



Performance Brief

Quad-Core

Intel/ESI Group Workstation

# Accelerating Virtual Product Design with Quad-Core Intel® Xeon® Processor-Based Workstations and ESI Group Software



Workstation supercomputers powered by the Quad-Core Intel® Xeon® processor 5300 series enable users of ESI Group simulation-based design and optimization solutions to dramatically enhance engineering productivity and deliver higher quality designs in less time, while improving the cost-effectiveness and flexibility of the high performance computing (HPC) infrastructure.

Built on next-generation Intel® Core™ microarchitecture and packing up to eight computational cores into a single system, these 64-bit systems deliver over 80 Gflops of performance and up to 64 GB of memory and performance is rising with each tick of the technology clock. These new systems truly earn the name workstation supercomputer.



# Executive Summary

## Enhancing Engineering Productivity and Leveraging HPC Resources with Quad-Core Intel® Xeon® Processor-based Workstation Supercomputers

*Today's workstation supercomputer powered by two Quad-Core Intel® Xeon® processor 5300 series and Intel® Core™ microarchitecture is vastly different from the workstations engineers may have at their desks.*

In aerospace, automotive, and other manufacturing industries, virtual product design solutions such as ESI Group's simulation-based engineering suite have become critical to maintaining a competitive edge. Yet as product designs grow more complex and deadlines grow tighter, manufacturers are increasingly challenged to optimize the combined HPC infrastructure and software application set in order to fully achieve the benefits of virtual engineering.

A new generation of workstations based on the Quad-Core Intel Xeon processor 5300 series delivers revolutionary performance for organizations running ESI Group's virtual product development suite. Built on next-generation Intel® Core™ microarchitecture and packing up to eight computational cores into a single system, these 64-bit systems deliver over 80 Gflops of performance and up to 64 GB of memory—and performance is rising with each tick of the technology clock. These new systems are earning the name *workstation supercomputers*.

Workstation supercomputers based on the Quad-Core Intel Xeon processor 5300 series can run existing applications significantly faster than the systems on most engineers' desks today. They offer additional throughput advantages by enabling engineers to work differently—to run more tasks in parallel and evolve from serial to simultaneous workflows. By deploying these workstations, manufacturers can increase design optimization, enhance innovation, accelerate time to market, and drive costs out of product design and manufacturing.

In addition, **these Intel®-based systems can be connected and virtualized to form workstation supercomputer clusters.** This can help further increase the individual engineer's productivity. It can also help improve the performance, flexibility, and cost-effectiveness of your high performance computing (HPC) infrastructure, and expand the computing resources available to run the largest HPC workloads. Vehicle manufacturers, for example, can more effectively optimize design and manufacturing, to generate quieter, safer, lighter, and more fuel-efficient cars and trucks.

This paper discusses working differently on Intel quad-core workstations. It also reports on work Intel and ESI Group have conducted to optimize and demonstrate the performance of ESI Group's virtual product development suite on workstation supercomputers powered by the Quad-Core Intel Xeon processor—including a proof of concept Intel and ESI Group conducted with a leading automobile manufacturer.

Our work shows nearly a **4X performance improvement** on PAM-CRASH<sup>1</sup>; ESI Group's flagship physics-based simulation software, when you cluster four workstation supercomputers with a total of 16 cores compared to the performance on two cores. The difference between native and virtual performance was minimal.

Earlier studies<sup>1</sup> showed that users could **improve total workflow throughput up to 2.7x** by moving from a serial to a simultaneous workflow on a workstation supercomputer with two Quad-Core Intel Xeon processor 5300 series.

### Performance Engine: Intel® Core™ Microarchitecture

Today's workstation supercomputer powered by two Quad-Core Intel Xeon processor 5300 series and new Intel Core microarchitecture is vastly different from the workstations your engineers may have their desks. Quad-Core Intel Xeon processor-based workstation supercomputers deliver on performance, price, and reliability—the three most important vectors demanded by manufacturing organizations today.

