uncover the root cause of the failure. This allows engineers to authenticate their hypotheses. With that insight, they can augment that feature or trait to make it feasible in ways they might not have previously considered. Simulation can reveal the engineering physics behind the failure, deepening engineering's knowledge about the behavior of their products.

"Our systems involve high-speed motion, so we need to verify the vibration characteristics of our designs and optimize the stiffness-to-mass ratio as much as possible. In today's fast-paced world, we simply don't have the time to do something a second time. With SOLIDWORKS Simulation, we have an integrated tool that helps us get it right the first time and improve the quality of our products."

— Yong Peng Leow,
Managing Director, Engineering Director, and Co-Founder
Akribis Systems Pte. Ltd.
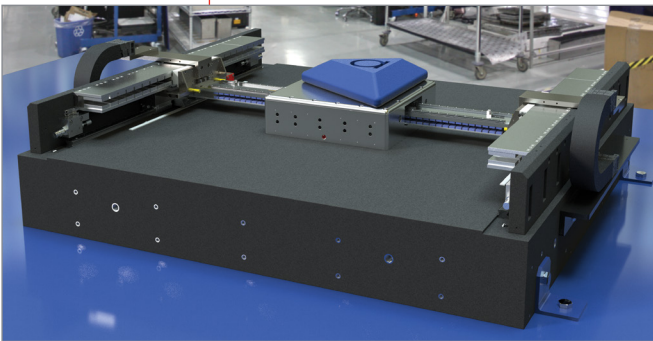
Using SOLIDWORKS design and simulation capabilities, Akribis Systems has shortened design cycles for its positioning systems, reduced development costs, and accelerated time-to-market.
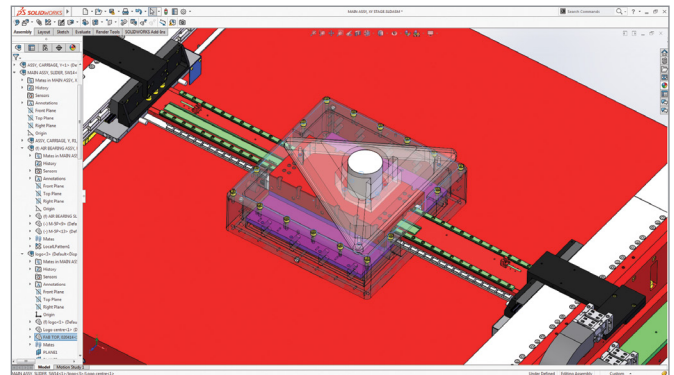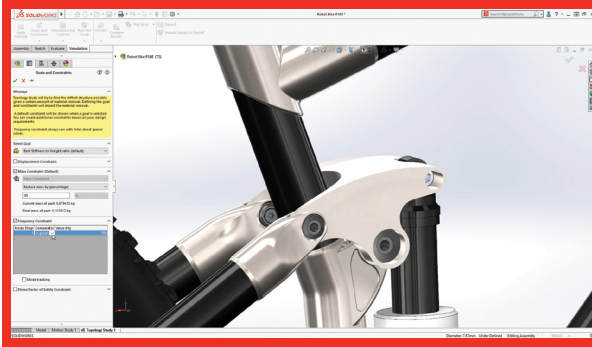
Engineers, of course, have a lot to gain by achieving more insight into product performance. Design flaws, once they get past design release, transform into change orders. Those are costly for the company, in terms of both money and time. However, there are serious implications for engineers as well. Those change orders are disruptive when they return to an engineer's desk. It means the engineer must drop their current project and dedicate time to addressing the change order. Meanwhile, the deadlines don't move for the current project, putting the engineer further and further behind. Simulation can enhance your experience in order to catch those issues before design release, allowing you to avoid change orders altogether.

Ultimately, simulation is meant to aid engineers. It augments their experience. It deepens their knowledge about the physics in their designs. It allows them to eliminate extra rounds of prototyping and testing as well as sidestep change orders. Simulation adds to the decision-making process; it does not replace it.

