Analysts can work Faster & Better

Studies show CAE analysts can boost their productivity by 5.4X by upgrading their software and hardware.

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This is the fifth in a series of benchmarking studies produced by Digital Engineering *with Intel, Dell and independent software vendor sponsors that is intended to explore the benefits of embracing simulation-led design.*

Executive Summary

Once a relatively obscure role focused on independent study, the computer-aided engineering specialist has become a highly sought-after asset. Engineering organizations have ramped up their simulation efforts to boost product innovation and become more competitive. The expanded focus has fueled a flurry of investment in new CAE analyst hires, but the number of on-staff simulation experts still pales in comparison to the broader engineering and design community.

The limited number of CAE specialists is highly valued not just for their in-depth knowledge of finite element analysis (FEA) and computational fluid dynamics (CFD), but also for their expertise in more specialized analysis and multiphysics domains. With only so many CAE experts to go around, engineering organizations are challenged to embrace new ways of working that can help propagate this rich source of intellectual capital throughout the engineering ranks and over the course of the complete design lifecycle.

The Struggle for Efficiency

In reality, most engineering organizations are still struggling to optimize their limited CAE resources. Research shows there can be as many as 10 CAD designers for every dedicated CAE expert, each vying for specialists' input and analysis results in a timely manner. The pumped up demand has created a serious simulation bottleneck causing frustration for design engineers, who are forced to put projects on hold as they await analyst feedback, and also among the CAE experts who are overworked and pulled in too many directions.

There are other pain points surrounding the simulation workflow, particularly for CAE experts. With model sizes and complexity on the rise, CAE analysts are spending more time on each modeling task, limiting their ability to tackle additional simulation work. In a similar vein, the simulation studies themselves are more in-depth, many demanding multidisciplinary analysis and complex meshing strategies. The time-consuming nature of the work is limiting the number of simulation studies and design iterations while also requiring experts to labor over tedious model setup, as opposed to high-value work like more advanced simulations and defining and promoting analysis best practices.

The struggle to efficiently leverage highly skilled CAE talent creates a domino effect throughout the product development cycle. CAE experts work on fewer, more complex simulations, vastly impeding an organization's ability to fully explore design options and home in on the best designs. In addition to undercutting the widespread use of simulation, the bottleneck makes it harder for analysis results to have a lasting impact on critical design decisions. For example, a longer than average analysis cycle can produce results that are too late or out of sync with the latest design iteration, undermining the chance of proper optimization.

Break the Bottleneck

The good news is there are a number of ways to break the bottleneck and achieve faster, highly integrated and effective simulation. Taking advantage of the latest simulation software can go a long way toward making analysis capabilities more accessible to design engineers, shifting some of the burden away from dedicated CAE specialists and promoting analysis-led design as a mainstream best practice. Faster solvers provide simulation results faster, enabling their use in critical decision making. In addition, integrated CAD/CAE platforms with open programming environments can provide a boost by capturing and automating simulation best practices, once again reducing dependence on CAE experts for every simulation function.

Upgrading to the latest hardware can also significantly help speed up simulation. Workstations equipped with state-of-the-art, multi-core processors, solid state drives (SSDs) and ample memory, among other enhancements, can dramatically boost simulation software performance and drive efficiencies throughout the analysis lifecycle. A workstation calibrated for simulation can break the logjam, allowing analysts to perform complex modeling work and explore more design possibilities throughout the design lifecycle.

Deploying state-of-the-art hardware and CAE software not only ensures simulations run faster, it also introduces the possibility of greater design exploration via more advanced, multiphysics analysis and more detailed and complex models. With a simulation platform tuned for optimal performance, CAE experts are empowered to explore more design possibilities more frequently throughout the process without taking their workstations offline for hours at a time and freeing up bandwidth to juggle multiple modeling requests. For example, our benchmark tests show the latest version of Siemens' NX Nastran on a state-of-the-art modern workstation will run some simulations up to 5.4X faster than on a comparable hardware-software setup from three years ago. ●

The Benchmarking Study

Many engineering organizations remain trapped by the simulation bottleneck because CAE experts are still running simulation studies on older workstation-class machines or even consumer-grade PCs as opposed to modern, higher performance platforms. The underpowered hardware constrains their simulation efforts, limiting the number of simulations that specialists can handle, discouraging more complex and challenging simulations, and preventing more widespread use of simulation by the rest of the engineering team.

Siemens PLM Software, along with partners Intel and Dell, collaborated with *Digital Engineering* to explore the impact of outdated software and hardware on present-day simulation studies. The partners conducted a benchmark study to test vendor claims that state-of-the-art hardware and simulation software upgrades can dramatically bolster the performance of simulation-driven design and optimization.

