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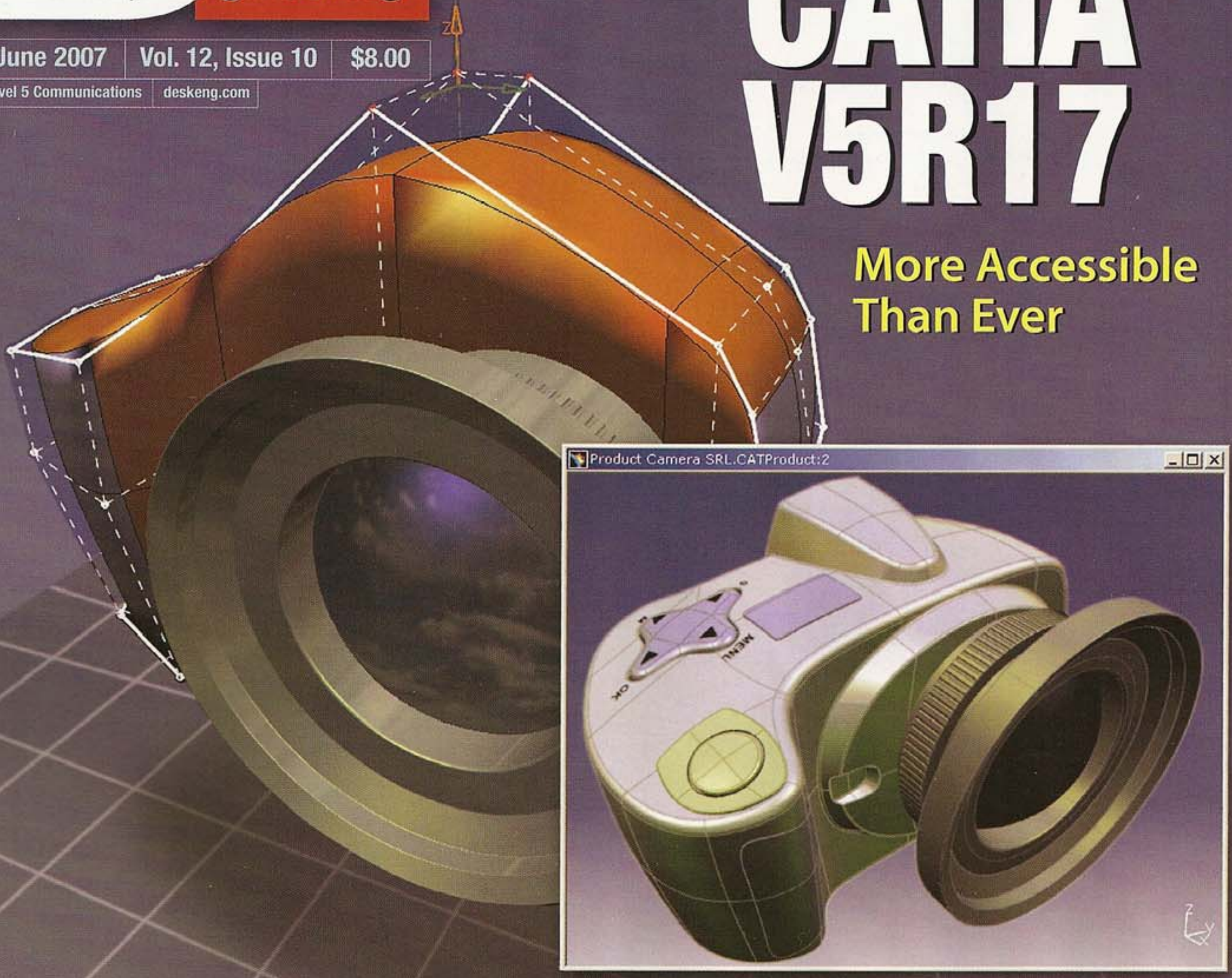

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composite materials show their strengths

By Pamela J. Waterman

From golf clubs to the Space Shuttle, composite constructions result in tough stuff.

The electronics housing of this Proba 2 micro-satellite, currently made of aluminum, was used as the basis for a comparative study based on ANSYS software to evaluate the properties of composite materials for a lighter-weight design. *(Image courtesy ANSYS and Verhaert Design and Development)*

You know a topic is hot when people don't want to talk about it for fear of divulging their design choices and techniques to the competition. Right now, that topic is composites as industries look to cut weight, increase durability, and save operating costs for customers. Despite the reticence to speak among some players, *DE* managed to get a look at some parts and products that bring composite performance to new heights. (For related analysis software information, see "The Life of Composite Materials," May 2007 *DE*.)

