FOCUS ON FASTER

Mechanical Simulation

Studies show you can slash the time spent on simulation runs by 6x when you upgrade to the latest workstation technology and software.

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Technology for Optimal Design Engineering

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

Executive Summary

Introducing the right product in a timely fashion, free of quality issues, remains the secret to success regardless of industry and despite the complexities of today's global competition. Simulation software is increasingly recognized as a critical asset for producing such optimal and reliable product designs. However, many organizations aren't realizing the full benefits of simulation, in part because outdated workstation hardware and software is still too prevalent among engineering teams.

Build a Strong Computing Foundation

Engineering organizations are stuck in a simulation rut for a variety of reasons. Some are saddled with consumer PCs or underpowered workstations that simply don't have the muscle to run large simulations or accommodate high-fidelity multiphysics models effectively. Without an adequate computing foundation, complex simulations can drag on for hours, maybe even days, swallowing up limited processing power, consuming precious development hours and wreaking havoc with project deadlines. As a result, engineering organizations often choose to scale back the number of variations they simulate or reduce the scope of the problem they're exploring, which runs counter to their mission of advancing product designs.

Beyond hardware limitations, there are other factors hindering more widespread use of simulation — even within the same organizations that recognize its potential for design transformation. For some, simulation software remains too costly and difficult to master, limiting its use to pockets within engineering as opposed to being established as an enterprise design tool. In addition, many organizations lack expertise in both simulation software and simulation practices. Some don't have access to on-staff IT personnel who can support the high performance workstations, clusters and servers optimized for the latest simulation software.

A >6x reduction in simulation run times can be achieved by using the latest Dell Precision workstations and ANSYS software.

Research and Testing

The pages that follow include results from two different research projects focused on discovering the pain points pertaining to design engineers' use of simulation and proving the productivity gains possible by upgrading to the latest workstation technology and software. The first, a survey sponsored by Intel and ANSYS, shows how many engineers are trying to perform simulations on hardware that is not up to the task, resulting in long waits for simulations to run. The second, a benchmarking study conducted by ANSYS, Intel and Dell, reveals a 4.1x reduction in simulation run times can be achieved by using the latest Dell Precision workstations and ANSYS software, as opposed to an equivalent three-year-old system and software with the same number of cores. When using all 16 of the modern Dell Precision workstation's cores, a simulation run time reduction of more than 6X was achieved. ●

68% of survey respondents are forced to limit the size and amount of detail in simulation models at least half the time.

The Survey Results Are In

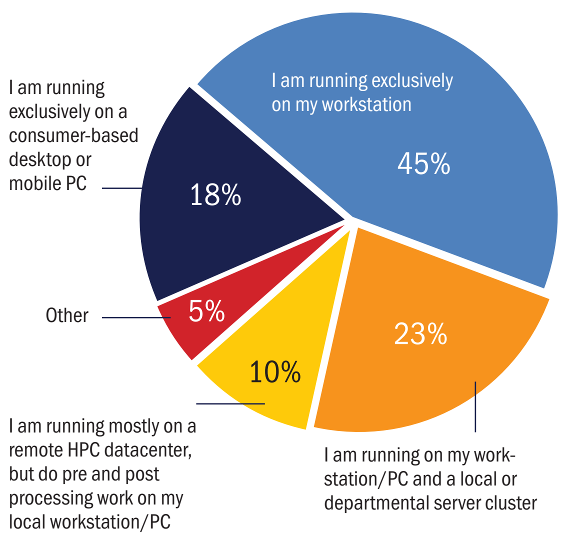
More than 1,400 research and/or design engineers responded to the simulation survey that was conducted by Intel and ANSYS in late 2014. According to the survey, 35% of respondents are using computing platforms stocked with only a single CPU, while 16% are working within the limits of 16GB of RAM or less. Less than a third (29%) are using systems equipped with solid-state drives (SSDs), which are essential for applications that read and/or write large amount of data. What's worse, 18% are working on consumer-grade PCs, as opposed to professional workstations or higher performance platforms. Of respondents who are using professional workstations, 17% of them are working on hardware that is more than 3 years old.

These purchasing choices lead to constraints that pose serious barriers to expedient and effective simulation efforts, the research shows. Twenty-four percent of those surveyed said they were grappling with simulations that took longer than nine hours to complete, some chugging away for up to two full days. In addition, 68% of respondents said they were forced to limit the size and amount of detail in simulation models at least half of the time due to the fact that more in-depth simulation practices pushed the limits of turnaround time and had a negative impact on project deadlines.

