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EYE ON INNOVATION

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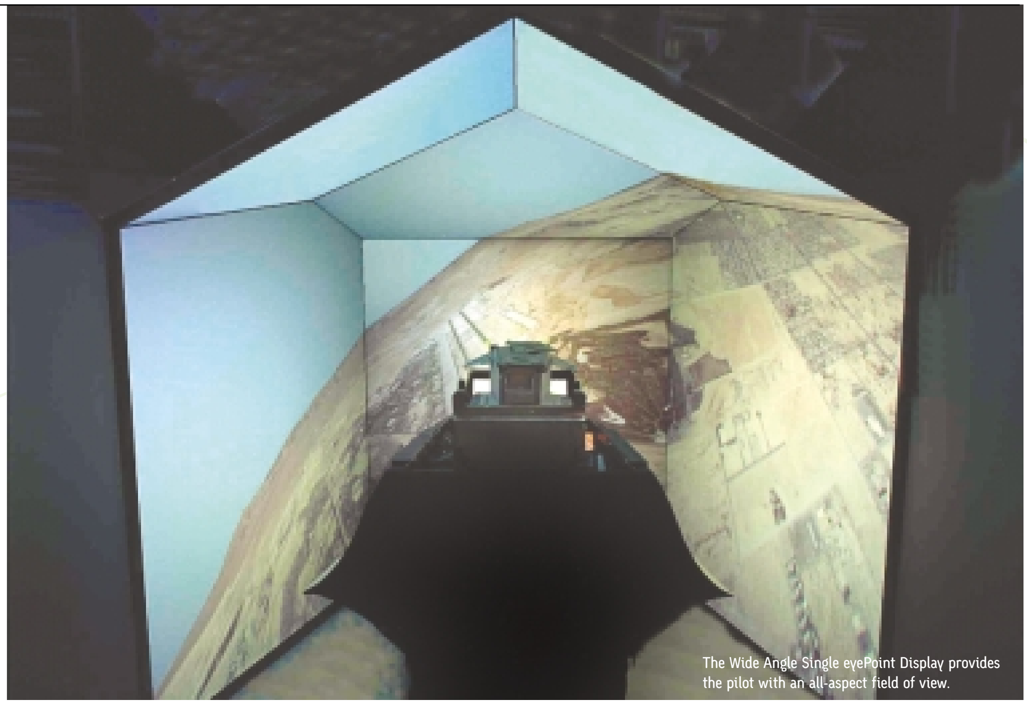

The Wide Angle Single eyePoint Display provides the pilot with an all-aspect field of view.

SGI™ Technology Supports Lockheed Martin Weapon System Simulators

"All of LMAero's simulators use SGI computer horsepower. With recent improvements in processing power, SGI is now able to do computations that used to take a Cray system to run. This permits us to use system models of unprecedented complexity, which significantly increases the fidelity of the simulation."

—Matt Landry
Manager
Flight Simulation Lab
Lockheed Martin
Aeronautics Company

In 1994, when the U.S. Navy, Marine Corps, and Air Force, together with allies, announced their Joint Strike Fighter (JSF) program to develop and field an affordable next-generation strike fighter aircraft, the team at Lockheed Martin Corporation competing for the contract knew that extensive modeling and simulation technology would be required.

Affordability through commonality was a key criterion outlined in the mission of the program. The military customer wanted three different designs that would share key, high-cost components—e.g., engines, avionics, and many of the high-cost structural components. Common components would not only save money in the manufacturing, but also in common depot maintenance and service interoperability. The JSF program projected that the new family of aircraft would have commonality in the range of 70 to 90%, with emphasis on commonality in higher priced parts.

The demands for this new family of aircraft were complex. While sharing common characteristics—such as common fuselage lines, structure, systems, and software; a single-seat cockpit; a side weapons bay; and a blended swept wing—each of the services had also outlined specific characteristics for the JSF. The Navy wanted the JSF to be a multirole stealthy strike aircraft, the Air Force needed a multirole (primary-air-to-ground) fighter, and the Marine Corps required a multirole, short take-off vertical landing (STOVL) strike fighter. The United Kingdom Royal Navy and Royal Air Force specified a supersonic STOVL craft.

To reduce costs in the development and testing of the JSF family of aircraft, Lockheed Martin's Aeronautics Company (LMAero) turned to SGI for its powerful, advanced suite of computers to simulate complex aircraft systems in every stage of design and testing.