SIMULATION CAN AID IN TESTING

Is there a fit for simulation in prototyping and testing?

Actually, yes. Much of the value that simulation provides focuses on reducing rounds of prototyping and testing. However, analysis applied in testing provides great benefit. To truly understand the impact simulation can have, it is key to think about the process without analysis.

Late in the design cycle, engineers and others build the first prototype. They set it up for various test cases. When one of these prototypes fails, they have proof of how, when, and where it failed. The problem is that they don't know why it failed. As a result, engineers must formulate a hypothesis for that failure and come up with design changes that address it. The problem, of course, is that the engineer doesn't know if their hypothesis is correct until the next test. If the next prototype fails, then they don't know if the hypothesis was wrong or the design change was inadequate. Furthermore, they don't know if the failure was due to the initial design flaw or a secondary or tertiary one. This process repeats until one of the prototypes passes testing. This high-stakes, high-risk, iterative, testing-reliant approach is costly. Remember, the Cloud Adoption study conducted by Lifecycle Insights found that a single round of prototyping and testing, costs $46,720 on average, and takes 30 days to complete.

This process changes dramatically with simulation. After the initial failure, an engineer or analyst runs an analysis on the current design. The results reveal not only the initial design flaw, but secondary and tertiary ones. This confirms or refutes the engineer's hypothesis of the failure. Armed with insight, the engineer can develop design changes that address the first failure and any other design flaws. As a result, they have a much higher likelihood of passing the second round of prototyping and testing. Note that this process change does not require the use of simulation at any point prior to testing.

Many think of simulation as something that happens long before testing. However, it can be a great aid in testing. Using simulation in testing reveals the cause of the initial failure as well as any secondary and tertiary ones. This accelerates the resolution of a failed prototype without using simulation at any other point in design.
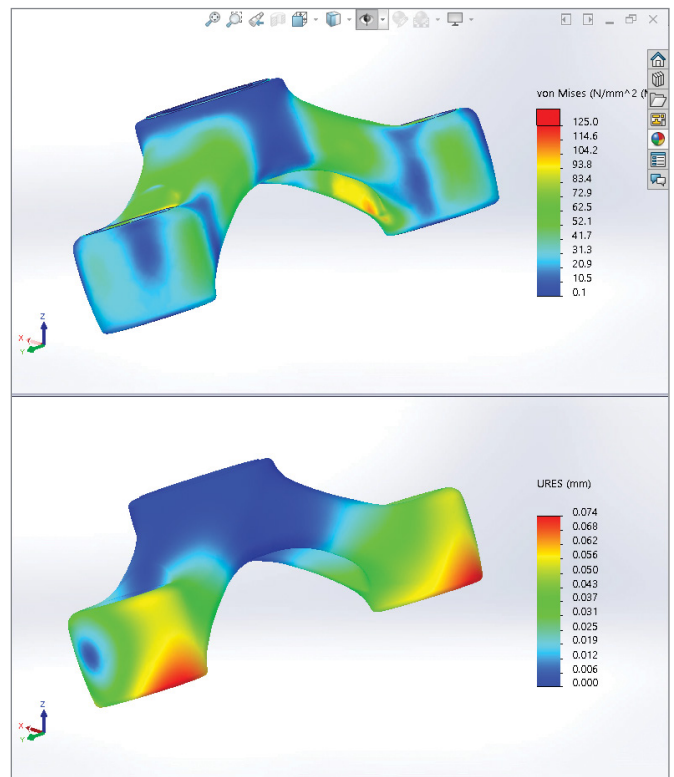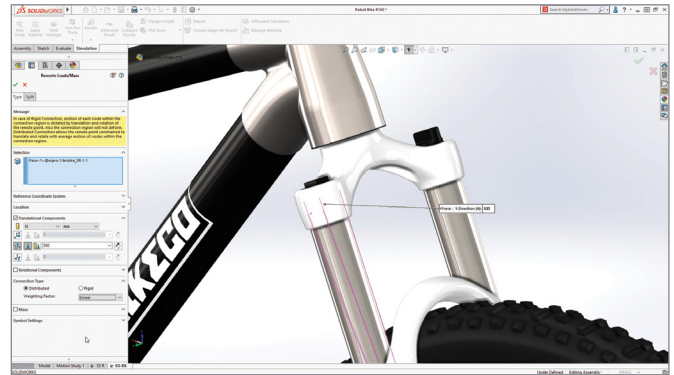
SOLIDWORKS SIMULATION ACCURACY

