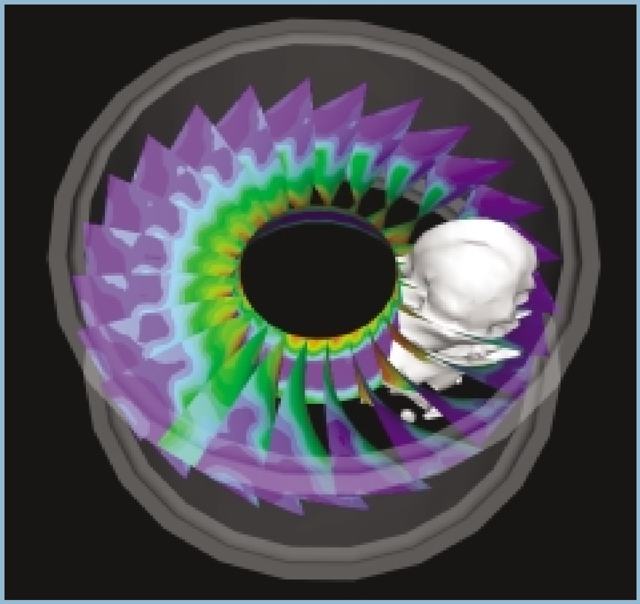
Applications Brief

MCAE Visualization: The New Frontier in Product Design

MCAE Complexity Drives Critical Visualization Requirements



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—Jay Horowitz, Visualization Manager, NASA Glenn

Manufacturing companies and research organizations increasingly rely on mechanical computer-aided engineering (MCAE) to improve product design and quality. MCAE applications allow engineers to evaluate the effects of mechanical stress, vibration, impact loading, fluid-induced pressure, and many other physical phenomena on potential designs while avoiding costly and time-consuming physical prototypes. Performing a rigorous set of MCAE analyses for a particular design improves product quality and saves time and money. MCAE is widely used in the automotive and aerospace industries and in a variety of other manufacturing design applications.

A typical MCAE analysis consists of three phases:

- Preprocessing: The modeling process usually begins with solid-model geometry of a particular design, from mechanical computer-aided design (MCAD) software. The MCAE engineer uses a set of tools to extract model surfaces from this geometry, generates a computational mesh on these surfaces, then completes the model geometry with generation of a volume mesh. Next, the engineer must specify the conditions to which the design will be subjected, meaning the loads and surrounding environment. Once model geometry and conditions are properly described, the simulation is ready for computation.
- Computation: Solution of the equations that govern the simulation is performed during computation. The output is numerical data that describes the results of the simulation. Typical models include computational fluid dynamics for fluid flow simulation or finite element analysis (FEA) for structural simulations.
- Postprocessing: Data from the simulation is processed into various forms of output for interpretation. Examination of these results enables engineers to determine what conditions to evaluate next if design improvements are required.

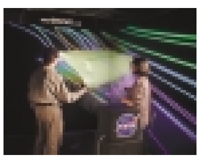
The postprocessing phase is critical to the understanding of an MCAE simulation. In the early days of MCAE, engineers reviewed the tabulated numerical output from MCAE simulations directly. Always difficult, this became completely impractical as solvers became more powerful and the amount of raw data resulting from simulations grew. Postprocessing software was developed to analyze and process the numerical data of a simulation into more useful, human-readable formats. This output is not only useful for an engineer, but makes it possible for the engineer to review and discuss the results with others.

The first postprocessing output consisted primarily of simple x-y plots and line plots depicting the relationship of one variable to another in the simulation. This form of output is still widely used today. While two-dimensional plots are a big improvement over raw data, they still represent an abstraction from 3D data and can be difficult to interpret. This is particularly true for the non-MCAE engineer, and thus these methods may inhibit the communication of information among designers, engineers, management, and others involved in the design process. Because of these and other limitations, these outputs are often supplemented with more visual forms including pre-rendered animations illustrating overall model behavior. Animations allow viewers to see the problem in 3D, but don't allow interaction with the data as it is being viewed.