- **Energy-efficient performance.** The Quad-Core Intel Xeon processor 5300 series extends an already impressive performance leadership position for both workstations and servers. The Quad-Core Intel Xeon processor 5300 series gives up to 50 percent better performance than Dual-Core Intel Xeon processor 5100 series and over 4x the performance of single-core Intel Xeon processors within the same system power envelope.<sup>2</sup>

1. See <http://www.intel.com/performance/workstation/xeon/workflow.htm>.

2. Source: [www.spec.org](http://www.spec.org), January 30, 2007.

- **Price.** The Quad-Core Intel Xeon processor delivers outstanding performance per dollar, performance per watt, and performance per dollar spent on software licenses.
- **Reliability.** The Quad-Core Intel Xeon processor is based on a proven, established architecture to reduce risks. Its energy-efficient architecture reduces stresses and strain and improves chip reliability. Intel has sold **more than one million quad-core processors**, demonstrating proven, industry-tested and trusted technology.

Intel Core microarchitecture is at the heart of Intel quad-core performance, combining five key technologies to improve energy-efficient performance over previous-generation platforms. Under the hood of Intel Core microarchitecture are the following capabilities:

- **Intel® Wide Dynamic Execution** delivers more instructions per clock cycle and enhances the efficiency of instruction execution.
- **Intel® Advanced Digital Media Boost** enables 128-bit SSE instructions to be completed at a rate of one per clock cycle, effectively doubling these instructions' execution speed compared to previous generations.
- **Intel® Advanced Smart Cache** is a multi-core optimized cache which increases the probability that each execution core of a multi-core processor can access data.
- **Intel® Smart Memory Access** contains an important new built-in intelligence to processes out-of-order instructions more efficiently.
- **Intel® Intelligent Power Capability** improves energy efficient performance and reduces noise and energy consumption.

### Applying the Power: From Serial to Simultaneous

The Quad-Core Intel Xeon processor provides additional performance features, which include faster system buses, larger caches, expanded memory capacity and others, in addition to Intel Core microarchitecture. With over 80 Gflops of performance and up to 64 GB of memory, dual-processor workstations based on the Quad-Core Intel Xeon processor place eight compute cores or computational engines at the

disposal of the user and the organization. These resources not only provide exceptional performance on individual applications, but also can be virtualized to enable users to shift from today's serial workflows to a more flexible style of simultaneous workflows. Intel calls this *working differently*.

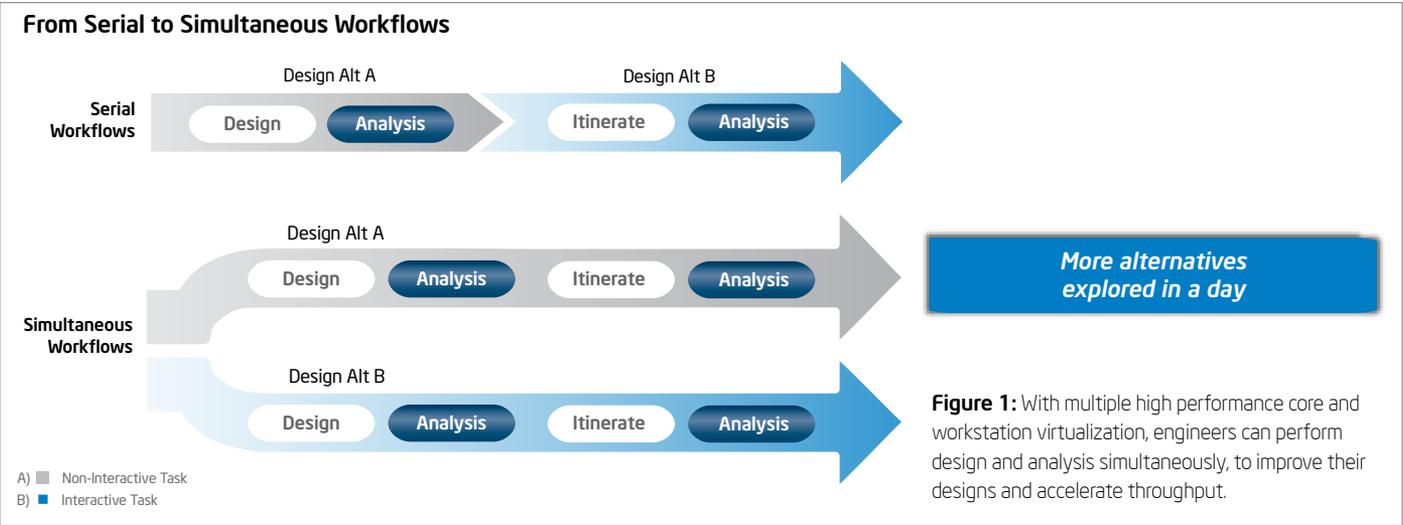
With an Intel-based workstation supercomputer, an engineer can run multiple applications and even multiple operating systems on his or her workstation simultaneously. Benchmarks show that users could increase their throughput by up to 2.7x. Working in this fashion, users can explore many variations of a design, including geometry, materials, and conditions, thus providing valuable feedback to the design team.