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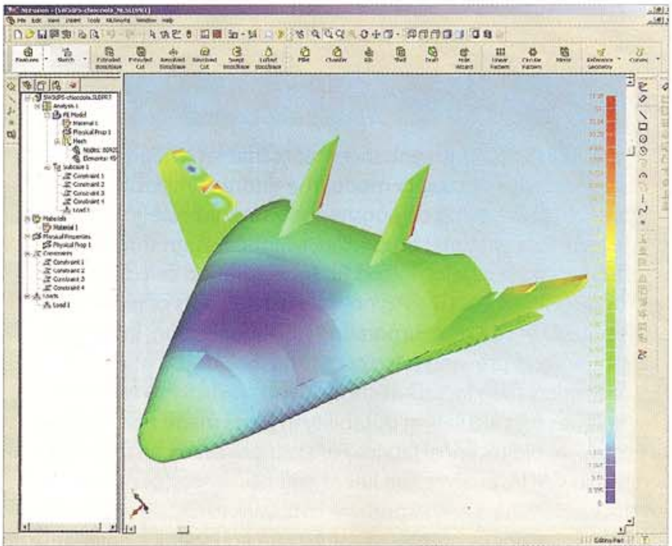

General stress analysis of initial X-33 design, as an example of a reusable NASA launch vehicle with composite material elements. *(Image courtesy Noran Engineering, Inc.)*

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As far back as the early 1990s, Noran Engineering participated in the Phase I design stage of the X-33 aircraft, a technology demonstrator for NASA's "next-generation" of reusable space launch vehicles intended to reduce both business and technical risks. One of the vendor teams, led by McDonnell Douglas, used NEiNastran to analyze the performance of a proposed lightweight thermal protection system (TPS) made of a high-temperature ceramic matrix composite called carbon-silicon carbide (C/SiC).

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McDonnell Douglas successfully demonstrated that NEiNastran provided accurate structural and thermal analysis results for a C/SiC system encapsulated with fibrous insulation and laminated to an external metal layer. (The X-33 program itself was later awarded to a Lockheed-Martin team, then subsequently lost its funding and was cancelled.) More recently, Scaled Composites, the aerospace composites development company that won Burt Rutan's SpaceShipOne contract, chose NEiNastran software as part of its analysis tool portfolio.

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Greg Brown, Simulia Product Manager for CAE, notes, "There are lots of niche tools out there, but the real advantage of V6.7 is incorporating [the information] into a general nonlinear FEA program, with all pre- and postprocessing included."

The unified approach considers such factors as contact and plasticity as well as fastening and bonding techniques for calculating durability in parts made from carbon fiber-reinforced plastics or uni- or bidirectional fabrics. For example, users can take a ply-stacking design generated in CATIA, analyze the linear and non-linear performance in ABAQUS, modify the stack parameters, and export the data back to CATIA in a closed-loop sequence. The process incorporates a plug-in of Advanced Fiber Modeler and Composites Link software from Simulayt.—PW

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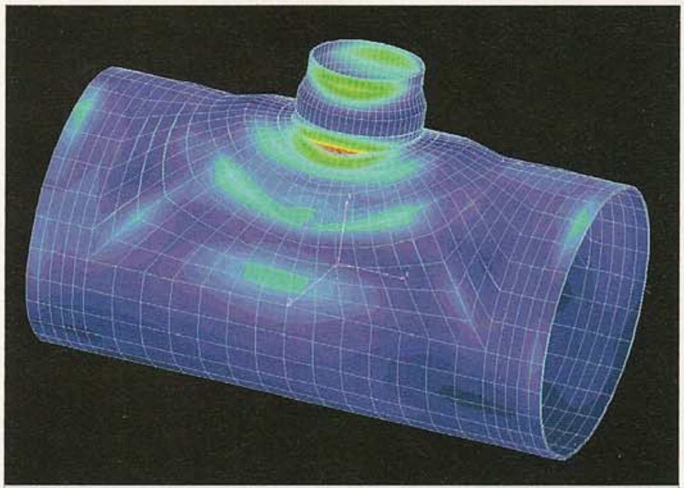
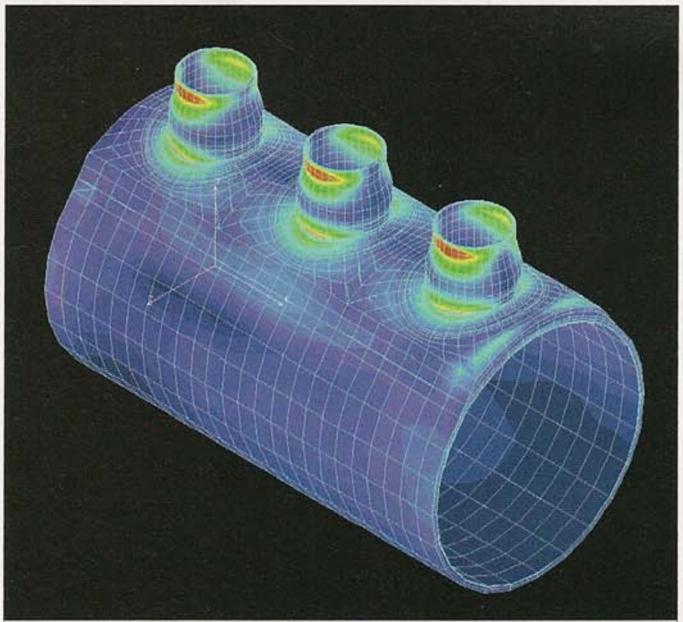