For the study environment, the partners employed a three-year-old workstation and a current-day workstation in addition to older versions of Siemens PLM Software's NX Nastran along with the most recent release. The purpose was to compare performance of the same set of simulation studies running on a three-year-old workstation using older simulation software versus the most current generation of both hardware and software.

Both small- and medium-sized models were used for the benchmark, but the older system did not have enough memory to run the medium-sized model.

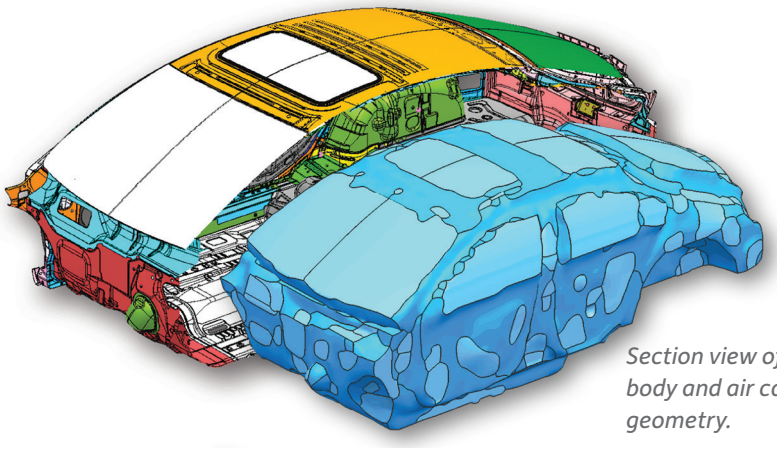
Benchmarking Model Descriptions

A coupled structure/acoustic model of an automotive vehicle was used for the benchmark. Performed as a frequency response solution, the results predict the sound pressure in the vehicle from a force at the suspension mount location. The response plot displays the total sound pressure as the result of the force along with the component path contributions to the total. The path contributions help noise, vibration and harshness (NVH) engineers understand transmissibility and identify component design changes to lower noise levels. This is the key value of CAE simulation; being able to quickly evaluate design changes is critical to achieving quality products in a fast moving development process. ●

The Benchmarking Setup

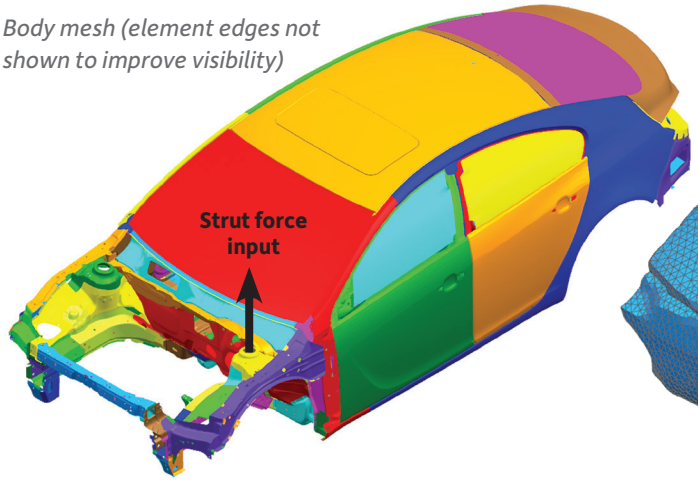
	Dell Precision T7500 workstation (3 years old)	**Modern Dell Precision Tower 7910 workstation**
Processor	1 Intel® Xeon® 5672 quad-core (3.2GHz)	2 Intel® Xeon® E5-2687W v3 processors (3.1GHz, Turbo, HT, 25M, 160W)
Cores	4	10x2
RAM	16GB	256GB
Storage	1TB (5400 RPM SATA)	PCIe 1 2TB +2X SSDs 512
Graphics	NVIDIA Quadro 2000	NVIDIA Quadro K2200
OS	Windows 7 and Red Hat Linux	Windows 7 and Red Hat Linux
Software	NX Nastran 9, 10 and 11	NX Nastran 9, 10 and 11

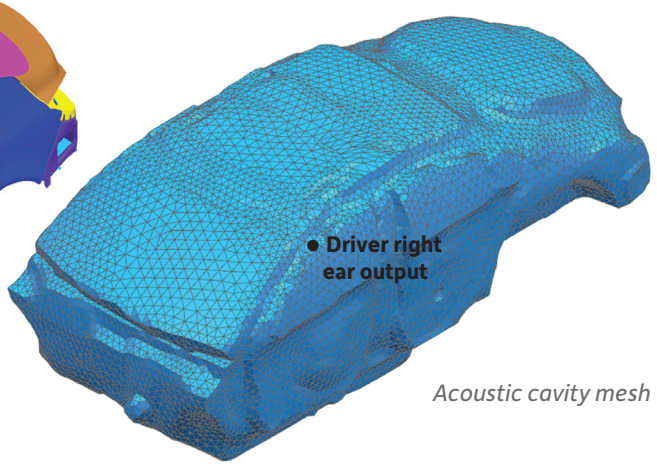
Real vehicle NVH models used by auto OEMs have 10M+ nodes. Siemens has been able to scale out to 500 processors on a compute cluster machine