Figure 1 illustrates the shift from a serial workflow (design, then simulate), to a simultaneous workflow of concurrent design and simulation. Users can create models with more complex properties and process them locally, retaining a greater measure of personal control and interactivity, and accelerating workflow throughput.

### Clustering Workstation Resources to Improve Flexibility and Performance

Virtualization emerged as a compelling technology for server platforms, offering data center managers the ability to consolidate multiple workloads on one physical server system. Now, virtualization is helping end users make the most of their Intel quad-core workstation supercomputers. Workstations with breakthrough Intel® Virtualization Technology (Intel® VT)<sup>3</sup> (the industry's first hardware-assisted virtualization technology) help enable users and organizations to virtualize workstations, capturing their resources and creating a powerful supercomputer cluster.

Intel VT provides a set of processor enhancements that improve traditional software-based virtualization solutions. These integrated features give virtualization software the ability to offload some of its work to the system hardware, enabling more streamlined virtualization software stacks and "near native" performance.



**Figure 1:** With multiple high performance core and workstation virtualization, engineers can perform design and analysis simultaneously, to improve their designs and accelerate throughput.

3. Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM) and, for some uses, certain platform software enabled for it. Functionality, performance or other benefits will vary depending on hardware and software configurations and may require a BIOS update. Software applications may not be compatible with all operating systems. Please check with your application vendor.

*Use the performance advantages of Intel® based workstation supercomputer clusters to deliver more work in less time.*

Virtualization solutions enhanced by Intel® VT allow a single Intel-based workstation to function as multiple “virtual” systems, running multiple operating systems and applications as independent virtual machines. In this way, a single workstation supercomputer can deliver both interactive and large-scale simulation processing.

This dramatically expands the flexibility of the HPC environment. During the day, workstations are first and foremost an interactive tool that enables engineers to visualize and interact with models and use productivity tools such as processors, presentation packages, and spreadsheets. But in many instances, the high performance of an eight-core workstation supercomputer means that organizations can capture idle resources and use them for large-scale jobs—to solve large virtual prototyping simulations without impacting the system’s responsiveness to the end user.