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Using SGI computing technology, Lockheed Martin has developed piloted simulators at the LMAero Flight Simulation Lab (FSL) in Fort Worth, Texas and Palmdale, California, which support design and evaluation of the flight controls and aerodynamics as well as the integrated tactical performance of the JSF.

Three flight control simulators support design and evaluation of the JSF advanced flight controls and aerodynamics. The Vehicle Management System (VMS) Control Law simulator in the FSL permits pilot assessment of the handling qualities of the designed aircraft, using simulations of the flight control and actuation systems. The VMS Hot Bench Simulator, also in the FSL, permits evaluations of the actual flight control computers with embedded airborne software. The VMS Integration Facility at the Palmdale facility integrates the flight controls, cockpit, and actuator hardware into a manned simulator located on a motion base platform. These simulators permit assessment of aircraft flight characteristics over the full spectrum of flight conditions, from taxi, takeoff, aerial maneuvering, and air-to-air refueling to landing on carrier decks and runways.

The Tactical System Simulator (TSS) facility supports assessment of the JSF tactical combat capabilities and includes integrated models of all primary on-board systems, including propulsion, aerodynamics, flight controls, weapons management, sensors, communications, pilot–vehicle interface, and avionics. In the TSS, pilots climb into the JSF cockpit and fly the aircraft in highly realistic simulated battlefield situations, including targets, threats, terrain, weather, and friendly forces. This allows pilots to evaluate system design in a realistic tactical environment and recommend changes early in the design process.

The heart of the TSS facility is the pair of full field-of-view displays, which surround the simulator cockpit with high-resolution imagery. The combination of Silicon Graphics® Onyx2® computers and MultiGen-Paradigm image computation software presents the pilot with an all-aspect visual display suitable for both air-to-air and air-to-ground engagements. The photo below shows one of the Wide Angle Single eyePoint (WASP) displays used in the TSS. While there are eight channels of display, two are projected onto the rear two panels, which open to allow access and close during operation. The photograph is taken through the open back panels.

Simulated battle conditions are displayed in the Virtual Battlefield Management Center.

The TSS also includes a large tactical visualization center, which is the heart of the Virtual Battlefield Management Center (VBMC) in which all the battlefield elements are represented. This visualization includes projections of pilot's displays (both heads-up and heads-down), god's eye views of the battlefield, viewpoints of any entity in the battlefield, and tactical map displays. Again, the large SGI computer complex provides the many sources of display that are projected in the VBMC.

The VBMC also includes several stations with simulated-piloted or human-operated Red and Blue tactical entities. The Manned Interceptor Control Station (MICS) provides heads-up and heads-down displays as well as primary flight controls for the simulation of friendly or hostile piloted aircraft in the simulated battlefield. Two Silicon Graphics® Octane® workstations power each of the four MICS, computing the aircraft dynamics, sensors, and avionics as well as the graphics for the two displays.

Manned interactive control stations represent red and blue forces in the simulated battlefield.

The use of simulation to support aircraft design at the Ft. Worth facility began with the General Dynamics B58 Hustler, says Matt Landry, manager, simulation programs at the LMAero Flight Simulation Lab. But since then, the complexity of tactical simulation has increased to the degree of sophistication where pilots who fly the TSS say they cannot "game" the simulation due to the high degree of realism. "They said, 'The workload in the simulator is comparable to that in the battlefield,'" Landry said.

The ultimate test for virtual reality is actual reality. The Navy version of the Lockheed Martin JSF demonstrator, X-35C, had its first flight test on December 16, 2000. It was the second Lockheed Martin JSF Concept Demonstration Aircraft to undergo flight testing. The X-35A, designed for U.S. Air Force use, successfully completed its flight-test program on November 22. A third JSF variant, the lift fan–equipped X-35B, is scheduled to begin vertical-flight testing later in 2001.

The JSF simulators have passed the reality test. "When we flew our first aircraft, the X35-A, the senior test pilot said it flew just like the simulator," Landry said proudly. "We are seeing a much stronger correlation between the simulator and the real world." The X-35A also set several flight-test records, one of which was directly related to the simulator. The entire test program successfully concluded without the need to change any of the flight control system software. This was a result of the intense, detailed testing of the software in the simulator, in which all flight modes, failure modes, transitions, and interfaces were thoroughly tested before going to flight.