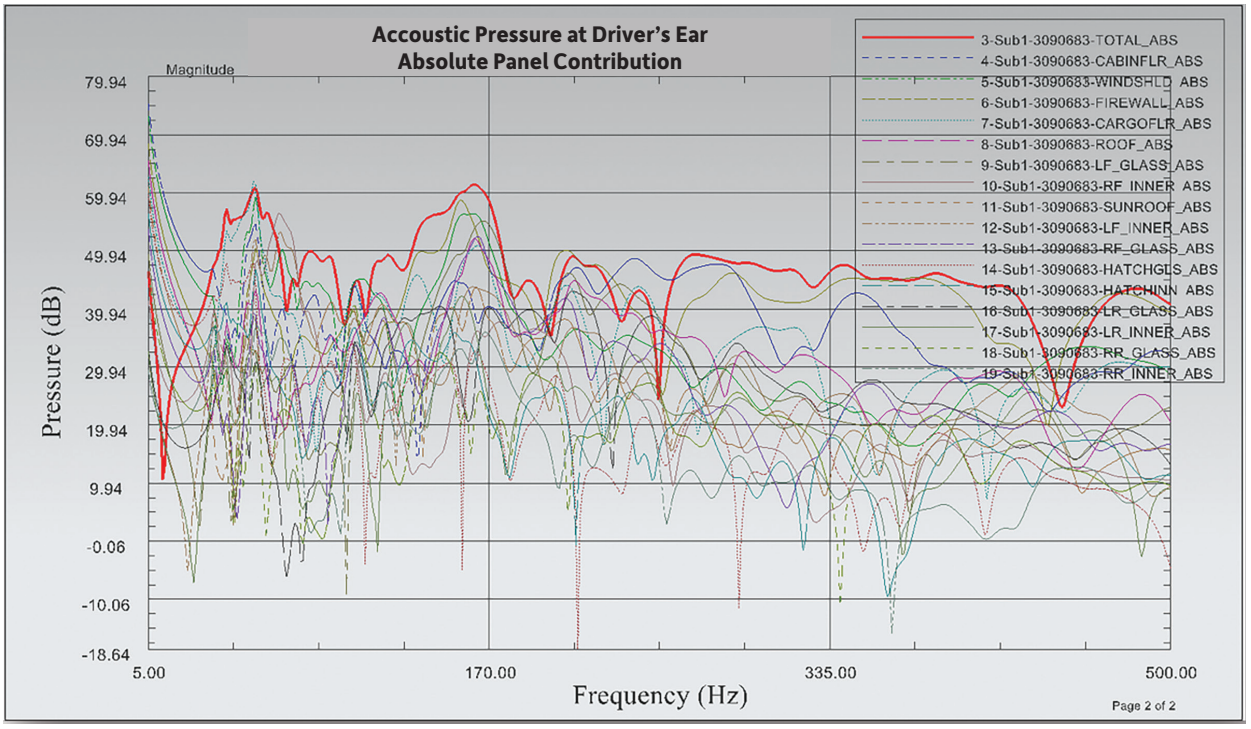
Section view of vehicle body and air cavity geometry.

Body mesh (element edges not shown to improve visibility)





Acoustic cavity mesh



Results of the simulation show the total sound pressure response at the driver's ear (see red line). Also shown are contributions from different panels, the largest of which were from the windshield, cargo floor, fire wall and left front door.

Analysis of Results

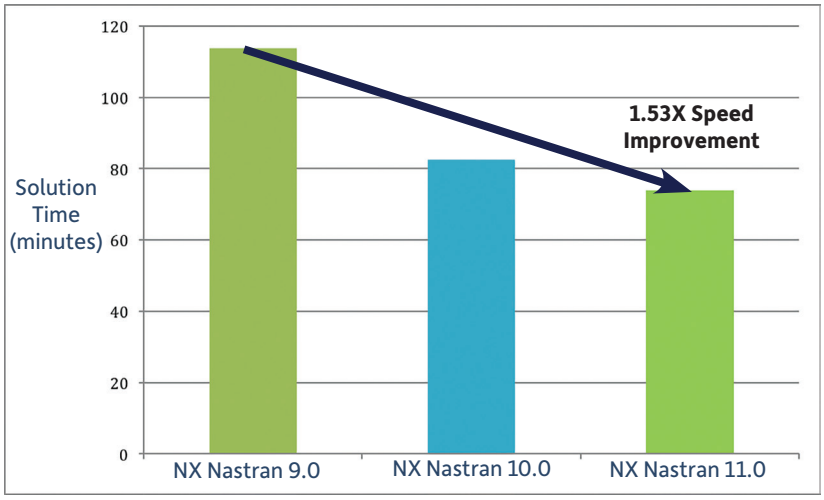
NX NASTRAN IS USED BY AUTOMOTIVE original equipment manufacturers for various types of simulations. Because simulating noise, vibration and harshness (NVH) is a common application, it was chosen for the benchmark.