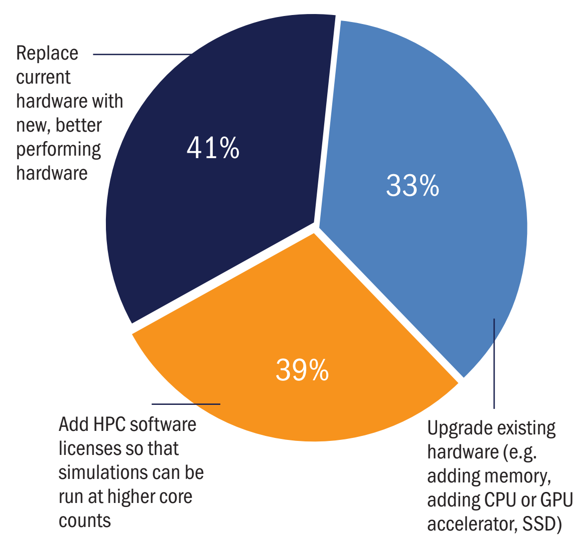
That's not to say organizations aren't fully aware of the benefits of simulation and don't have a desire to expand its use throughout the design workflow. More to the point, they were less apt to do so without the ability to accommodate faster simulation so there wasn't a drain on engineering resources. Almost two-thirds of respondents (64%) said the lack of proper hardware or computing capacity was a very important or somewhat important barrier to increased use of simulation tools and workflows. Similarly, 65% said the substantial time it took to perform simulations was a very important or somewhat important hurdle to taking steps to expand simulation practices.

At the same time, there was universal acknowledgement that hardware replacements or hardware and software upgrades could dramatically change the equation and make simulation speed a non-issue. Forty-one percent of respondents who limit the size and/or detail of their simulation models at least half the time said replacing current hardware with new, better-performing platforms was the best solution for reducing the turnaround time limitations that affect simulation outcomes while for 33% of respondents, upgrades to existing hardware (for example, adding memory, CPUs, GPU accelerators or SSDs) was the preferred approach. More than a third (39%) were inclined to add HPC software licenses as a solution for running simulations faster by taking advantage of a higher core count. ●

Statement that best fits most frequent computing usage scenario for running engineering simulation applications



Solutions that could best reduce the turnaround time limitations effecting your simulation models and outcomes*



* Based on respondents who limit the size and amount of detail in simulation models at least half the time. Multiple responses chosen; will not equal 100%.

The Benchmarking Study

35% of our survey respondents are using computing platforms stocked with only a single CPU.

Based on this feedback, ANSYS, Dell and Intel decided to collaborate with *Desktop Engineering* on a benchmark study designed to explore the impact of outdated software and hardware on present-day simulation studies. Vendors routinely make claims that state-of-the-art hardware or simulation software upgrades can make a big difference on the scope and performance of simulation studies. The benchmark was intended to put those claims to the test while examining how updating hardware and software can elevate simulation performance and help companies achieve a richer and more valuable set of results.

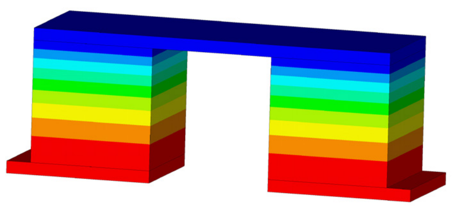
Refreshing Benefits

The study environment consisted of a three-year-old and a current-generation Dell Precision workstation in addition to the older 13.0 version of the ANSYS Mechanical simulation software along with the most recent 16.0 release. The goal of the study was to compare the performance of the same set of simulations running on the three-year-old workstation loaded with older simulation software, on state-of-the-art hardware using the older simulation software, and finally on the most current generation of both hardware and software. ●

The Benchmarking Setup

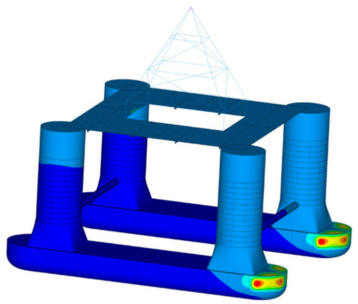
	Dell Precision T7500 workstation (3 years old)	**Modern Dell Precision Tower 7910 workstation**
Processor	Dual Intel Xeon X5672, running at 3.2GHz	Dual Intel Xeon E5-2667 v3, running at 3.2GHz
Cores	8	16
RAM	128GB	256GB
Hard Disk System	13GB SSD, no RAID	128GB SSD, no RAID
Hard Disk Working Directory	2X558.37GB 1500RPM SAS (RAID 0)	2x512GB SSD, RAID 0
Software	ANSYS Mechanical release 13.0	ANSYS Mechanical release 16.0
Operating System	Windows Server 2012 R2	Windows Server 2012 R2