As noted earlier, the need for simulation accuracy varies according to the stage of development. In concept design, the accuracy of analyses can be low because the results are used to directionally select design ideas. However, in verification and validation, the accuracy must be stringently high in order to catch design flaws before investing hard monies in physical prototypes.

In 2019, Dassault Systèmes benchmarked SOLIDWORKS Simulation using the "Guide de validation des progiciels de calcul de structures" (Structural Analysis Software Validation Guide) as published by AFNOR (Association Française de NORmalisation, French Standardization Association), and written and compiled by the SFM (Société Française des Mécaniciens). The effort comprised 101 different examples covering a wide range of domains, including linear static analyses, vibration, dynamic response, and thermal and nonlinear engineering physics.

For each example, the modeling guidelines detailed in the Structural Analysis Software Validation Guide were meticulously followed. When not possible, an equivalent approach was used.

The full details of this effort can be downloaded here. Here are a few examples of the results.

- The four moment calculations for the FRAME WITH LATERAL CONNECTIONS all matched the benchmark within 0.13 percent.

- The two pressure calculations for the THIN CYLINDER UNDER UNIFORM RADIAL PRESSURE both matched the benchmark within 0.4 percent.

- The natural frequency calculations for the THIN CYLINDER FIXED ON BOTH ENDS all matched at 2.41 percent or less.

- The natural frequency calculations for the ASSEMBLY OF THIN RECTANGULAR-SHAPED SHEETS matched within 1.82 percent.

- The temperature calculations for the PIPE: CONVECTION matched within 0.27 percent.
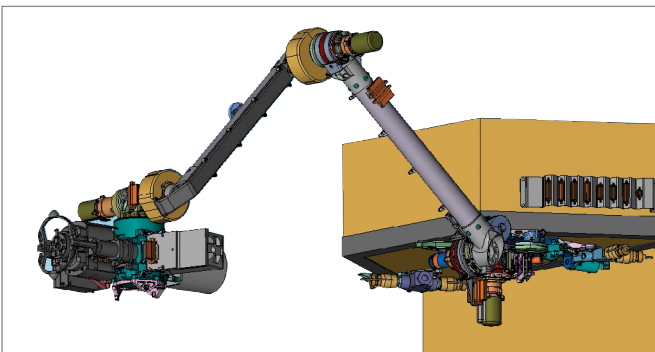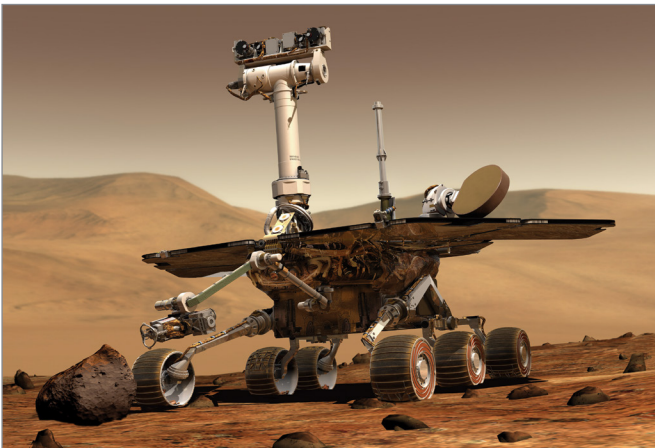
Using SOLIDWORKS software, ASI engineers developed the robotic arms for NASA's Mars Exploration Rover (MER) mission, which provided the first opportunity for detailed scientific studies on the Martian surface.