The test results showed a 5.4X speed boost when running the NVH simulation using NX Nastran 11 on the modern Dell T7910 workstation vs. using NX Nastran 9 on the three-year old workstation. Hardware improvements were responsible for about 3.5X of that boost. Not only would such a speed boost allow design engineering teams to get simulation results back sooner, it would allow them to explore more designs and more complex designs at higher fidelity.

The NX Nastran structure/acoustic solution is quite sophisticated. It involves techniques to couple the structural mesh of the car body with an acoustic mesh of the air cavity. The meshes are incompatible because the acoustic mesh is generally less refined. The 5.4X speed boost was seen when using a smaller model with 391,000 nodes, but when attempting to benchmark a medium-sized model with 1.86 million nodes, the old workstation did not have enough memory to complete the simulation.

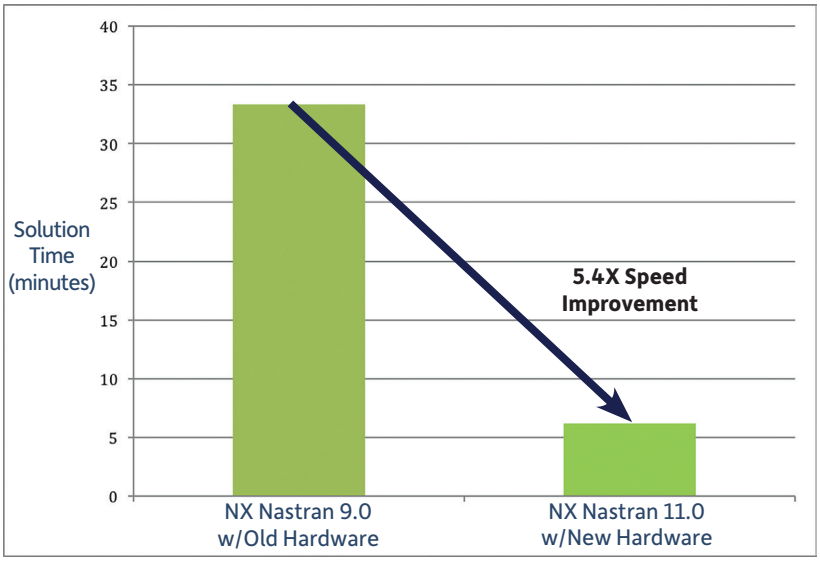
The fact that even a medium-sized simulation could not run on the older workstation underscores the importance of staying current. Simulation engineers using older hardware and software are not only slowing their solver run times, which affects productivity, they may have to spend time simplifying models just to get them to run. They are either forced to run less sophisticated models on older worksta-

The Results: New Software

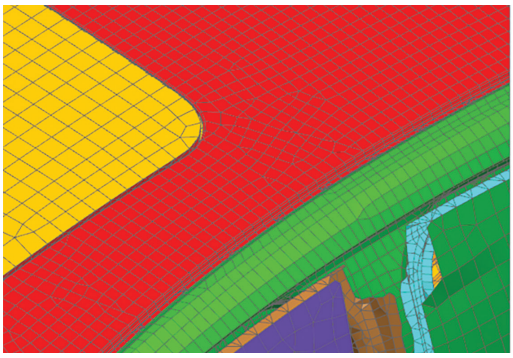
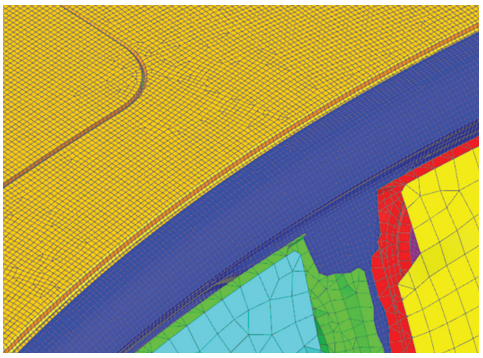


Updating from NX Nastran 9 to NX Nastran 11 on the same modern workstation provided a 1.53X speed improvement using the medium-size model and newer hardware.

The Results: Old vs. New



Using NX Nastran 11 on modern hardware provided a 5.4X speed improvement when solving the smaller model vs. using NX Nastran 9 on the three-year-old workstation. The older workstation could not complete the medium-size model simulation.