The Benchmarking Models



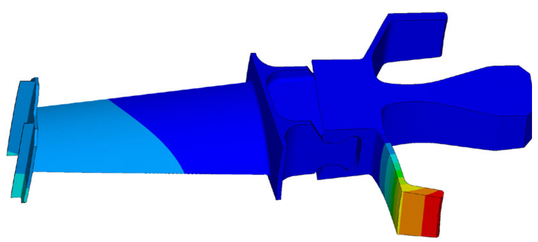
Model 1

A static nonlinear thermal-electric coupled field analysis of a Pelletier cooling block.
Model Characteristics: Sparse solver, non-symmetric matrix, 650K degrees of freedom (DOFs)



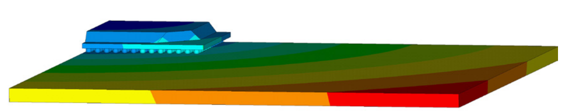
Model 2

A transient nonlinear structural analysis of a submersible drilling rig.
Model Characteristics: Sparse solver, symmetric matrix, 4.7 million DOFs



Model 3

A static nonlinear structural analysis of a turbine blade comparable to those found in aircraft engines.
Model Characteristics: Sparse solver, symmetric matrix, 3.2 million DOFs



Model 4

A transient nonlinear structural analysis of an electronic ball grid array.
Model Characteristics: Sparse solver, symmetric matrix, 6 million DOFs

The Benchmarking Results

65% of respondents cite time to perform simulations as a very/somewhat important hurdle to expanding the use of simulation.

The benchmarking study showed that a workstation upgrade did deliver significant performance improvements, enabling the older ANSYS Mechanical 13.0 release to take advantage of advancements such as more compute cores per CPU, additional and faster memory, and faster disk storage. Running the latest version of ANSYS Mechanical 16.0 on a three-year-old workstation platform also boosted performance incrementally.

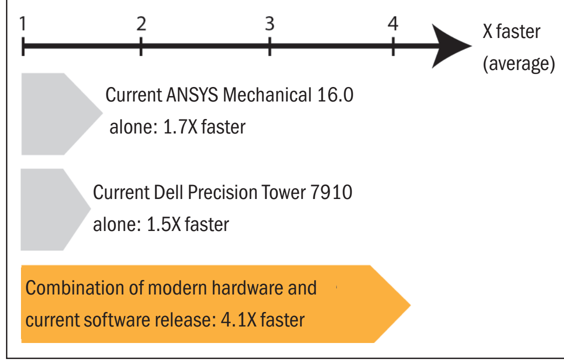
In addition to the faster hardware and software speeds, the benchmark found that the ability for ANSYS release 16.0 to leverage additional cores enables it to run 3.1x faster than ANSYS 13.0 as it scales from 8 to 16 cores.

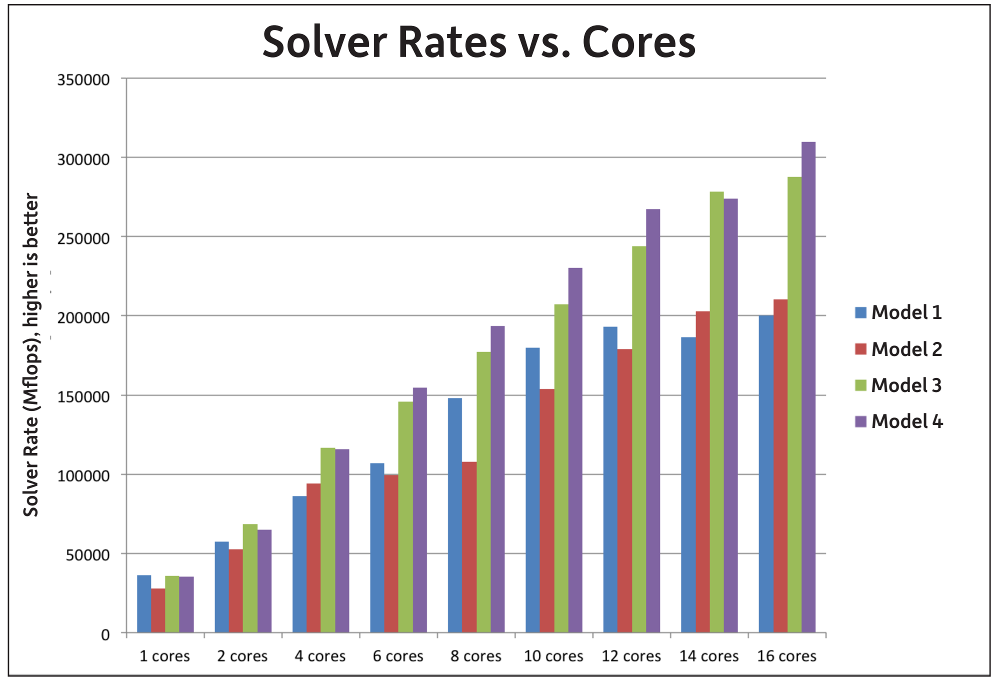
Greater Than the Sum of its Parts

However, the combination of the latest Dell Precision workstation model with Mechanical 16.0 had the most significant impact, according to the benchmark, boosting simulation performance by up to 4.1x over what is possible on a three-year-old hardware-software platform with a similar number of cores. For example, the transient nonlinear structural analysis simulation on an electronic ball grid array (Model 4 to the left) ran 1.5x faster on the Dell Precision 7910 with the older Mechanical 13.0, 1.7x faster on older hardware with Mechanical 16.0, and 4.1x faster when deployed on the latest Dell Precision hardware and the most current ANSYS version when using eight cores.

