Success Story

SGI® High-Performance Computing and Visualization Technology—Helping Build America's Backbone

"Our best example of putting visualization technology to work for us has been on CVNX. In this program, visualization is an integral part of all Integrated Product Team [IPT] design/build meetings."

— Bill Kunz, Visualization Engineering Solutions, Northrop Grumman Newport News

The backbone of U.S. defense is the aircraft carrier and its battle group. It is the largest warship in the world, runs on nuclear power, and is the world largest assembled product, with over one billion parts. Construction of an aircraft carrier, from design to delivery, takes 12 years, the latter five just to build it. Its life cycle is 50 years—two 25-year tours of duty—with a three-year break for refueling and complex overhaul.

Newport News

Northrop Grumman Newport News, a sector of Northrop Grumman located in Newport News, Virginia, is the only company that designs, builds, refuels, and overhauls nuclear aircraft carriers, and it is one of only two to do the same for nuclear submarines. When a carrier's life cycle is complete, Newport News handles the decommissioning and disposal. SGI workstations, high-performance computing systems, and advanced visualization technology play an important role in helping Newport News build a better, stronger backbone for the U.S. Navy.

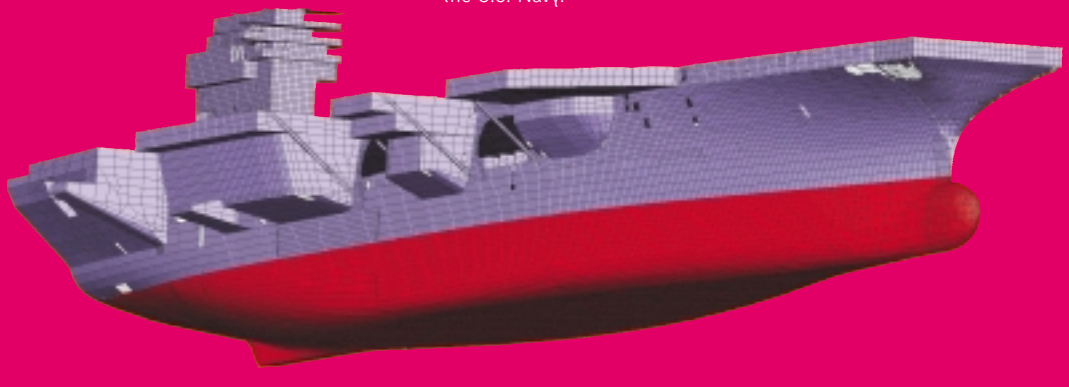
Aircraft Carrier Facts: Nimitz Class

- Length: 1,092 feet
- Width: 251 feet, flight deck at widest point
- Height: 20 stories, waterline to mast
- Displacement: 91,209 tons
- Propulsion: Nuclear
- Flight deck: 196,000 square feet
- Air wing: 9–10 squadrons, 80 aircraft
- Personnel: 6,000+

Today, Newport News employs more than 4,000 design and construction engineers, each integrally involved in the design, testing, and construction of aircraft carriers for the Navy. Their job is to develop, evaluate, and insert new technologies that reduce the total cost of ownership while enhancing the capability, flexibility, survivability, and combat effectiveness of the ship.

The merging of Northrop Grumman, a defense electronics powerhouse in its own right, with Newport News, created an organization ideally suited to serve as the Navy's one-stop shop for nuclear aircraft carriers. The company's ability to provide concept-to-completion shipbuilding provides a twofold benefit to the Navy—lower acquisition costs and lower total cost of ownership throughout the life cycle of the aircraft carrier.

SGI workstations and high-performance computing systems have long been instrumental in helping Newport News reduce the total cost of ownership for Navy ships, specifically in areas of 3D solids modeling, finite element analysis (FEA), and the management of complex data.



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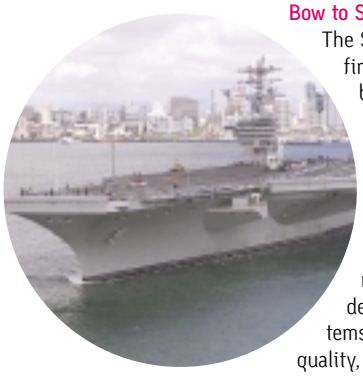


Bow to Stern

The Seawolf-class submarine was the first Navy ship to be entirely designed by Newport News using 3D solids modeling. The move to full-blown 3D product model design for submarines and, later, for select aircraft carrier components, enabled Newport News to fully implement steel fabrication automation, maximize preoutfitting and neat-build processes, transfer digital design data to drive work-execution systems, and improve accuracy control, design quality, design validation, and configuration management.