Small Model	Medium Model
	
Structural Mesh Nodes: 391,000	Structural Mesh Nodes: 1,855,000
Sructural Mesh Shell Elements: 384,000	Sructural Mesh Shell Elements: 1,953,000
Acoustic Mesh Nodes: 29,000	Acoustic Mesh Nodes: 29,000
Acoustic Mesh Tetrahedron Elements: 144,000	Acoustic Mesh Tetrahedron Elements: 144,000

tions, or send higher fidelity models out to other engineering computing resources and wait for results. Either way, bottlenecks are created that throw product development timetables into disarray.

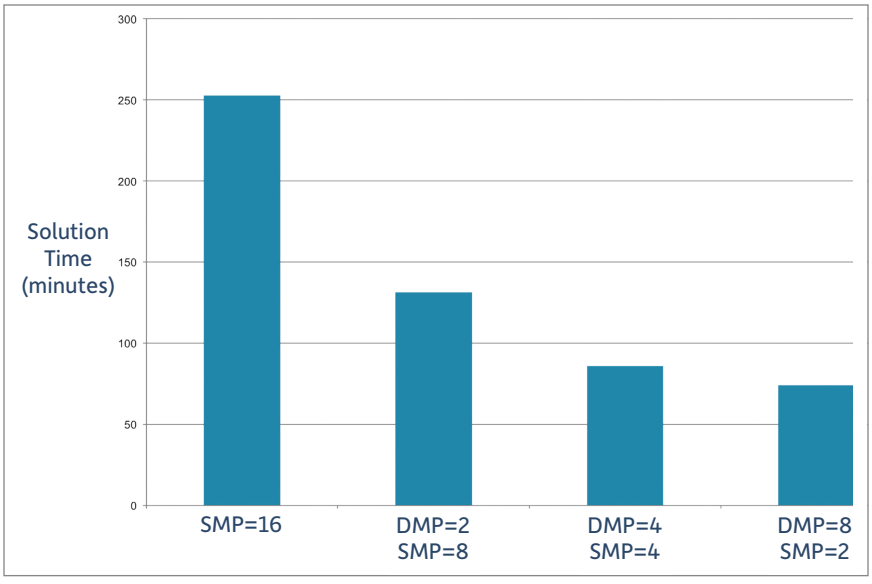
The benchmark also employed the NX Nastran RDModes eigenvalue solver, which uses an automated substructuring method to solve for the modes of the system. Automated substructuring techniques are much faster than the traditional Lanczos techniques, and also scale more on both Precision Workstations and high-performance computing (HPC) clusters. For example, Siemens has been able to scale out to 500 processors on a compute cluster machine. The hardware for this benchmark allowed scaling to 16 processors.

Solver Parallelization

Solver performance is central to boosting analyst productivity. In particular, the multi-discipline solver technologies at the core of Siemens PLM Software's Simcenter 3D platform have been architected to fully exploit parallelization, which leads to faster performance for a number of routine simulation tasks. The benchmark test results showed that using more processors gives close to linear scaling.

NX Nastran parallelizes solutions over multiple cores using both shared memory (SMP) and distributed memory (DMP) or combination of both. Shared memory works on low level math operations like the operators for matrix decomposition. Distributed memory works at a higher level and divides the matrices into partitions that are distributed. Using distributed memory over a greater number of cores scales the solution better than just increasing the number of cores for shared memory processing. ●

The Results: Memory Performance



Using distributed memory processing (DMP) over a greater number of cores scales the solution better than just increasing the number of cores for shared memory processing (SMP).

Improve Your CAE Productivity

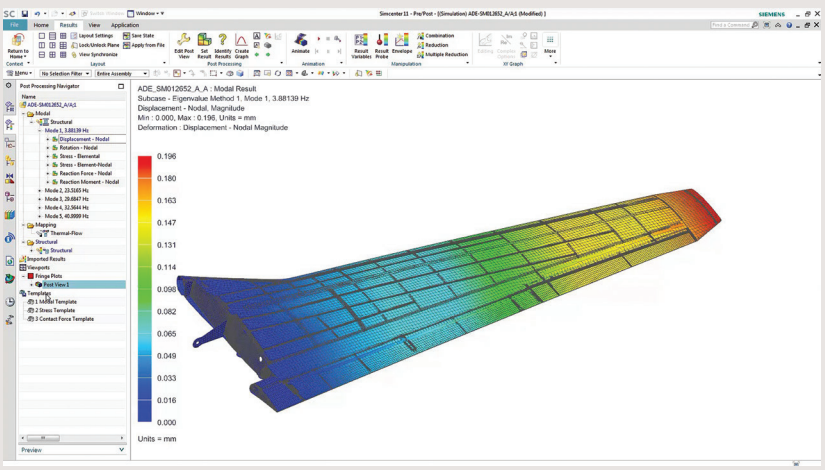
Companies looking to bolster simulation productivity should look no further than the CAE analyst, who lies at the heart of a simulation-driven workflow. This group, which has fast become a coveted resource throughout the engineering organization, is continually being pushed to perform more simulations, representing far more complex problems. Analysts are being pressured to complete these design studies more frequently and with greater expediency than in the past. Upgrading to the latest hardware and CAE software can deliver benefits to the simulation expert at each stage of their workflow, from more efficient model preparation to boosting productivity when creating effective post-processing reports.