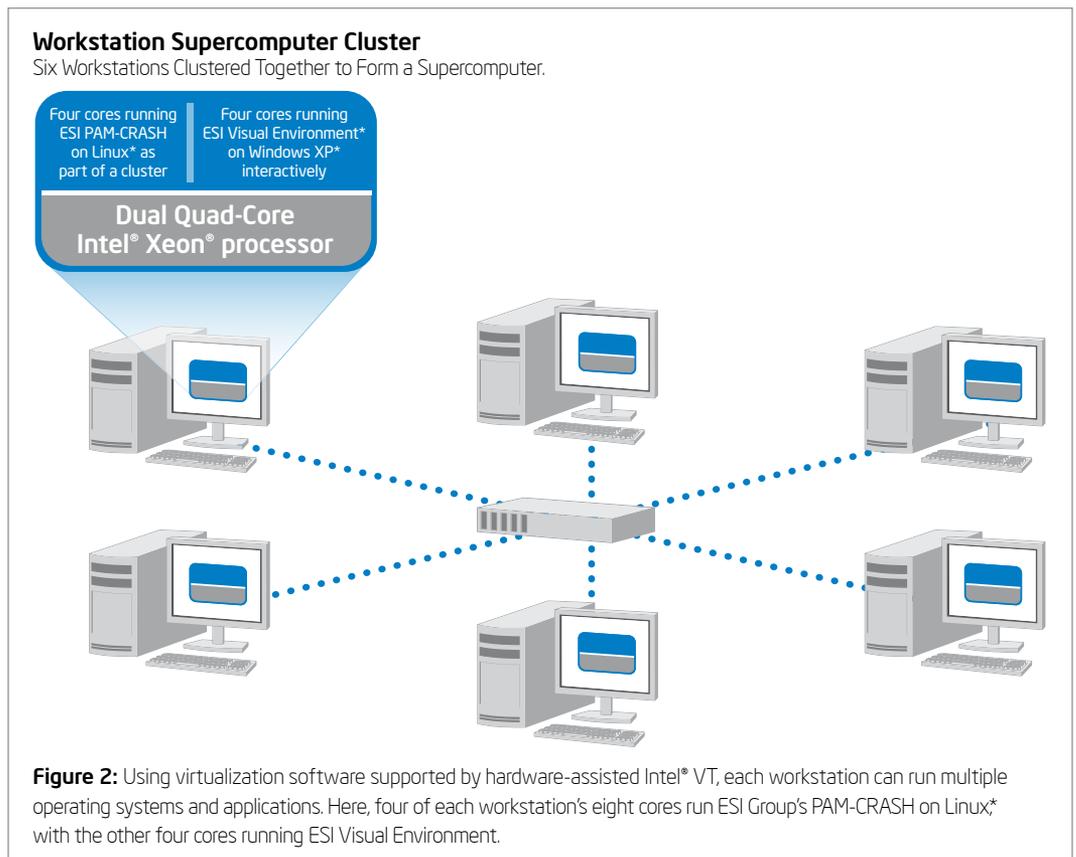
Whether during peak or off-shift hours, all workstation resources can be virtualized and dedicated to running the most demanding workloads and solving even the largest problems, such as a full scale car crash simulation of hundreds of thousands of elements. The result is performance where you need it, day and night. Performance scales and you can optimize your investment in workstations, clustered workstation

supercomputers and server clusters—to maximize the throughput of expanding workloads and reduce total cost of ownership.

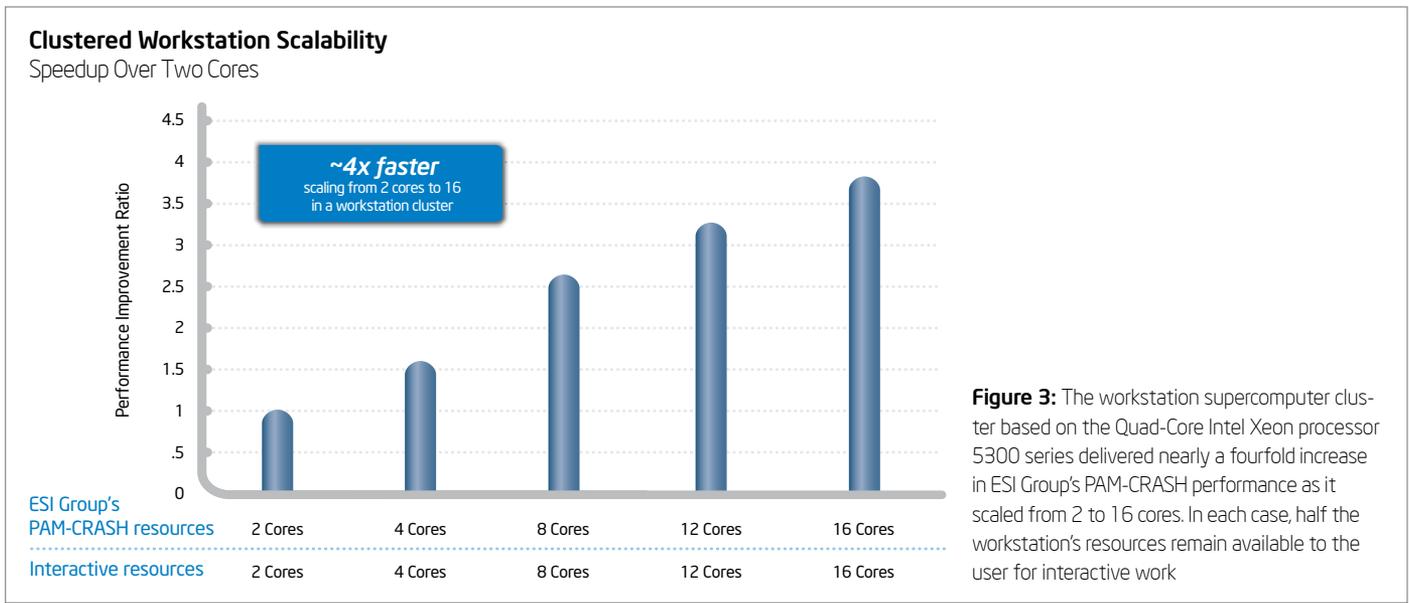
These capabilities can be particularly valuable in providing extra flexibility for exploring new simulation methodologies such as optimization loops that call for intensive compute resources. For example, the resources of clustered workstation supercomputers can accelerate design-of-experiments (DOE) workloads that may need to run thousands of simultaneous jobs in order to iterate and validate changing design parameters, and thereby optimize simulation-based design.