"All of LMAero's simulators use SGI computer horsepower," Landry said. "With recent improvements in processing power, SGI is now able to do computations that used to take a Cray system to run. This permits us to use system models of unprecedented complexity, which significantly increases the fidelity of the simulation."

Landry said one of the obvious advantages of using SGI machines is that more of the simulation tasks can be run on a single computer. Older simulators relied on special-purpose compute engines for computation of the complex, wide field-of-view display; nonlinear aerodynamics; in-cockpit graphics; and sensor imagery. With the new generation of SGI technology, all these computations can now be done on a single computer, reducing the cost of ownership—a necessity for multiple development environments—and maintenance costs. According to Landry, "A specific advantage of SGI is its application to the full field-of-view display used in the TSS. This display immerses the pilot in a wrap-around visual scene consisting of eight back-projected images.

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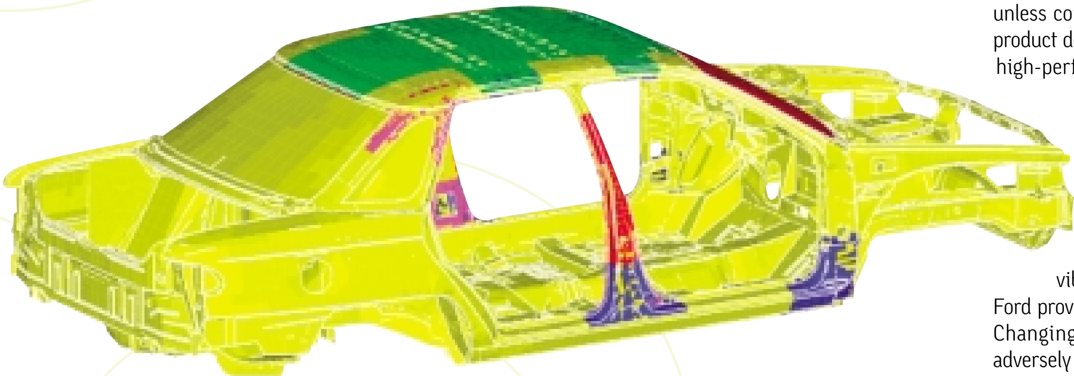
MDO Enhances Design Process with Breakthrough Technology



In the manufacturing industry, a new product design involves intensive collaboration among teams with specialized disciplines.

In the design process, specialized teams often have conflicting considerations, such as aerodynamics, structures, propulsion, and controls, as well as costs and returns on investment. In an engine-blade design, a thin leading edge might be desirable from an aerodynamics point of view, but structurally, a high degree of stress would result.

"At Ford, we want to bring quality products to market faster. With SGI and NASA, we were able to demonstrate that with high-performance computing, a conventionally impractical multidisciplinary optimization problem becomes feasible and thereby impacts the product design cycle."

—Dr. Ren-Jye Yang
Senior Staff
Safety R&D Department
Ford Researcch Laboratory

A successful design requires manufacturers to integrate the parameters and come up with an overall optimum design across disciplines. Often designs are passed between the product teams several times until the differences are minimized and a mutually acceptable solution is found.

In the aerospace industry, multidisciplinary design optimization (MDO) methods have been effectively deployed to overcome the drawbacks of this sequential design process. Algorithms have been developed to compute data from different disciplines and provide an optimal solution.

"MDO has been implemented in the aerospace industry for 30 years or so," said Srinivas Kodiyalam, of SGI, who led a joint research project in 1999 with NASA Langley, Ford Research Laboratory, and Engineous Software, Inc., to apply MDO methods to the automotive industry.

Until recently, MDO was not feasible for applications in the automotive and other manufacturing industries, partly because these industries typically did not invest in developing in-house software tools. "The automotive industry is heavily reliant on commercial off-the-shelf, vendor-provided tools," Kodiyalam said.

The good news is these key technologies are now emerging as commercial tools. Traditional CAE and CAD vendors now support the capability to do optimization, and software vendors focused primarily on process integration, simulation, and optimization environments are emerging.

Another challenge in applying MDO to automotive manufacturing is the sophisticated high-fidelity models that have evolved as the standard in the industry. Without superior computing power, elapsed computing time for such detailed models could take years. "New technology is great, but such technologies can't be useful unless computing time can be reduced to decrease the product design cycle," Kodiyalam said. "That's where high-performance computing machines come in."