"I don't think this project would have been possible without SOLIDWORKS software and its integrated tools, such as SOLIDWORKS Simulation. We were searching for every gram of weight, every millimeter of space. … The ability of our analysts to use the simulation software for stress and thermal analysis enabled them to backstop our designers and collaborate efficiently to optimize the design."

— Brett Lindenfeld,
Director of Engineering
Alliance Spacesystems, LLC

In general, the analysis results from SOLIDWORKS Simulation matched the SFM's calculations within 1 percent across these examples. This shows that SOLIDWORKS simulation delivers highly accurate analysis results.

In May 2019, Dassault Systèmes benchmarked SOLIDWORKS Simulation against 32 standard example problems from NAFEMS, the not-for-profit International Association for the Engineering Modelling, Analysis, and Simulation Community. In aggregate, the results from SOLIDWORKS Simulation measured to within 2 percent of 111 out of the 116 measures for these 32 problems.

These two benchmarking efforts show that SOLIDWORKS simulation is a highly accurate analysis solution, offering engineers deep insight into how their designs work in operating environments.

3DEXPERIENCE WORKS SIMULATION

Early in development, the simulation requirements for accuracy and complexity can be lax. However, later, the needs for both are high. Recent technological advancements allow for innovative new approaches to these requirements. **3D**EXPERIENCE WORKS Simulation is a tightly integrated, cloud-based set of solutions that use the Abaqus solver, a long-standing, industry-renowned, accurate solution. **3D**EXPERIENCE WORKS Simulation powers structural static, frequency, buckling, modal dynamic response, and structural-thermal analysis of parts and assemblies.

When the mesh truly matters, these tools provide advanced and rules-based meshing controls with a wide variety of solid and shell element types. In addition, **3D**EXPERIENCE WORKS Simulation's feature recognition automates the task by auto-identifying holes, fillets, and beads. **3D**EXPERIENCE WORKS Simulation also includes a nonlinear solver that addresses a range of advanced structural analyses. It provides general contact simulation for components that touch one another in an assembly. It covers complex material behaviors such as metal plasticity, rubber hyperplasticity, viscoelasticity, and material failure.


Another significant advantage for **3D**EXPERIENCE WORKS Simulation lies in the tight integration with SOLIDWORKS. SOLIDWORKS models can be easily shared and vice versa. Being cloud based, engineers can access it from anywhere through a browser and share models and results with any internal or external stakeholders by simply providing a link. The cloud-based nature also offers flexible computer power. Multithreaded processing delivers rendering and visualization of large-scale simulations fast.

The combination of SOLIDWORKS Simulation and **3D**EXPERIENCE WORKS Simulation delivers a powerful set of analysis tools, allowing engineers to use the right simulation tools for the job at hand.
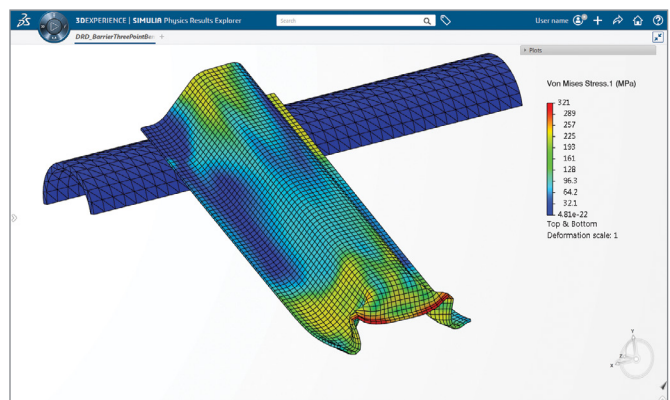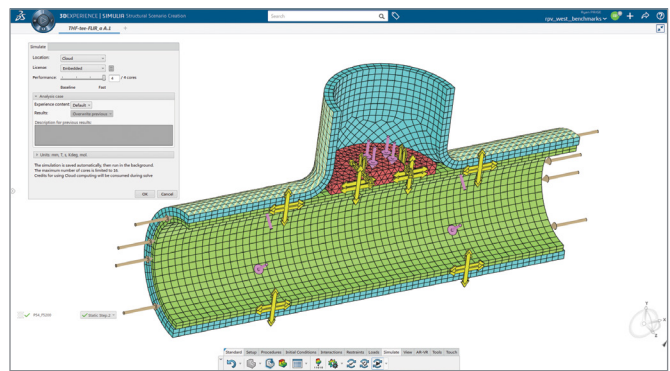
MEETING INDUSTRY VALIDATION GUIDELINES