### Enhancing Virtual Product Development, Enhancing the Data Center

Clustered workstation supercomputers can help ensure that power users have access to large, robust tools for individual investigation, as well scalable tools that enable fast, efficient solution time for large-scale runs of software such as ESI Group’s PAM-CRASH. IT managers can configure one workstation build that can function independently as both a workstation and an HPC resource, keeping software loads and resource requirements separate and running different operating systems and software for different tasks.



**Figure 2:** Using virtualization software supported by hardware-assisted Intel® VT, each workstation can run multiple operating systems and applications. Here, four of each workstation’s eight cores run ESI Group’s PAM-CRASH on Linux;\* with the other four cores running ESI Visual Environment.



Tests were performed June 2007 at ESI facilities by Intel and ESI engineers. Workstation cluster had 4 Quad-Core Intel Xeon processor 5345, with workstations connected via 1 GB Ethernet using Intel MPI Library 3.0 for Linux.\* For additional configuration details, see Table 1.

Using the performance of an eight-core workstation supercomputer, engineers can elect to:

- Iterate faster through smaller coarse-grain solutions. They can rapidly test their hypothesis within their own resource and not wait on remote systems to queue up and process their assumptions only to learn that the results were not what they expected. Once they have refined and tested locally, they can then process fine-grain solutions on the larger resources of a workstation supercomputer cluster or traditional cluster. The result is that users can iterate faster through assumptions and develop more refined larger models in less time.
- Test larger hypotheses on clusters of workstation supercomputers. This solution not only provides individual users with the power they need to help iterate through designs faster. It also helps enable corporations to optimize asset utilization by ensuring a stream of jobs is being processed 24x7x365. No available cycle is left idle as users can quickly submit, schedule, and monitor CAE simulations to a cluster with little or no administrative intervention. Products like Platform Computing's Platform LSF\* CAE Edition offer pre-integrated solutions that ease the use of this new breed of clusters with widely used CAE software solution providers such as ESI Group for crash, durability, and fluid dynamics.

As a result, you can supply your engineers with computational and visualization tools that help accelerate their insight, start your investigations sooner and arrive at higher quality decisions in less time. Engineers using the ESI Group suite of products can digitally validate total product functionality at speeds they only dreamed of. That means fewer physical prototypes and a significantly more agile and less costly product development schedule. Engineers can run significantly more simulations and solve large numerical simulations, assisting them to have a better understanding of system dynamics and more optimized system

design. They can perform "what if" analysis faster and use simulation-based design to help them arrive at higher quality designs and products in less time than ever before, without relying on costly, dedicated HPC grid infrastructure.