In March 2002, FEA Information asked a number of engineers what they thought the future of MCAE post-processing was. The answer was advanced visualization and virtual reality.[1] As the size and complexity of MCAE models continue to increase, the use of interactive 3D visualization during postprocessing is increasingly supplementing and in some cases replacing traditional data representations. A fully immersive, interactive visualization environment makes it simpler to evaluate many of the important features of a model, increasing the accuracy and speed of interpretation. This is ultimately reflected in improved product designs and decreased time to market.

Interactive Visualization: A New Paradigm in Postprocessing

The latest technologies for interactive visualization—ranging from desktop visualization systems to fully immersive environments with video projected on multiple surfaces—coupled with specialized postprocessing visualization software from companies such as Computational Engineering International (CEI), Vircinity, and Intelligent Light are providing advanced visualization capabilities that enable engineers to interact with numerical MCAE results in new ways. Users can literally immerse themselves in 3D representations of the data under study and manipulate that data in real time.



At NASA Glenn Research Center, engineers are using Ensight Gold software from CEI running on a Silicon Graphics® Onyx2® system driving graphics displays in a Fakespace RAVE™ virtual reality environment. Their goal is to evaluate air-fuel mixture flow in jet engine combustors or to determine the dynamic response of a broken turbine rotor blade as it travels through a jet engine. According to Jay Horowitz, visualization manager at NASA Glenn, "A detailed model of an intricate structure with many components, such as a jet engine, can be viewed from all angles and diverse vantage points. We can now bring our data visualization more 'out of the screen' than ever before. It is surprising how much better you can understand complex phenomena when you have more control over how you view it."

Anthony Iannetti, an aerospace engineer in the combustion branch at NASA Glenn adds that, "We are able to pick up flow features and phenomena that are not normally seen by other methods such as line plots and cut planes. The 3D environment enables people such as managers, who are not specifically familiar with the geometry, to immediately comprehend what's going on."

The latest developments in advanced graphics and virtual reality are helping engineers visualize data in ways never before possible, improving productivity and increasing collaboration. As the technology becomes more widely available and costs decrease, increasing numbers of manufacturing operations are taking advantage of visualization to improve the quality of their MCAE simulation environment.

Although it has clear advantages for engineers, MCAE visualization poses significant challenges for visualization systems. According to Andreas Wierse, managing director and founder of Vircinity, a leading supplier of postprocessing visualization software, "MCAE visualization is extremely demanding. A single model may contain several million cells and a time-dependent simulation can yield tens of gigabytes of results. These results must be quickly postprocessed for visualization, placing a huge burden on the visualization system in terms of storage, I/O bandwidth, memory, CPU power, and graphics power."

In a recent survey by D.H. Brown & Associates, SGI was named the platform of choice for MCAE analysis.[2] Advanced computer systems from SGI uniquely provide the necessary combination of throughput, computational power, and graphics capability to accommodate the most complex models and to visualize the resulting data.

SGI offers a number of products to meet the demands of MCAE visualization. The SGI® Onyx® 300 system with InfiniteReality3™ graphics provides an excellent midrange platform for MCAE visualization. Onyx 300 is an ideal system for an MCAE workgroup or a small department, providing the compute capacity necessary to execute advanced MCAE models and the visualization capabilities to meet all but the most demanding needs.

For the most demanding requirements, SGI offers the SGI® Onyx® 3000 series of visualization systems with InfinitePerformance™ graphics. InfinitePerformance is designed exclusively for interactive visualization, making it ideal for MCAE applications. InfinitePerformance

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allows the output of up to 16 independent graphics pipes to be composited together into a single image for unparalleled interactive performance, providing full interactivity with even the largest and most complex MCAE simulations.

A combination of improved interactive capabilities and improved price/performance should make InfinitePerformance an attractive solution for even the most demanding visualization customers, allowing them to economically resolve problems that would have been impossible to solve only a few years ago. According to Kent Misegades, president of CEI, “The earlier a design problem can be detected, the more money and time can be saved. Only recently, models consisting of 1 million elements were considered large. Currently, engineers and scientists are using models with hundreds of millions of elements. CEI has proven that it can handle models containing more than a billion elements, and we expect that number to extend into the tens of billions in the near future. High-end systems from SGI are the only ones capable of meeting this need.”

Improving Access and Collaboration with Visual Area Networking

A major limitation to the use of advanced visualization is access to the latest tools. Employees dispersed within an organization—possibly at geographically remote sites—have to make special arrangements to use advanced visualization resources or to collaborate on visual decision making for important projects.