When tested on the modern Dell Precision workstation and allowed to use all 16 cores, the benchmark showed the current version of ANSYS Mechanical was more than 6X faster than the older, 8-core machine.

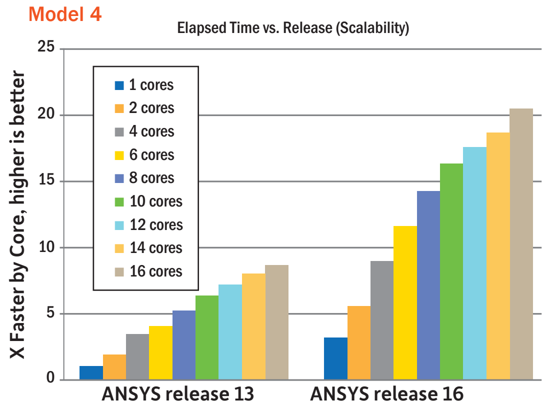
Comparison of three-year-old software and hardware to modern equivalents based on an identical number of computer cores





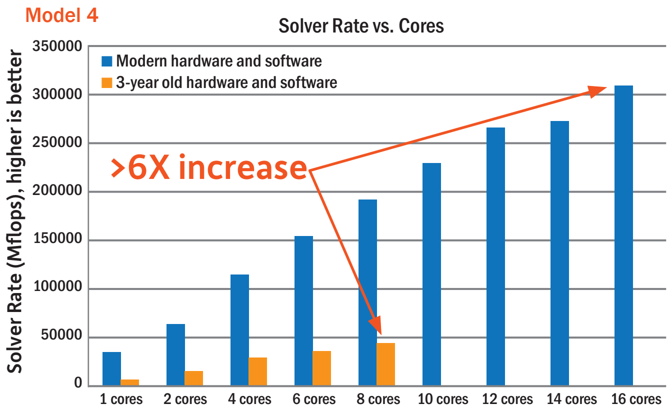
ANSYS release 16 has the ability to leverage additional cores, which enabled it to run the benchmarking models faster than ANSYS release 13.

Modern vs. 3-year old (same hardware)



Both ANSYS release 13 and ANSYS Mechanical Release 16 scale to take advantage of more cores, but ANSYS release 16 does so more effectively.

Modern vs. 3-year old (hardware and software)



Combining the latest version of ANSYS Mechanical with a modern 16-core Dell Precision workstation increased simulation performance on one model by more than 6X compared to the three-year-old hardware and software.

3 Paths To Faster Simulations Using ANSYS Mechanical 16.0 and Intel Architecture

INCREMENTAL PERFORMANCE GAINS for simulation can do wonders to improve productivity and shrink product development windows, but imagine the possibilities for design workflow transformation when simulation performance is tripled.

Today, those gains are possible thanks to a collaborative effort between ANSYS, Dell and Intel to deliver up to 3.2x higher performance for simulations by optimizing ANSYS Mechanical 16.0 for the multi-core Intel Xeon processor E5 v3 family and the many-core Intel Xeon Phi coprocessor. While companies can expect the highest performance gains by a full hardware and software upgrade, they can also achieve compelling gains through the following Xeon upgrade strategies:

1 Add one or more Intel Xeon Phi coprocessors to an existing Dell Precision system: This approach delivers substantial performance gains with minimal hardware changes and one additional HPC software license for each Phi coprocessor.
Proof Point: ANSYS Mechanical simulation running on four cores plus a single Intel Xeon Phi coprocessor 7120 delivers up to 2.6X the performance of the same simulation running on only four cores.

2 Migrate to a new Intel Xeon processor E5 v3-based Dell Precision workstation: Replacing a system is more expensive, but licensing costs won't change if simulations continue to run on the same number of processor cores.
Proof Point: This upgrade can deliver up to 1.6x the performance of typical three-year old systems based on the Intel Xeon processor E5 family.

3 Migrate to a new Dell Precision system and add a coprocessor: Clearly more expensive, but with the highest potential gains for ANSYS mechanical simulations.
Proof Point: Upgrading from a system using a previous-generation Sandy Bridge E5 processor to a new system based on the Haswell E5 v3 processor and adding a single Intel Xeon Phi coprocessor 7120 can increase ANSYS Mechanical performance by a factor of up to 3.2x.