In a recent joint project, between Ford and SGI, the Ford team set out to reduce the elapsed computing time to optimize a vehicle system for minimum weight while meeting international crashworthiness standards and Ford's standards for noise, vibration, and harshness (NVH) levels. The design Ford provided violated both the NVH and safety targets. Changing the design solely for NVH attributes might adversely affect the safety targets.

The compute-intense, nonlinear analysis required for optimizing this particular design was daunting. "Using MSC.Nastran and RADIOSS, Ford estimated it would require almost three years of computing time using a single processor on SGI Origin 2000*," Kodiyalam said. "On an SGI Origin 3000 series system with 256 processors, we reduced that computing time to less than two days."

"At Ford, we want to bring quality products to market faster," said Dr. Ren-Jye Yang, senior staff at Ford. "With SGI and NASA, we were able to demonstrate that with high-performance computing, a conventionally impractical multidisciplinary optimization problem becomes feasible and thereby impacts the product design cycle."

Not only was elapsed computational time reduced, the team was able to turn an unfeasible design into a feasible one. The integrated technology is capable of presenting previously unimagined solutions and could change the overall design process. "Manufacturers can reverse engineer products," Kodiyalam said. "They know what they'd like to see, and MDO shows them how to optimize the design."

The technology creates the possibility for remarkably unique product innovations, a departure from derivative or heritage designs. "MDO analysis will come up with a design solution that engineers haven't thought of," Kodiyalam said.

MDO technology has a wide range of applications. "I can see as much application in a general manufacturing world as there is for automotive design," Kodiyalam said. "The set of algorithms is applicable to the biomedical world, to general manufacturing, and to the financial world."

For more information, go to *www.sgi.com/manufacturing/mdo*.

*Origin™ 2000 is now being marketed and sold as the SGI™ 2000 series.

SGI Partner News Update

MSC.Software and SGI Team up for MSC.Nastran 2001 Enhancements

MSC.Nastran

MSC.Software (*www.mscsoftware.com*) and SGI have combined their development efforts to enhance the performance of MSC.Nastran 2001 for all SGI systems that are based on the IRIX® 64-bit operating system. The list of efficiency enhancements includes improvements to several solution sequences for single-processor turnaround performance, file I/O throughput, and increased parallel scalability.

MSC.Nastran is an implicit finite element analysis software application that simulates and predicts the structural performance of a product design before commitment to prototyping and manufacturing. Major manufacturers worldwide utilize MSC.Nastran to analyze and improve both simple and complex designs, from components to complete systems such as aircraft and automotive vehicles.

An important application in the automotive industry where MSC.Nastran makes valuable contributions is in design of vehicles for reduced levels of noise, vibration, and harshness (NVH), which can improve passenger comfort, ride, and handling for a more competitive design. Every major automotive manufacturer worldwide uses MSC.Nastran for NVH, due to the efficiency and accuracy of the software's dynamic response capabilities.

Generally speaking, finite element analysis exhibits a range of compute behavior depending upon the kind of structural response and size of the model being evaluated. The demands of NVH on high-performance computing (HPC) resources in the automotive industry substantially exceed those of any other MSC.Nastran application. This includes virtually all HPC resources—fast CPU, large memory and storage, and very high rates of memory and I/O bandwidth on the order of terabytes for a single NVH job.

SGI works cooperatively with MSC.Software for performance improvements on all aspects of MSC.Nastran, but particular attention is given to those solution sequences used for NVH analysis, namely 103, 108, and 111 for modal and direct frequency response. For example, MSC.Nastran 2001 will include improved parallel scalability of SOL 103 where a typical automotive body-in-white (BIW) of 1.5M DOF and more than 1,000 modes achieves a nearly five-fold speed-up on an eight-CPU SGI™ Origin™ 3000 series system. This means the turnaround time of the BIW example would reduce from about nine hours on a single R14000™ 500 MHz MIPS® processor to about two hours on eight processors.

SGI and MSC.Software are also joining forces to provide simulation software on SGI servers running the Linux® operating system on the new Intel® Itanium™ processor. SGI is participating in the development of MSC.Nastran to optimize system performance with Itanium 64-bit processor–based Linux clusters.