SGI is helping companies overcome this problem with Visual Area Networking (VAN). With VAN, engineers and scientists can remotely access visualization resources, allowing them to perform MCAE analysis and improving collaboration and decision making.

The OpenGL Vizserver™ computing solution, the flagship SGI® product for Visual Area Networking, uses centralized rendering to deliver high-resolution graphics to clients across a network. No application changes are required to use OpenGL Vizserver with OpenGL® applications. An SGI® Onyx® family visualization server runs the application, processes the data, and renders the graphics. Graphical images are then compressed and sent across LANs or WANs to the user. Since the client receives pre-rendered graphics, it requires no accelerated graphics capabilities. Collaborative sessions can be set up between local and remote users in which each user sees the identical on-screen image and interaction and control of the application are shared.

Visual Area Networking with OpenGL Vizserver has substantial benefits for a typical engineering workgroup. The productivity of engineers goes down every time they have to leave their offices. With OpenGL Vizserver, engineers can take advantage of local and geographically remote visualization systems without leaving their offices, and they can tackle problems far beyond the capabilities of desktop systems. VAN provides an alternative to frequent upgrades to desktop systems to accommodate work that may be only infrequently performed, extending the useful life of existing desktop systems. New desktop systems won’t require advanced graphics, making them substantially less expensive. It is also common for an engineer to have two systems in his or her office, one for advanced computation and visualization and another for more mundane tasks. OpenGL Vizserver can eliminate the need for a high-end system, decreasing infrastructure expenses and administration costs.

A typical workgroup visualization server might include four to six InfinitePerformance or InfiniteReality3 graphics pipes, be configured with 48GB of memory and 24 CPUs, and have I/O bandwidth of 1GB per second or greater. A single system can be tailored to meet both the visualization and computation needs of the group. The same visualization sys-

tem can be used to drive an SGI® Reality Center™ facility with a desk, wall, or room display when not in use by OpenGL Vizserver users to facilitate design reviews and other group collaborations. OpenGL Vizserver can also be used to include remote collaborators or share information with suppliers as necessary.

MSX International, a leading supplier of engineering services for automotive and other engineering-intensive industries, immediately recognized the advantages of Visual Area Networking for its operations and has been using OpenGL Vizserver in its MCAE group for over a year.

“With OpenGL Vizserver, we can bring the compute and visualization power of our Onyx 3000 series system directly to our engineers’ desktops,” said Iain Gibb, CAE manager at one of MSXI’s U.K. sites. “Our engineers no longer require expensive desktop systems to do their work, and the quality of OpenGL Vizserver output, even on a laptop system, is sufficient to allow us to use visualization regularly in meetings and design reviews, improving productivity.”

MSXI will soon be using OpenGL Vizserver to improve collaboration between sites in the U.K. and ultimately to improve collaboration worldwide. “MSXI believes in pushing the envelope to maximize our return on investment,” said Gibb. “We are already selling unused compute time on our Onyx 3000 series system to other companies, and, with OpenGL Vizserver, we are now able to offer visualization as well. OpenGL Vizserver is opening up whole new markets for MSXI.”

Visualizing Success

Interactive visualization is the technology of the future for MCAE postprocessing. As the size of MCAE simulations continues to grow, the burden on visualization systems will also increase. As the recognized leader in advanced visualization technology, SGI is uniquely positioned to meet this challenge with innovative hardware and software products that help engineers execute MCAE simulations, visualize the results, and collaborate with peers around the globe. The result is better product designs, created more quickly for improved time to market and increased competitiveness.

[1] FEA Information Monthly Newsletter: Post-Processing—A Tool for Solving Problems Through Visualization. *www.feainformation.com*

[2] “Symmetric Multiprocessing (SMP) Dominates High Performance Computing in CAE,” April 2001 study by D.H. Brown & Associates

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Corporate Office
1600 Amphitheatre Pkwy.
Mountain View, CA 94043
(650) 960-1980
www.sgi.com

North America 1(800) 800-7441
Latin America (52) 5267-1387
Europe (44) 118.925.75.00
Japan (81) 3.5488.1811
Asia Pacific (65) 771.0290

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