Real-World Benefits of Faster Simulation

47% of respondents say a primary benefit of simulation is producing higher quality products than competitors.

Faster simulation encourages more widespread use of the practice throughout the entire design cycle. As a result, engineering organizations can achieve more iterative workflows, enhancing their ability to explore a greater number of design alternatives while offering a much better chance of zeroing in on the optimal designs.

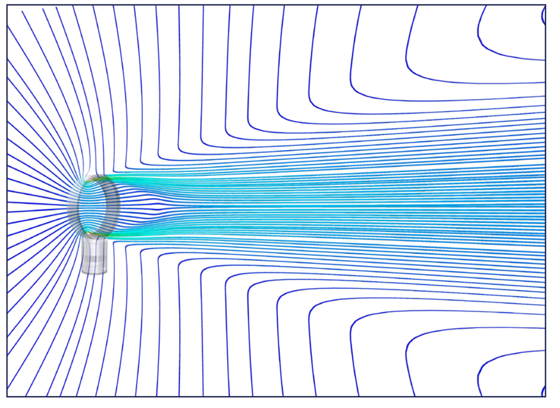
Used consistently, faster simulation can help organizations find potential design problems early on when it is far easier and less expensive to make changes and the practice also ensures quality issues are hammered out early during the design phase — not when the product is in the hands of the customer and it is more difficult to make changes out in the field. Another big win for simulation-driven product development: It dramatically reduces companies' reliance on physical prototypes, which cuts costs while also serving to shrink protracted development cycles.

These wins can translate into huge business advantages from both a revenue and competitive standpoint. Producing higher quality products that are unique and a grade above competitive offerings is one of the primary benefits of simulation and one raised by nearly half (47%) of respondents to the simulation survey.

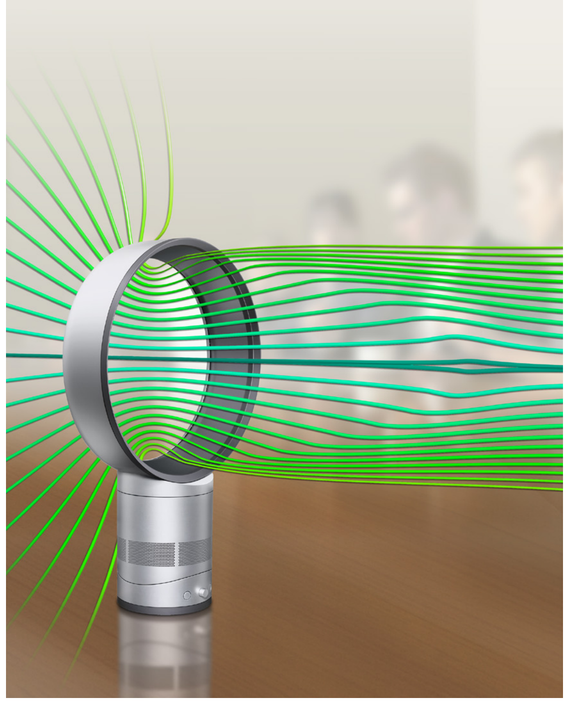
Higher Quality Products

Dyson, a recognized leader in high-performance household appliances, attributes widespread use of computational fluid dynamics (CFD) simulation to the success of its Dyson Air Multiplier. The fan is lauded as much for its unique styling as its innovative design that eliminates the need for external blades. Dyson engineers were challenged to create an optimal design for a new fan without the benefit of a previous foundation. Starting from scratch was tricky. The team needed an accurate and efficient way to iterate concepts to home in on the optimal design while meeting aggressive cost and time constraints.

In lieu of using physical prototypes to prove out designs, the team turned to ANSYS Fluent CFD software to expedite the process and evaluate more possibilities in a virtual world. Instead of taking up to two weeks to evaluate each prospective design with rapid prototyping techniques, Dyson engineers simulated fluid flow to gain



Air is initially drawn in through the base of the Dyson Air Multiplier and is injected through the annular slot, inducing more flow from the surrounding air.



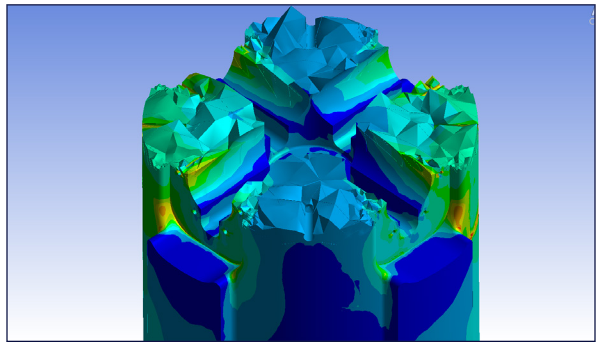
Dyson investigated 200 different design iterations using simulation, which was 10 times the number that would have been possible if physical prototyping had been the primary design tool.

an understanding of the basic design while enabling subsequent iterations that vastly accelerated the process of making design changes. With the CFD-led approach, the team was able to steadily improve the performance of the fan to the point where the final design had an amplification ratio of 15 to one (a metric depicting the amount of air possible for a given size and power consumption), which was a 2.5-fold improvement over the original concept. To get there, Dyson engineers were able to investigate 200 different design iterations using simulation — 10 times the number they would have be able to explore with physical prototyping as the primary design tool.