Consider the model preparation stage, which is a laborious process for most CAE experts. Finding and importing the relevant geometry data from outside CAD sources can be tiresome, as is the laborious manual effort associated with modifying or defeaturing models to remove unnecessary details along with various other clean-up work. CAE experts either get bogged down doing a lot of these menial prep tasks on their own, which takes time away from actual high-value simulation work, or they become dependent on CAD operators to do model preparation, which increases the number of handoffs and slows the simulation cycle. Prepping data for meshing along with other meshing-related activities—mesh refinement, the application of loads, etc.—can also be a burden for CAE experts increasingly pressed for time.

Siemens PLM Software's Simcenter 3D facilitates efficient model preparation. One of Simcenter 3D's more notable capabilities is Synchronous Technology (ST), which enables direct geometry editing. This allows CAE analysts to directly edit geometry models imported from any CAD source without having to understand or have access to the original design intent, be proficient in advanced CAD capabilities, or be dependent on CAD operators to implement the requisite geometry changes. Moreover, Simcenter 3D supports several options to simplify meshing and model preparation, such as a very robust tetrahedral element mesher that can handle the most complex geometry. What's also unique is its ability to tie the analysis model to the underlying geometric model, which automatically updates the analysis model whenever the underlying geometry

Introducing Simcenter

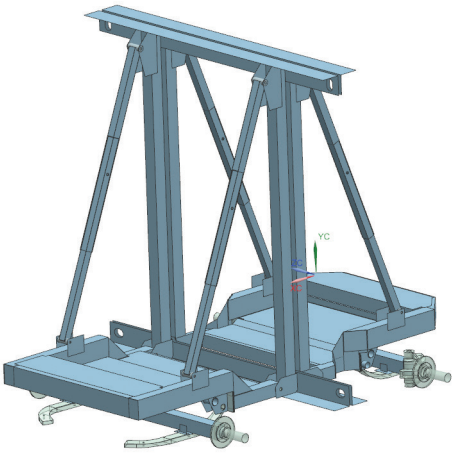
SIMCENTER™ software from Siemens PLM Software is a portfolio of simulation and test solutions that help companies predict performance across all critical attributes earlier and throughout the entire product lifecycle.

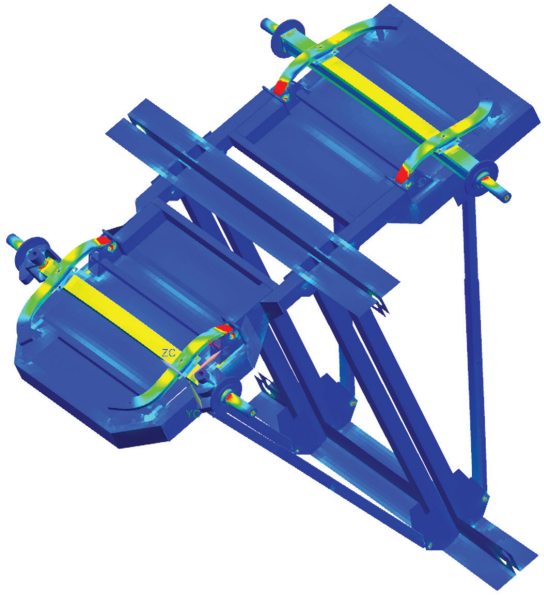


Within this portfolio, Simcenter 3D delivers a unified, scalable, open and extensible environment for 3D CAE. Simcenter 3D speeds the simulation process by combining best-in-class geometry editing, associative simulation modeling and multi-discipline solutions embedded with industry expertise. It integrates fast and accurate solvers that power structural, acoustics, flow, thermal, motion and composites analyses, as well as optimization and multiphysics simulation.

Simcenter 3D is available as a standalone simulation environment. It is also available completely integrated with NX delivering a seamless CAD/CAE experience.

Siemens.com/simcenter





With Simcenter 3D, the analysis model is associated to the geometry. Design Automation Associates used Simcenter 3D to provide results 30% faster to its customer, CIGNYS, for its military mobilizer.

changes—saving an engineer from having to perform a lot of manual rework.