Dassault Systèmes benchmarks show that SOLIDWORKS Simulation results are extremely accurate, coming to within 1 percent of the calculations of the Structural Analysis Software Validation Guide, as published by AFNOR, and with 2 percent of standards maintained by NAFEMS. SOLIDWORKS Simulation integrates seamlessly with with **3D**EXPERIENCE WORKS Simulation, cloud based tools that leverage the Abaqus solver, a long-standing, industry renowned, accurate solution. .
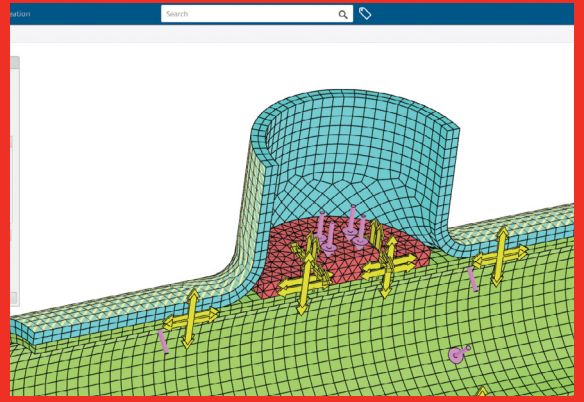
SUMMARY AND CONCLUSIONS

Today's simulation plays a wide range of roles in development. In concept design, engineers use analyses to assess the feasibility and innovation potential of new ideas. During detailed design, they apply it to refine designs and make better, more informed decisions. With verification and validation, they employ simulation as a way to check performance digitally. During prototyping and testing, they use it to confirm the root cause of failures and identify secondary and tertiary failures. Each use of simulation delivers separate, independent benefits.

Accuracy, of course, is an important topic to address with simulation. It can start at a low fidelity in concept design. However, the need for higher accuracies increases as development progresses. Our benchmarks against the AFNOR standard show that SOLIDWORKS Simulation matches standard calculations closely, often within 1 percent.

3DEXPERIENCE WORKS Simulation naturally extends SOLIDWORKS Simulation's capabilities. The two integrate tightly and with the rest of the **3D**EXPERIENCE platform. Designs can be passed back and forth. These simulation solutions deliver advanced functionality, ranging from fine-tuned control over meshing to nonlinear structural analyses to cloud-based processing. It is a natural extension of SOLIDWORKS Simulation.

Simulation is now a key part of development. Dassault Systèmes provides a powerful, integrated set of tools, SOLIDWORKS Simulation and **3D**EXPERIENCE WORKS Simulation, for anyone to be productive and confident with analysis.

TO FIND OUT WHAT'S NEW IN SOLIDWORKS PRODUCT DEVELOPMENT AND LEARN MORE ABOUT HOW INTEGRATED SOLIDWORKS SOLUTIONS CAN HELP YOUR COMPANY TAKE ADVANTAGE OF THE OPPORTUNITIES PRESENTED BY INTEGRATED SIMULATION TOOLS, CLICK HERE OR CALL 1 800 693 9000 OR +1 781 810 5011.

Our **3D**EXPERIENCE® platform powers our brand applications, serving 11 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the **3D**EXPERIENCE Company, is a catalyst for human progress. We provide business and people with collaborative virtual environments to imagine sustainable innovations. By creating 'virtual experience twins' of the real world with our **3D**EXPERIENCE platform and applications, our customers push the boundaries of innovation, learning and production.

Dassault Systèmes' 20,000 employees are bringing value to more than 270,000 customers of all sizes, in all industries, in more than 140 countries. For more information, visit **www.3ds.com**.

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