Faster Design Cycles

Beyond improving the ability to innovate, simulation has also proved to be clutch for shrinking design cycles — a benefit cited by 38% of respondents to the simulation survey. Like Dyson, which significantly compressed its time-to-market cycle for the bladeless fan, Cognity Limited, an engineering consulting firm, was able to leverage simulation to turbocharge the design of the first steerable conductor to enhance oil recovery for offshore drilling rigs.

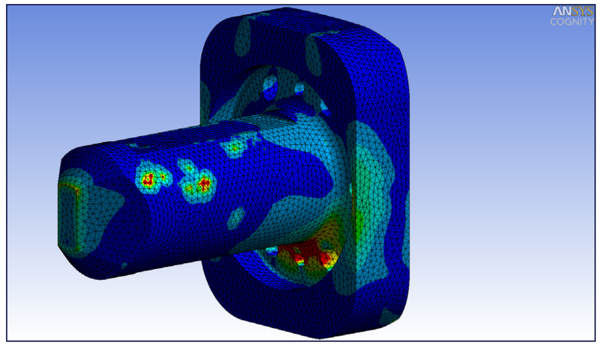
Conductors help maximize field production when drilling, but they have to be positioned accurately — a challenge when dealing with variable soil conditions.



Stress analysis of the hydraulic deflection housing (HDH) helped Cognity engineers double system capacity by optimizing design.

The Cognity team was able to double the load-carrying capacity of the steering mechanism, aided by ANSYS Mechanical simulation software. The change made it easier to manipulate in deep soils and aided in increasing oil production and reducing drilling costs.

Instead of building numerous full-scale prototypes, each tested to failure, Cognity engineers used ANSYS Mechanical simulation software to develop virtual prototypes, evaluating each alternative for design performance. The traditional physical prototyping approach is a very expensive, time-consuming process. In comparison, the team was able to leverage ANSYS simulation software to come up



Stresses on radial locking pads that hold the HDH in place. Engineers optimized the shape of the HDH through an iterative process.

with the steerable conductor design in five months, which is months, perhaps even years less than what would have been possible using traditional design methods.

In addition, simulation played a role in driving cost efficiencies for the conductor design. The original model employed custom hydraulic cylinders that cost about $160,000 each and required four months for delivery. Using simulation, the team was able to prove that off-the-shelf hydraulics could replace the custom components, resulting in substantial time and cost savings. The off-the-shelf hydraulics cost $7,000 each and could be delivered in one month — a design change that helped fuel the 70% time reduction for the project compared to conventional design techniques.

Simulation — and more specifically, faster simulation driven by HPC resources — was instrumental in helping Metso Minerals Oy design a new version of its jaw crusher (a machine that crunches large rocks into gravel) that was higher capacity, but not heavier, in a substantially shorter time frame. Using a combination of ANSYS SpaceClaim and ANSYS Mechanical for simulation, the Metso team created the C130 jaw crusher design that could handle a capacity of 270 metric tons per hour with the same weight as its predecessor, which could only process 245 metric tons per hour.

HPC resources allowed the team to explore a wider range of design alternatives in a shorter time period. Given the geometrical complexity of the jaw crushers, it previously took nearly 21 hours on a dual-core machine to solve a typical moving jaw non-linear model with 7 million degrees of freedom and 1.5 million elements. Using ANSYS simulation software on an HPC platform configured with two Intel 10-core processors, 192GB RAM and a pair of NVIDIA Tesla GPUs, the team was able to solve each model in only 78 minutes — amounting to up as much as a 16 times faster turnaround time than with previous simulations.

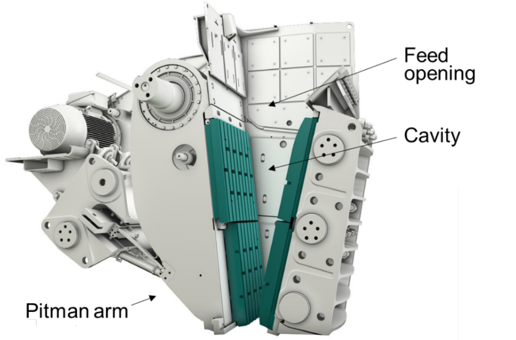
New Design Workflows

The Emirates Team New Zealand also increased their design turnaround times, but in the process it also revolutionized how it designs boats for the America's Cup yacht race. To stay competitive, the team needed to design a new class of multihull boat, which led them to partner with Dell to deploy an HPC cluster running the Platform HPC stack Enterprise Dell Edition featuring Dell PowerEdge servers connected to Dell EqualLogic storage through Dell Networking switches.