### Putting Performance to the Test

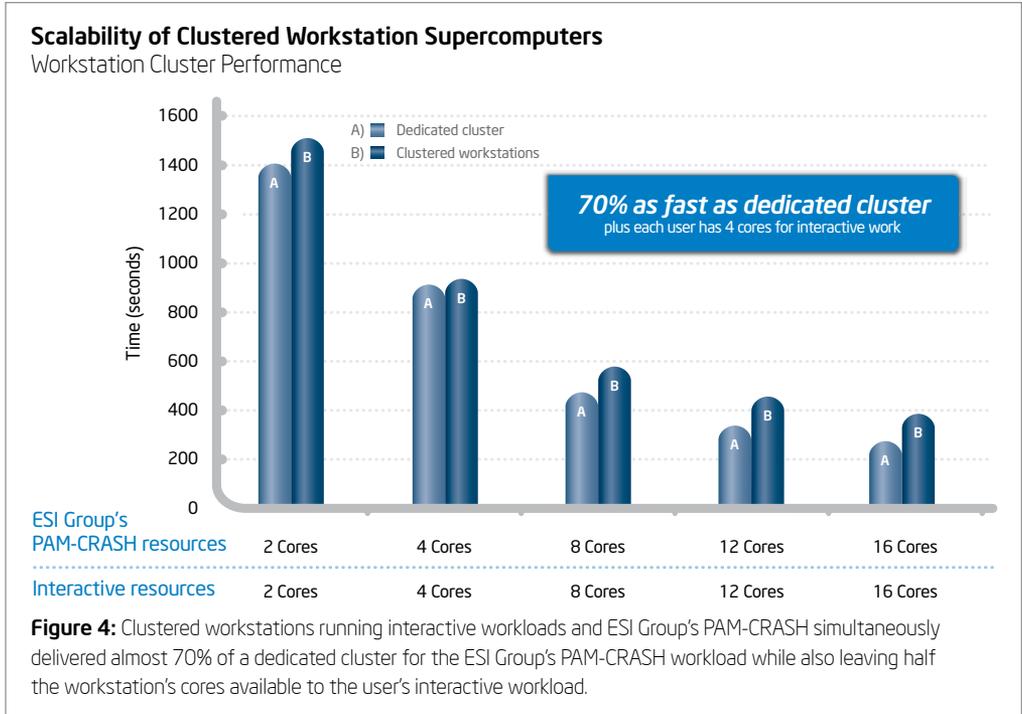
Figures 3 and 4 summarize results from tests in which ESI Group and Intel collaborated with a leading auto manufacturer to expose the ability to use the performance advantages of Intel-based workstation supercomputer clusters to deliver more work in less time. For these tests, we focused on ESI Group's PAM-CRASH and ESI Group's Visual Environment,\* an open collaborative engineering framework.

ESI Group PAM-CRASH jobs can be submitted to Platform Computing's Platform LSF family of virtualization software solutions. These simulations can run in batch mode on workstation supercomputers and are run as soon as resources become available. LSF dynamically selects the computers, starts the tasks, and keeps full control of the distributed job. LSF can also periodically save a checkpoint file of an ESI Group PAM-CRASH job so that, in case of machine failure, the job can be automatically restarted from its last checkpoint, minimizing lost computations.

We ran Visual Environment 3.5 locally on four workstation cores and ESI Group PAM-CRASH V2006 on the other four cores as part of a workstation cluster. Table 1 describes the workstation configurations and Figure 3 summarizes performance scaling across a workstation supercomputer cluster with four Quad-Core Intel Xeon processor 5345 series (a total of 32 cores) running ESI Group PAM-CRASH on half of each workstation's cores.<sup>4</sup> Workstations were connected via 1 GB Ethernet using Intel® MPI Library 3.0 for Linux. This workload scaled to **deliver nearly a fourfold performance increase** in ESI Group PAM-CRASH performance compared to performance on two cores.

4. The 2-core performance was on a workstation with dual Quad-Core Intel® Xeon® processor 5345.

Clustered workstation supercomputers give power users access to large, robust tools for individual investigation, as well scalable tools that enable fast, efficient solution time for large-scale runs of software such as ESI Group's PAM-CRASH.



Tests were performed June 2007 at ESI facilities by Intel and ESI engineers. Workstation cluster had 4 Quad-Core Intel Xeon processor 5345, with workstations connected via 1 GB Ethernet using Intel MPI Library 3.0 for Linux.\* For additional configuration details, see Table 1.

Figure 4 demonstrates that when half the available cores on the workstation supercomputer are allocated to the clustered workload, **the delivered performance is almost 70% of a dedicated cluster** and each user still has interactive access to half the workstation's cores. The end user still has a powerful workstation that can be used to quickly iterate through moderate sized jobs or to run check-runs to validate the investigation will yield expected results.

### Collaborating to Enhance Virtual Product Development

Intel and ESI Group have collaborated to deliver high performance virtual product development for simulation-based design and optimization environments. Our collective focus on performance and the use of Intel® software tools such as Intel® VTune™ performance analyzer and Intel® compilers to maxi-

mize threaded application performance deliver more usable power and performance to end users. Our joint work enables the power of ESI Group's PAM-CRASH and other software suites from ESI Group to effectively and efficiently harness the power and performance of both parallel and distributed computing systems.

