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.
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 However, many organizations aren't realizing the full benefits of simulation, in part because outdated workstation hardware and software is still too prevalent among engineering teams.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.

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.
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, 55% 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 amounts 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 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.

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.

The Benchmarking Study

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 updated hardware, software upgrades — and more importantly, the combination of the two — 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

<table>
<thead>
<tr>
<th>Statement that best fits most frequent computing usage scenario for running engineering simulation applications</th>
<th>Solutions that could best reduce the turnaround time limitations effecting your simulation models and outcomes*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am running exclusively on a remote HPC datacenter, but do pre and post processing work on my local workstation/PC</td>
<td>I am running exclusively on my workstation</td>
</tr>
<tr>
<td>18%</td>
<td>45%</td>
</tr>
<tr>
<td>I am running mostly on a remote HPC datacenter, but do pre and post processing work on my local workstation/PC</td>
<td>I am running on my workstation/PC and a local or departmental server cluster</td>
</tr>
<tr>
<td>5%</td>
<td>23%</td>
</tr>
<tr>
<td>Other</td>
<td>I am running on my workstation</td>
</tr>
</tbody>
</table>

* 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%.

**Processor**
- Dell Precision T3500 workstation (3 years old)
  - Dual Intel Xeon X5672, running at 3.2GHz
- Modern Dell Precision Tower 7910 workstation
  - Dual Intel Xeon E5-2667 v3, running at 3.2GHz

**Cores**
- 8
- 16

**RAM**
- 128GB
- 256GB

**Storage**
- 2X558.37GB 1500RPM SAS (RAID 0)
- 128GB SSD

**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

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.

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

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.
Real-World Benefits of Faster Simulation

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.

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

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 3x-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 from 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 T210 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 hardware and adding a single Intel Xeon Phi coprocessor T210 can increase ANSYS Mechanical performance by a factor of up to 3x.

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 have 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 ANSYS simulation software to come up 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 crushes 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 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 Americas’ 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 Plat- form 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.
More Reliable Products

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 BECOME MORE COMPLEX, many engineering organizations want the horsepower to run larger and more detailed simulations, but they don’t want 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. ANSYS is developing a set of best-practice solutions to address these challenges.

The ANSYS Enterprise Cloud provides a turn-key simulation platform within a dedicated corporate account on the public cloud. Powered by 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. This single-tenant solution, delivered today on the Amazon Web Service (AWS) global platform, offers secure storage and data management.

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 (both at 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.

Taking the Next Steps

While companies don't need to be sold on the powers of simulation, they are often deterred 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 workstations 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.

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.

Taking the Next Steps
Appendix

Debunking 6 Myths of High-Performance Computing
ANSYS.com/hpc-myths

The Value of High-Performance Computing for Simulation
ANSYS.com/hpc-value

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

Dell Precision Engineering & Manufacturing Resources
Dell.com/CAD

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

Dell Precision Workstations
Dell.com/Precision

Dell High Performance Computing

Desktop Engineering
Deskeng.com/de/category/engineering-computing/

Making the Case for Professional Engineering Workstations
Deskeng.com/de/proworkstations

ANSYS, ANSYS Mechanical, ANSYS SpaceClaim, ANSYS Fluent and the ANSYS Logo are registered trademarks or trademarks of ANSYS, Inc.
Intel, Xeon, Intel Core and Intel Logo are registered trademarks or trademarks of Intel Corporation in the U.S. and/or other countries.
Dell, Dell Precision, PowerEdge, EqualLogic and Dell Logo are registered trademarks of Dell Inc.