The HPC solution enabled the team to reduce their dependency on physical tank testing, in which scale models of individual hulls were tested as a predictor of actual race day performance. That required a three-month cycle with around four tank sessions scheduled per year, each testing five to six new boat designs. With HPC and an increased use of ANSYS CFD solutions, all of the team's prototyping is computer generated.

"We can now complete an entire boat design test in three days using the Dell HPC cluster," said Nick Holroyd, Technical Director, Emirates Team New Zealand. "We've gone from 30 to 40 design candidates being tested physically for our 2007 Cup campaign to testing 300-400 designs for this edition of the America's Cup."

Doing that many iterations led to the need for design engineers to collaborate more closely with sailors and other non-technical team members. Their digital design process, powered by HPC, enables the team to share simulation visualizations and CAD models that include the performance characteristics of each design.



In Metso Nordberg C series jaw crushers, incoming material is crushed between the jaw crusher's fixed movable die plates through advancing and retreating motions of the jaw crusher's Pitman arm. ANSYS tools enabled Metso to design a higher capacity — but not heavier — jaw crusher while reducing design iteration time by 94%.

The Dell Precision Tower 7910 Workstation

THE CURRENT GENERATION of Dell Precision workstations includes the Tower 7910, which features a new generation of dual-socket performance with the Intel® Xeon® Processor E5-2600 v3 processor series featuring up to 18 cores per processor, the latest NVIDIA® Quadro® and AMD FirePro™ graphics and up to 1TB of system memory using the latest DDR4 RDIMM memory technology.

On the storage front, the Dell Tower 7910 has an actively-cooled PCIe solid-state drive, which is up to 180% faster than traditional SATA SSD storage. Traditional hard drive options are also available, and 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 Precision Tower 7910 comes with an integrated 12 Gb/s RAID Controller, doubling the I/O speed of the company's previous generation Workstation.

All Dell Precision workstations are independent software vendor-certified to ensure the most popular engineering design applications, including ANSYS, run smoothly. Also free with Dell Precision workstations, the Dell Precision Optimizer automatically tunes the workstation to run specific programs at the fastest speeds possible, enhancing productivity.

The Dell Precision Tower 7910 also features endpoint security solutions that include encryption, advanced authentication and malware protection from a single source. Dell.com/precision

More Reliable Products

Emirates Team New Zealand (right) was only able to physically test 30 to 40 design candidates for the 2007 America's Cup campaign, but now simulation allows them to test 300 to 400 designs.

The ability to achieve faster turnaround time on simulation plays an equally important role in increasing product reliability. Thirty-five percent of simulation survey respondents cited the production of more reliable products that could result in lower warranty-related costs as a goal — one they believed to be a primary benefit of simulation.

Simulation helps address this challenge by delivering a systematic way of quickly validating, modifying and discarding new product ideas based on their likely performance in a way that would be impossible with physical prototyping. With simulation, engineering teams can mitigate the risk of encountering quality problems (and the resulting high warranty costs) down the pike. Simulation allows engineers to consider the widest possible range of materials properties, manufacturing processes and real-world operating conditions as they optimize designs at the earliest stages. With simulation software running on high-performance Dell Precision workstations, engineering teams are unencumbered by constraints that limit design studies, and instead can conduct robust multiphysics simulations that consider many sources of variation and uncertainty, leading to the optimal design with the least amount of risk. ●

HPC on the Cloud

AS PRODUCTS GROW MORE COMPLEX, many engineering organizations want the horsepower to run larger and more detailed simulations without the expense of building, provisioning and maintaining data centers.

"Using the cloud for simulation presents unique challenges with different solution types required for specific use-cases," says Wim Slagter, Lead Product Manager, ANSYS Inc. "We are developing a set of best-practice solutions to address these challenges."

The ANSYS Enterprise Cloud provides an end-to-end simulation platform within a dedicated corporate account on the public cloud. Using the ANSYS Cloud Gateway portal and ANSYS engineered reference architecture, the Enterprise Cloud solution can be managed by either internal IT experts or by a service partner, Slagter says. This single-tenant solution offers a virtual-private cloud for enterprise simulation.

In addition, ANSYS has developed an ecosystem of cloud-hosting partners who provide HPC infrastructure and IT services to companies for burst or steady-state extension of in-house computing capacity.

And, ANSYS also supports the use of ANSYS products in a corporate private cloud, provided that these solutions are architected using component technologies (such as operating systems, VMs, and job schedulers) that are certified by ANSYS. The ANSYS Engineering Knowledge Manager software provides an integrated job and data management portal that can dramatically improve engineering productivity for these private cloud deployments.