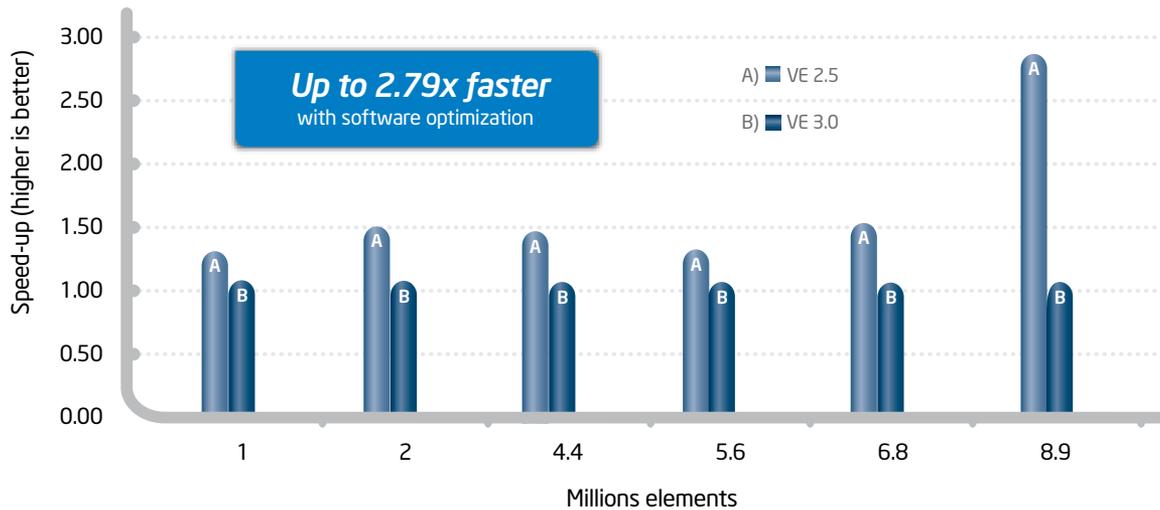
This collaboration has initiated a new approach in the way companies can address virtual engineering and take further benefits from engineering software and HPC infrastructure. To substantiate this shift, Intel and ESI Group continue working closely together to leverage Intel Virtualization Technology with ESI Group simulation software suite. Our combined efforts aim to reduce overall total cost of IT ownership, unlock idle resources and open new possibilities in virtual engineering methodology. See Figure 5 for an example.

**Table 1: Partitioning the Workstation to Run Visual Environment Locally and ESI Group's PAM-CRASH Clustered**

	ESI Group's PAM-CRASH* Cluster Resources per Workstation	Local Visual Environment* Resources	Total Cluster Resources for ESI Group's PAM-CRASH
Disk Space	100 GB	60 GB	400 GB
RAM	4 GB	8 GB	16 GB
Number of Cores	4	4	16
Operating System	Red Hat Enterprise Linux* Using VMware*	Microsoft Windows XP Pro* 64-bit native	
I/O	Windows XP Pro	Windows XP Pro	

### Collaborating to Optimize Performance

Speed-up of Visual Environment loading time on the Dual-Core Intel® Xeon® Processor 5100 Series



**Figure 5:** Intel and ESI Group collaborate to improve performance of ESI Group solutions on Intel-based multi-core workstations. In this example, they improved data processing time up to 2.79 times faster for huge crash models (10 million elements) moving Visual Environment 2.5 to VE 3.0 on a Dual-Core Intel® Xeon® processor 5100 series.

Tests performed March/April 2007 by Intel and ESI Group engineers at the ESI Group lab in France on a Bensley platform with two Dual-Core Intel® Xeon® processor 5160 (3.00 GHz) and 8 GB memor.

### Conclusions

Virtual product development and simulation just got easier. ESI Group's software suite powered by the Quad-Core Intel Xeon processor is built to match the demands of challenging virtual prototyping environments. With outstanding performance and flexibility, including the ability to dynamically provision ESI Group applications and other software across shared global infrastructure of high powered workstation supercomputers, **Quad-Core Intel Xeon processor-based workstation supercomputers help enable you to reach better decisions faster.**

Individual workstation supercomputers powered by the Quad-Core Intel Xeon processor help enable ESI Group users to iterate through more what ifs and test large-scale jobs before submitting them to either a cluster of workstation supercomputers or a dedicated high performance cluster.