Both companies have taken a leadership role in the industry to promote Linux OS–based applications for MCAE. Two of these development projects are now close to completion. The first is the availability of MSC.Nastran on Linux clusters from SGI. This plug-and-play packaging of MSC.Nastran includes an SGI cluster of high-performance, Pentium® III processors. This phase I development is nearing final product release for SGI systems.

The phase II development project will involve tuning of MSC.Nastran for the soon-to-be-released Intel Itanium high-performance 64-bit processor. SGI will make MSC.Nastran and MSC.Patran available on SGI servers based on Itanium processors and the Linux operating system. The availability of the Itanium processor–based system from SGI will be announced in the second half of 2001 with volume shipments available immediately thereafter.

As in the past, SGI continues to collaborate with application software leaders such as MSC.Software to deliver high-performance computing and advanced graphics solutions that enable customers to understand and solve their most demanding engineering problems. As a result of this strong collaboration, manufacturing companies worldwide continue to improve the engineering aspects of their design processes such that product quality is improved at a lower cost and with faster time to market.

For more information, go to *www.sgi.com/manufacturing/cae*.

Visualization Benefits for the Automotive Industry

Leaders in the automotive industry have advanced beyond conventional CAD modeling and are using 3D visualization throughout the complete vehicle development process. Modifications to components, assemblies, and even fully integrated vehicle systems can be made without committing to a final product specification until the very last minute.

Several major automotive companies, including Renault, DaimlerChrysler, and Toyota, continue to report success with Silicon Graphics Onyx2 systems for visualization applications that make virtual product design a valuable alternative to costly physical prototypes.

This article features examples from these automotive companies, in diverse areas such as styling, occupant safety, and manufacturing where the SGI visualization environment enabled an interdisciplinary and collaborative framework that significantly reduced time, improved design quality, and provided cost savings.

SGI Reality Center 3300W Wall Display

Competitive Styling

At the Mercedes-Benz car development facility in Sindelfingen, Germany, an SGI™ Reality Center™ facility allows designers at DaimlerChrysler to introduce new concept vehicles to their colleagues in a 3D simulated space. New design concepts can be examined as they operate under everyday traffic conditions or compared side by side with competitive vehicle designs.

"Simulations and visualization allow us to examine a greater number of variants in a shorter period of time and at lower costs," said Hans Joachim Schopf, chief engineer for Mercedes-Benz passenger cars. "As a result, we can rule out nonviable options more quickly." Imperfections and inconsistencies in the shape of vehicles can be detected early in the process, enabling many key design decisions to be made without the development of expensive clay modeling.

Virtual Crash Testing

Virtual reality technology not only gives DaimlerChrysler a significant return on investment in cost, time savings, and product quality, but also reduces material waste and environmental impact while at the same time allows manufacturers to improve occupant safety and crashworthiness.

"We can work through a lot more variations than is possible in real tests without having to destroy a Mercedes every time," said Bharat Balasubramanian, a director at Mercedes-Benz car development. With a Silicon Graphics Onyx2 InfiniteReality2™ system configured with 60 CPUs, 15GB of main memory, and 14 independent graphical high-performance pipes, data-rich, full-scale crash tests can be simulated and visualized.

Virtual crash tests allow a more detailed examination from inside the vehicle that is not possible in a physical crash test. For instance, overlapping components or assemblies can be visually "removed" to reveal how concealed components were affected in the crash.

Company	DaimlerChrysler	Renault	Toyota
Visualization Software	Alias|Wavefront™, Dassault	Alias|Wavefront, Dassault, Tecnomatix	Delmia
SGI Hardware	SGI™ Onyx® family of high-performance visualization systems	SGI Onyx family of high-performance visualization systems	SGI Onyx family of high-performance visualization systems
Display Technology	Walls, rooms, desks, SGI™ Reality Center™ 3300W	Walls	Walls, rooms

"From inside the vehicle we can see considerably more on a virtual level than we could show in a real crash using the most advanced high-speed camera," Balasubramanian said.

Design Collaboration

Visualization also enables increased collaboration between different disciplines. For example, if design conflicts arise between styling and the manufacturability of a particular body feature, these issues can be resolved quickly with access to a lifelike model in a team discussion. Visualization allows an investigation of the aerodynamic effects for certain body shapes and the ability to manufacture the body panels for those shapes. Collaboration means time savings. Using visualization to explore different design and engineering options together, engineers at Renault said the time required to review, resolve, and incorporate a change to a powertrain component, such as an engine cylinder head, was reduced as much as 55%.