"When it comes to cloud adoption, there is no one-size-fits-all model – any approach has upsides and downsides and you need to pick the approach that's the right fit for your business," writes Adeel Omer, Global Cloud Solutions Marketing Lead, Dell Inc. But there are some basic steps to evaluating your options, according to Omer. These are:

1. Ensuring strategic cloud adoption is grounded in business objectives.
2. Making sure cloud is subject to IT governance.
3. Confirming that all aspects of your cloud are committed to flexibility.
4. Ensuring that your cloud is future-ready.

Learn more: https://goo.gl/SCKDvt

Taking the Next Steps

While companies don't need to be sold on the powers of simulation, they are often derailed by misconceptions about what's required to run the tools effectively along with an inability to sufficiently champion efforts to get management onboard. Nearly 80% of respondents to the simulation survey cited lack of access to powerful enough hardware to perform simulation in a reasonable timeframe as a barrier to introducing simulation in a broader capacity throughout their organizations. Yet many have not made the case for more robust efforts due to reservations about the cost and complexity of hardware they believe is necessary to get simulation work done.

For example, many companies associate HPC horsepower with high-end, incredibly expensive supercomputers, which is just not the case anymore. Today's high-end Dell Precision workstations and clusters configured with multiple, multi-core processors, sophisticated graphics accelerators, SSDs and ample high-speed memory are powerful enough to run complex multiphysics simulations fast and are far more affordable than "big iron," even for small- and mid-sized companies. In addition, streamlined cluster management platforms, user-friendly workload schedulers and turn-key HPC appliances preconfigured and optimized for leading simulation suites like ANSYS eliminate most of the complexity of traditional HPC environments. It's feasible for organizations to deploy, manage and configure clusters without dedicated HPC experts and with limited handholding from IT.

As HPC and workstation technology come down in price, there is a strong argument that an investment in the technology will quickly pay for itself by supporting faster simulations and in-depth design iterations that will inevitably lead to better and more innovative products. While calculating a return on investment (ROI) is very important to more than half (53%) of simulation survey respondents, many don't know how to effectively build a case for the technology beyond an analysis of base upfront expenses such as simulation software licenses, HPC hardware and training.

68% of survey respondents said a management sponsor was essential to the success of simulation design practices.

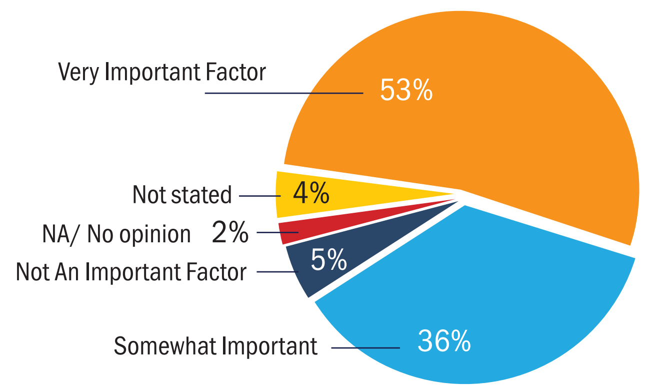
In fact, there are many other factors to consider when calculating ROI for a simulation effort. Among them: improved time to market, which can be reduced by months or even years with effective simulation; drastic reductions in physical testing, which saves costs and helps with time to market; improved design optimization for getting to the best design with less time wasted on bad candidates; improved accuracy, which prevents costly over-engineering; and a reduction in the number of product failures saving companies exponentially on repair costs and warranty expenses.

To help demonstrate simulation's ROI and build a case for an investment in the optimal hardware and software resources, engineering groups need to align with a key leader who can champion the benefits of a simulation-driven design in a language that resonates with top management. In fact, 68% of survey respondents said a management sponsor was essential to the success of simulation design practices and for demonstrating clear ROI in order to ensure proper funding.

To properly engage potential sponsors, engineers need to present the results of their analyses in the context of how it fosters the business. For example, in addition to showing the details of the actual simulation, showcase how a specific set of parameter studies performed in a certain timeframe helped reduce the need for physical prototypes that cost more and would have taken longer.

By focusing on specific ROI data, companies can effectively demonstrate that an investment in the proper hardware and software to support fast and effective simulation is not a luxury. Rather, in today's age of global competition and mounting product complexity, simulation is an asset that has real and lasting value for the business. ●

Producing an accurate ROI analysis that shows with "no brainer" clarity what our organization could gain by investing in new simulation software, hardware, training and new processes.



Appendix

Save Money & Maximize Performance with ANSYS Mechanical 16.0 on Intel Platforms
ANSYS.com/Campaigns/intel-phi4fea

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

Dell Precision Workstations
Dell.com/Precision

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