When the Seawolf project was getting underway, Newport News was migrating its main FEA application, I-DEAS, from the mainframe to a workstation-only platform. SGI® Indigo® workstations were selected, in part, because of their support for I-DEAS and because they could also be used to handle 3D modeling of various project components.

Moving Forward

In the years since the Seawolf project began, I-DEAS and VIVID tools and files were migrated to a single CAD tool—CATIA® software, a commercially available and continually upgradeable solution from Dassault Systemes that supports industry-accepted best practices. Moving to CATIA enabled Newport News to realize an overall reduction in software maintenance costs. The first of the next class of aircraft carriers, CVNX (carrier, vessel, nuclear, experimental), will be modeled using CATIA for all new design work.

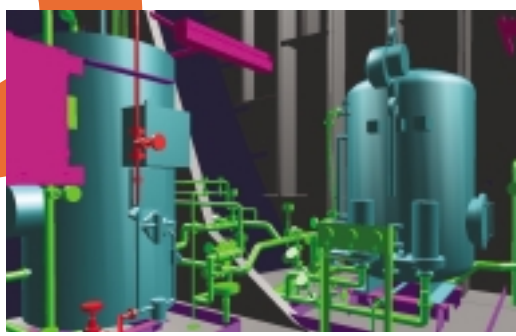
Newport News' engineering visualization software of choice is PTC's dvMockup, which enables visual analysis, simulation, and real-time design collaboration of 3D CAD models across multiple machines in both LANs and WANs. Also now widely used at Newport News for supporting proof-of-concept studies and other R&D projects is Alias|Wavefront™, a comprehensive suite of 3D industrial design software applications.

Newport News' compute and visualization power recently grew when the shipbuilder refreshed its Silicon Graphics® Octane® workstations with 47 high-powered Silicon Graphics® Octane2™ visual workstations and an SGI® Origin® 3000 series system with 24 processors, eight of which are dedicated solely to FEA work. The remaining 16 processors handle 3D modeling and simulation. The SGI Origin 3000 series system's high-performance shared memory enables Newport News to perform complex computational tasks. By including SGI® InfiniteReality® series graphics, the system also enables advanced visualization. The ability to do these concurrently is unique among supercomputers and provides Newport News with a single-platform price/performance solution that can grow with the shipbuilder.

FEA Structural Analysis

The integrity of the structure of an aircraft carrier is infinitely essential to its survival. That means using SGI high-performance computing to conduct rigorous FEA analyses on every component of the carrier structure. Newport News puts carrier components through structural analyses (static, modal, transient) to test how the ship will react to every conceivable stressor once deployed. This includes load conditions such as hurricane-force winds, vibrations from routine maneuvers, explosions above and below the waterline, and a range of other war-type events. Everything possible is done to ensure that the FEA work results in the best structural engineering solution being applied to the final product.

The analyses are conducted in computer simulations to determine their validity. If the simulations are small enough (under 200,000 degrees of freedom) they are performed on the Silicon Graphics Octane2 workstations. The FEA-dedicated portion of the SGI Origin 3000 series system handles large-scale simulations, turning out results virtually around the clock. The results of each simulation are then given to the product modeler who, in turn, uses the new information to update the 3D model of the entire ship.



"You can expect to perform evaluations on several iterations of a typical model, depending on where you are in the design process," said Kevin Arden, senior project engineer for Northrop Grumman Newport News. "However, with the next class of aircraft carrier, CVNX, still in the earlier stages of development, the project engineers are conducting as many as five simulations a day just to keep up with the product modeler changes and then using the FEA results to make further design refinements almost daily."

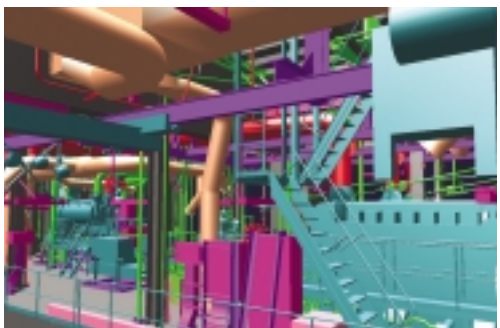
Typical FEA structural analysis applications used by Newport News include MSC.Nastran (MSC.Software), ABAQUS (ABAQUS, Inc.), and LS-DYNA™ (Livermore Software Technology Corporation).