Mobilizing with CAE

Design Automation Associates, Inc. (DAA), which provides CAE consulting services for customers in a variety of industries, was able to reap the benefits of associativity between the design and analysis model on a stress analysis project for a new military mobilizer being built by its customer, CIGNYS, a precision manufacturing company. The company had been spending excessive amounts of time on preprocessing simulation work on a legacy CAE tool—as much as 63 hours for one iteration, which was deemed unacceptable by both DAA and its client. By switching to Simcenter 3D, DAA was able to complete its preprocessing steps in half the time, and the linked analysis and geometry models made things even faster, enabling the DAA team to spend more time engineering instead of on analysis modeling.

"The heart of any successful project is the reliability

The Dell Precision Tower 7910 Workstation

THE DELL PRECISION TOWER 7910 workstation was used as the baseline for the current workstation in our benchmarking tests. It features a new generation of dual-socket performance with the Intel Xeon Processor E5-2600 v4 processor series with up to 22 cores per processor, the latest NVIDIA Quadro or AMD FirePro graphics and up to 1TB of system memory using the latest DDR4 RDIMM memory technology.

Dell has collaborated with Intel on the storage acceleration software application, Intel CAS-W, which improves workstation application performance. With the Intel CAS-W software solutions, users can enable I/O speeds close to that of solid-state drive configurations at the storage and price of traditional drives.

The Dell Tower 7910 can be configured with up to 4 actively cooled M.2 PCIe solid-state drives, which are up to 180% faster than traditional SATA SSD storage. Traditional hard drive options are also available. The Dell Precision Tower 7910 comes with an integrated 12 Gb/s RAID Controller (SAS), doubling the I/O speed of the company's previous generation workstation.

The Dell Precision Tower 7910 also features endpoint security solutions that include encryption, advanced authentication and malware protection from a single source. Plus, the Dell Precision Optimizer automatically tunes the workstation to run specific programs at the fastest speeds possible, enhancing productivity. Dell also offers a rack workstation (Rack 7910) that has similar configuration options, ideal for customers that prefer to place the system in a machine room for reduction of heat, noise and physical space in the working environment.

Dell.com/precision

VIRO, a multidisciplinary engineering firm, reduced development time by enhancing collaboration between NX CAD design and Simcenter 3D analysis.

of up-front schedule and cost estimates. Anything that increases uncertainly and limits flexibility hurts both the project and the business performance of associated organizations," said John Lambert, DAA's president and CEO. "DAA made significant strides in reducing uncertainly and increasing flexibility using Simcenter."

Upgrades Pay Off

Damping Technologies Inc. (DTI), which specializes in solving noise and vibration problems, was able to greatly accelerate its robust FEA program by moving to the latest version of Siemens PLM Software's NX Nastran solver in addition to upgrading its hardware to an eight-CPU system with 16GB of memory. While NX Nastran's speed advantage was evident during the evaluation process, it was even better than anticipated, according to Kristopher Notestine, manager of R&D at DTI. In some cases, simulations now take about a quarter of the time they took with competing simulation software.

"The type of analysis we do requires a lot of iteration and a lot of resolution in the model in terms of degrees of freedom," explained Notestine. "A typical analysis on a very small structure can take four to eight days to run."

Streamlining Simulation Processes

Given the rising complexity of products, today's engineering teams are dealing with more simulations and analysis data—not less. Keeping track of that burgeoning intelligence while avoiding laborious rework for every simulation is an ongoing challenge made significantly easier with Siemens PLM Software's simulation data management and process management tools.

Teamcenter Simulation Process Management, a component of the leading PLM platform, Teamcenter, integrates with Simcenter 3D to help engineering teams standardize analysis methods while achieving greater speed and accuracy in building models. In the area of data management, the solution manages CAE-specific geometry, meshed models, results and reports, allowing an extended team to easily find and reuse the right data for virtual prototypes.

Teamcenter Simulation Process Management can also accelerate certain aspects of the CAE workflow, applying rules-based processes to build CAE structures from the design structure while automatically generating reports. The solution also rapidly updates models after design changes, initiating workflows that regenerate results and validate changes, minimizing rework and ensuring model accuracy.

United Launch Alliance LLC (ULA), a leader in building launch vehicles for spacecraft, tapped Teamcenter Simulation Process Management as part of its Teamcenter and NX deployment to help manage volumes of simulation data and to coordinate data sharing across multiple simulation tools and CAE experts. The company, which had been mired down with labor intensive, highly redundant administration processes to facilitate and share simulation data, now has an automated process that streamlines collaboration.

"The ability to quickly understand and compare changes in analysis inputs and results from mission to mission is enabling us to project months of improvement in process throughput," said Marc Solomon, ULA's PLM chief engineer and engineering systems architect. "We use the Teamcenter Simulation Process Management solution to close the loop with the tools that are used."