As problems scale in size and you require clustered systems to perform computing-intensive tasks, clustered workstations represent a new way to not only help provide appropriate resources to users testing and validating moderate to large models on their workstation supercomputer, but to also enable organizations to combine these workstation into larger configurations capable of solving the very largest problems. This approach also provides the organization with easy to access idle cycles and **helps increase individual workstation usage from 10-12 hours up to 24x7x365.**

Clustered workstations offer organizations innovative and cost-effective ways to create HPC systems. By utilizing the workstations' idle and off-shift resources, you can supplement existing HPC resources while giving

workstation end users a huge increase in performance, responsiveness, and interactivity. The result is a platform that helps **improve resource utilization, and helps enhance the cost-effectiveness and flexibility of the HPC infrastructure.** Clusters of workstation supercomputers can also help cost-effectively relieve power and floor space constraints faced by many manufacturing data centers.

These workstations and clusters help engineers to:

- Quickly and efficiently process numerical simulation of prototype and manufacturing process engineering in applied mechanics, to investigate larger problems faster.
- Experiment quickly and ultimately be more productive and creative, delivering higher quality results in less time.
- Streamline and accelerate the work of building, testing validating, refining, and automating functional virtual prototypes at optimal speeds.
- Run significantly more simulations and solve larger numerical simulations, to develop deeper understanding of system dynamics and more optimized product designs.

Talk to Intel and ESI Group today to learn more about how ESI Group virtual product development solutions running on Intel-based Quad-Core workstation supercomputers can not only help provide users with more individual power, but also, when clustered together via standards-based technology, help deliver nearly the performance of dedicated high performance clusters.



[www.intel.com](http://www.intel.com)

[www.esi-group.com](http://www.esi-group.com)

## About ESI Group

ESI Group is a world-leading supplier, and a pioneer of digital simulation software for prototyping and manufacturing processes that take into account the physics of materials. ESI Group has developed an extensive suite of coherent, industry-oriented applications to realistically simulate a product's behavior during testing, to fine-tune manufacturing processes in accordance with desired product performance, and evaluate the environment's impact on product performance. ESI Group's products, which have a proven track record in manufacturing and have been combined in multi-trade value chains, represent a unique collaborative and open virtual engineering solution known as the Virtual Try-Out Space (VTOS), enabling virtual prototypes to be improved in a continuous and collaborative manner. This integrated protocol allows all the company's solutions to work with each other and with applications developed by independent software vendors. By significantly reducing costs and development lead times and enabling product/process synergies, VTOS solutions offer major competitive advantage by progressively eliminating the need for physical prototypes during product development.

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\*Other names and brands may be claimed as the property of others.

Relative performance for each benchmark is calculated by taking the actual benchmark result for the first platform tested and assigning it a value of 1.0 as a baseline. Relative performance for the remaining platforms tested was calculated by dividing the actual benchmark result for the baseline platform into each of the specific benchmark results of each of the other platforms and assigning them a relative performance number that correlates with the performance improvements reported.

Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel® products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, reference [http://www.intel.com/performance/resources/benchmark\\_limitations.htm](http://www.intel.com/performance/resources/benchmark_limitations.htm) or call (U.S.) 1-800-628-8686 or 1-916-356-3104.

Intel processor numbers are not a measure of performance. Processor numbers differentiate features within each processor family, not across different processor families. See [http://www.intel.com/products/processor\\_number](http://www.intel.com/products/processor_number) for details.

64-bit computing on Intel architecture requires a computer system with a processor, chipset, BIOS, operating system, device drivers and applications enabled for Intel® 64 architecture. Processors will not operate (including 32-bit operation) without an Intel® 64 architecture-enabled BIOS. Performance will vary depending on your hardware and software configurations. Consult with your system vendor for more information.

Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM) and, for some uses, certain platform software enabled for it. Functionality, performance or other benefits will vary depending on hardware and software configurations and may require a BIOS update. Software applications may not be compatible with all operating systems. Please check with your application vendor.