Visualization Technology

In 1998, Newport News committed fully to integrating visualization technology into its shipbuilding business model. According to Bill Kunz, Visualization Engineering Solutions project lead at Northrop Grumman Newport News, "We felt that in order to remain the world's most advanced shipyard we needed to up our competitive edge. To achieve our goal, and based on our previous successes using SGI products, we selected the SGI® Reality Center™ facility. SGI was the only company that met all of our functional requirements. We also were quite impressed with the price/performance quotient." SGI was responsible for the installation of the Silicon Graphics® Onyx2® workstation and the overall systems integration. Display provider Panoram Technologies was selected for all display and control equipment for the SGI® Reality Center™ theater.

SGI and Newport News then conducted a full-fledged trade study before finally selecting PTC DIVISION dvMockUp as the company's large-scale visualization tool, which could be optimized on SGI hardware. Kunz said, "Besides liking the 64-bit capability and large address memory space, dvMockUp's ability to import all CAD formats was a real plus. And it was highly customizable." At the end of the selection process, everyone involved felt that having and getting to work on the best visualization tools available would serve as a powerful incentive to the engineers.

"Our best example of putting visualization technology to work for us has been on CVNX," said Kunz. "In this program, visualization is an integral part of all Integrated Product Team (IPT) design/build meetings. The team also uses visualization collaboratively with our design partners and external customers, using it to bring them into the design process from the very beginning. Our IPTs use visualization to make movies of erection and build sequences as well as facility layouts that support preproduction planning. Future plans will support physics-based simulations as well as work and operational simulations. Ultimately we see visualization playing a huge role in life-cycle support for the ships we build."



Newport News also is very interested in the recently introduced SGI® InfinitePerformance™ scalable graphics subsystem and how it can further enhance the shipbuilder's visualization capabilities. InfinitePerformance graphics, with 16-way scaling available in fall 2002, will deliver a much-elevated class of geometry performance and will enable Newport News to visualize, interact with, and collaborate on even the largest of models and most complex simulations. The enormity of an aircraft carrier and the number of files required to create a single, complete 3D model has, to date, kept view rates to about one to two frames per second. SGI InfinitePerformance graphics, with 16-way scaling and interactive graphics performance of up to 283 million triangles per second, will enable Newport News to achieve better frame rates and visualize its largest models in even greater detail.

Having a distributed visualization system also was part of the vision. Today, the SGI Origin 3000 series system located within the Newport News complex is connected directly to visualization centers located in four separate buildings. The facilities range from a large auditorium, a visualization center, and a design/build theater to a series of five small-scale visualization rooms.

From a marketing and public relations standpoint, the SGI Reality Center installations help Newport News confirm its leadership role in the shipbuilding industry.

The Rewards

With the addition of the SGI Reality Center installations and through the use of SGI and other visualization software applications, Newport News looks to reap further time and cost savings in the area of physical prototyping.

While there are obvious time- and cost-savings opportunities to be realized through using digital prototyping, there are still some concerns that need to be overcome. Bryan Marz, enterprise project analyst for Newport News, had this to say: "Customer acceptance of a digital, design-only approval process isn't likely to happen as rapidly in shipbuilding as in other manufacturing arenas, due to customer concerns surrounding human interaction with the model."

"To facilitate acceptance, simulations in which ship personnel staff operations stations, perform casualty drills, and engage in operations that the ship is designed to perform must be created. Every design review is a proving ground for the validity and reliability of digital mock-ups."

Other areas in which digital prototyping inroads are being made, albeit at a slower pace, are the testing of dynamic events. However, Newport News' engineers will continue using the results of physical prototype testing to prove the validity of the digital model.

VASCIC

The Virginia Advanced Shipbuilding and Carrier Innovation Center (VASCIC), also located in Newport News, Virginia, is a state-of-the-art R&D integration facility managed by Newport News. The institution, which opened in 2001, brings together manufacturing, defense, and academia and serves as a collaborative proving ground for advancing visualization and other technologies that support Navy initiatives—future naval capabilities, total ownership cost reduction, and technology transfer. Newport News hopes to implement the technology advancements made through VASCIC directly into its aircraft carrier design and construction.

Into the Future

In the years and projects ahead, large-scale shipbuilders such as Northrop Grumman Newport News will continue to increase their reliance on visualization technologies as expressed through digital prototyping, visual mock-ups, and SGI Reality Center facility presentations to their customers. Because moving tremendous amounts of data forward to current technology platforms takes innumerable staff-hours to accomplish, the first fully digitally designed aircraft carrier is still some years away. However, there appears to be no doubt among industry insiders that it will happen.

To ensure that shipbuilders and manufacturers realize their visualization technology benchmarks, SGI will continue to design and develop robust workstations and high-performance computing solutions with optimum speed and graphics capabilities that will further improve upon the capability, survivability, and combat effectiveness of the backbone of America's defense.

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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) 6771.0290

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