Improved Manufacturability

At Toyota, visualization is improving communications on the assembly floor. Using a video conferencing system combined with Envision software from Delmia, a division of Dassault Systemes, designers and assembly line managers can look at simulations of individual components as they are being virtually installed into a vehicle during assembly. Engineers and factory workers in Japan and overseas can see and talk to each other while simultaneously viewing the same information.

Before introducing this Visual and Virtual Communication (V-Comm) system into the manufacturing process, different factories relied on faxes to announce assembly procedure changes. As a result, changes sometimes took two months to be uniformly implemented. With V-Comm, the information is reviewed and discussed in real time. Suggestions and feedback from floor workers are received and implemented long before the vehicle moves into the mass production.

These are just a few examples of how advanced visualization technology from SGI has helped car companies bring new better quality models to market faster, at lower cost, and with more options for their customers. The way forward for the automotive industry will require a technology environment that efficiently manages increasing complexity in the vehicle development process. SGI continues to invest in visualization and other technologies to provide the automotive industry with leadership required for meeting the challenges ahead.

For more information, go to *www.sgi.com/manufacturing/automotive*.

Guest Commentary

Toward Collaborative Design and Engineering

The growing complexity of today's global manufacturing industry is influenced by both market conditions and technology trends. Global business drivers such as increasing competition, consumer desires, and government regulations continue to fuel investments in manufacturing product and process development. At the same time, the economics of product development are rapidly shifting as engineering costs continue to increase compared with decreasing costs of design tools such as computer systems and IT infrastructure.

As such, investments in design and simulation environments emphasize increases in overall engineering productivity and quality, a recurring challenge that is examined in each of the features that appear in this first edition of *Eye on Innovation*. The benefits from technology advancements in cost-effective and high-capability design, simulation, and visualization applications have brought on new methodologies in product development.

Industry and manufacturing research organizations are investing toward a vision of collaborative design and engineering to fully integrate and capture all product development activities within a single environment. SGI continues to invest in this industry initiative and provide the necessary leadership to achieve this goal.

Stan Posey
Manager
Manufacturing Industry Development
SGI

[continued from page 2]

Our fully immersive simulation environments require extremely powerful hardware to do distortion correction and image computation in real time using open-format databases. This is an ideal application of the SGI and MultiGen solution."

Simulations such as the TSS are beneficial to Lockheed Martin because they allow the company to assess the tactical effectiveness of its weapon systems. Before building a physical prototype costing millions of dollars, simulations allow Lockheed to test its designs in virtual space. "You want to quantify and demonstrate that the vehicle is controllable, lethal, and stealthy while assessing its tactical effectiveness," Landry said. "These models are high enough in fidelity to satisfy our goals. We are meeting our own high standards."

The current simulation technology is at an unprecedented level of fidelity, Landry said. A major area left for improvement is the out-the-window visual system, where the transport delays and resolution still need improvement. According to Landry, however, this is a narrow niche and he doesn't expect innovations to develop quickly. Another area where Landry sees improvement needed is the speed of computer interfaces.

Lockheed Martin's simulation initiatives are paying off. In November 1996, the JSF program entered the concept demonstration phase and selected two contractors, Boeing and Lockheed Martin, to build and fly concept demonstration aircraft. The successes realized in the first phase of flight test of the X-35A are in part due to the investment in the simulators. The final selection of one contractor for engineering and manufacturing development is scheduled for late 2001, after flight testing concludes.

Foreign interest in the program is high, and a number of agreements are in place for the current phase of the program. The United Kingdom became a full collaborative partner in the program in 1995. Denmark, Norway, The Netherlands, Canada, and Italy subsequently joined the program as cooperative partners. Singapore and Turkey recently became foreign military sales participants for this phase.

For more information, go to *www.sgi.com/manufacturing/aerospace*.

SGI Is Top Choice for CAE Applications, D.H. Brown Study Finds

SGI is the vendor of choice for computer-aided engineering [CAE] applications staged on high-performance computing platforms, according to a new study of manufacturing product development users in such industries as automotive and aerospace.

For the study, released in early April, leading research and consulting firm D.H. Brown Associates, Inc. queried a limited but representative sample of product developers about their platform preference. Of the six hardware vendors cited by respondents, SGI was the leader, with 36 percent.

For the full story, go to *www.sgi.com/newsroom/press_releases/2001/may/brown.html.*

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