The latest version of Simcenter 3D also offers dramatic performance improvements when it comes to post processing and reporting productivity. Simcenter 3D offers a multi-analysis environment so engineers can simulate and view results of myriad analyses types (structural, thermal, flow and motion analysis, for example) within a single environment, eliminating the need to juggle different tools and streamlining the analyst's workflow. Simcenter 3D can also easily import result files created by popular third-party solvers like ANSYS and Abaqus, making for easier post processing and reporting.

Like DTI, multidisciplinary engineering company VIRO is challenged to make quicker, smarter decisions earlier in the design process while meeting tight customer deadlines. By enabling design and analysis to be performed concurrently through NX CAD and Simcenter 3D the firm creates better design and effective workflow. Different analysis modules of Simcenter 3D like fatigue and flow combined with the powerful geometry engine provides all the functionality needed to complete their engineering projects. Teamcenter enables real-time transparency on the evolving product data, honing further the efficiency and competitiveness.

Taking Composite Technologies to the Real World

Composites are another area where Siemens PLM Software's industry-specific expertise is providing a simulation boost. Consider the Composites Innovation Centre Manitoba Inc. (CIC), a non-profit focused on commercializing composite materials and related technologies.

With market demand for composites at an all-time high thanks to cross-industry light weighting initiatives, CIC needed a more streamlined and cohesive workflow for CAD and CAE. Switching to a tightly integrated design and simulation environment eliminated the need for manual updates and provided a huge productivity boost.

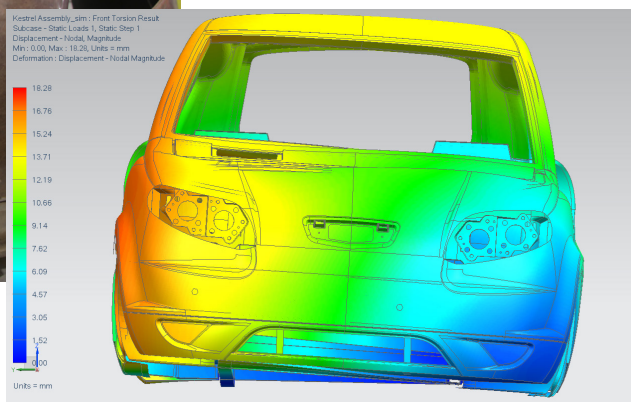
> **"The switch to NX and Simcenter software allowed us to perform design and analysis projects thatwould have previously been impossible."**
> ***— Alastair Komus, CIC***

Use of NX and Simcenter helped the CIC team secure 41% weight reductions on a front tub component in a very competitive timeframe without compromising safety or durability of the vehicle. With NX and Simcenter in place, CIC engineers are able to take on increasingly complex projects and explore a greater number of design variants while delivering results to clients in record time.

"The switch to NX and Simcenter software allowed us to perform design and analysis projects that would have previously been impossible," said Alastair Komus, CIC principal engineer. "The efficiency with which we can make design changes and verify their performance has dramatically increased." ●

Download the Case Studies

Composites Innovation Centre Manitoba Inc.
Damping Technologies Inc.
Design Automotive Associates
United Launch Alliance
VIRO



The Composites Innovation Centre Manitoba Inc. used the associativity between NX design geometry and Simcenter analysis models to accurately represent and analyze laminate composite structures.

Empower Analysts

With so much in product development riding on smart simulation, boosting CAE analyst productivity is a sound investment. Providing CAE experts with the software and modern-day hardware to solve problems faster enables organizations to inject valuable analysis input into the development cycle earlier when it has the most potential to optimize designs. In addition, simulation analysts are able to channel their skills toward simulation problems that advance product designs as opposed to non-value-added model prep and rework.

By empowering CAE analysts to do faster and more advanced simulation, companies are making a sound investment in their future. Today's complex problems demand a thoughtful approach to product design, and boosting simulation productivity will not only accelerate the development cycle, it will result in innovation that delivers a competitive edge.

As the results of the benchmarking study show and are supported by the real-world examples in this paper, combining current design and simulation software with modern hardware helps meet many technical challenges being faced by manufacturers today. However, the biggest benefit to being able to do more simulations faster is the productivity it gives to the CAE analyst. The benefit of breaking the CAE bottleneck reverberates throughout the entire development process, allowing the design engineering team to explore more innovative solutions faster without compromising.

More Information

Siemens Simcenter
siemens.com/simcenter

Dell Workstation Advisor and Configurator
Dell.com/solutions/advisors/us/en/g_5/Precision-Workstation-Advisor

Dell Precision Workstations
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Dell High Performance Computing
Dell.com/learn/us/en/555/high-performance-computing

Intel Workstation Products
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Making the Case for Professional Engineering Workstations
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Top 10 Reasons to Choose a Workstation
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