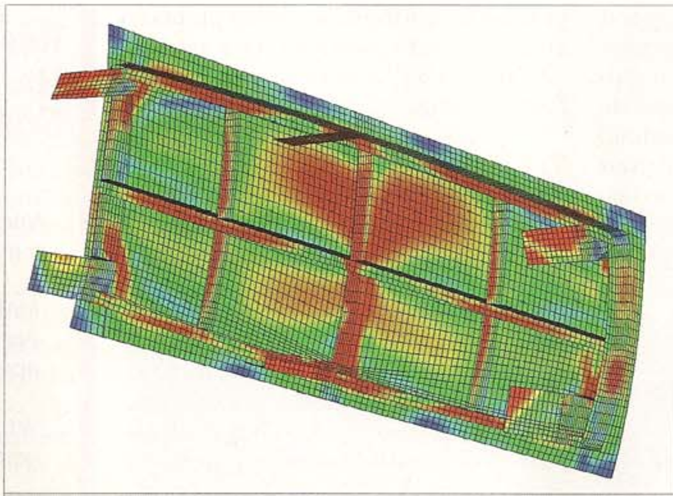
Composite pipe reducing tee (reinforced) developed using COSMOSM. The Finite Element Model, developed using the COSMOS Command Language, enables dimensional parameters, mesh density, and materials to be quickly changed to assess a wide range of size configurations. *(Image courtesy of Grantec Engineering Consultants, Inc.)*



This composite multibranch pipe manifold section model was developed using COSMOSM. Five discrete composite materials are defined through the pipe walls. Input parameters including geometry can be quickly changed to regenerate an FE model to assess various configurations. *(Image courtesy of Grantec Engineering Consultants, Inc.)*

of the original door was left unchanged; composite rupture at smaller deformation levels was allowed as long as the desired strength and energy absorption was achieved; and impact testing required ramming a 12-in. diameter cylinder sideways into the panels to create a static deformation at various depths of intrusion per standard automotive testing.

ESG used LS-DYNA from Livermore Software Technology Corporation and Optistruct software from Altair Engineering to analyze the strength of both materials. The proposed composite design showed higher strength and energy absorption than steel at displacements below 8 in. and had a mass that was 60 percent of the original. Typical automotive industry design requirements such as dent resistance, local structural resistance to buckling, and overall stiffness were also shown to be on par or better than standard designs. An optimized design would improve even these results.



Stress analysis of proposed advanced thermal protection system for a vehicle such as the X-33. Designed of composite materials (improved carbon fiber protected by silicon-carbon matrix) that would eliminate the current practice of recoating Space Shuttle tiles for waterproofing after each flight. *(Image courtesy Noran Engineering, Inc.)*

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ABAQUS customers such as Boeing know that this software has long been capable of modeling nonlinear damage and fractures in composites. Its latest revision is also capable of predicting the durability of the adhesives used in composite laminate manufacturing as well as final part assembly. While traditional aircraft used riveted metal sheets (and every drilled hole compromised strength), designs with today's composites offer equal or superior performance when properly analyzed and assembled. (*See sidebar, "ABAQUS V6.7 Unifies FEA with Pre- and Postprocessing," page 4.*)

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When you've been successfully transferring corrosive fluids through stainless-steel power-plant piping for years, switching to fiber reinforced plastic (FRP) pipes simply to trim costs isn't enough. Proving that FRP will do the job equally well was the task taken on by analyst Richard Grant of Grantec Engineering Consultants. A long-time user of COSMOS analysis tools from SolidWorks Corp., he finds the flexibility of the COSMOSM command language gives him the speed he needs to analyze the complexities of composite structural behavior.

The piping design in question had a thin liner surrounded by four additional layers that could vary in their individual designs. By scripting an analysis sequence, Grant could quickly change parameters like the internal diameter (ID) of the main pipe, the IDs of the branches, the thickness of layers, and any material properties to evaluate the effect of reinforcements around nozzle openings. Automatic remeshing made it easy to do multiple studies of pipe diameters ranging from 12 in. to 48 in. while comparing structural results to ASME code requirements.

Grantec Engineering also has years of experience analyzing the structure of large ships, offshore structures, and submerged equipment. Grant says that COSMOSM gives him the ability to readily handle designs with both complex geometries and intense loading by the forces of ocean waves or seismic shocks.

High-Flying Ideas

UGS has had composite analysis capabilities for years in both its NX and Femap lines, as evidenced by the success of the design program for Adam Aircraft's A500, a pressurized twin-engine aircraft (with both engines mounted along the centerline) featuring carbon-fiber composite (CFC) airframe construction. When Adam Aircraft decided on a CFC skin in the late 1990s, the idea seemed unusual to the conservative general aviation crowd; later, Boeing's decision to use composites for its 787 Dreamliner made it seem obviously the right choice — just ahead of its time.

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Information

Altair Engineering, Inc.
Troy, MI
altair.com

ANSYS
Canonsburg, PA
ansys.com

Componeering Inc. (Convergent Mechanical Solutions)
Seattle, WA
bconverged.com

COSMOS, the Analysis Division of SolidWorks
Santa Monica, CA
cosmosm.com

ESG Engineering
Tempe AZ
esgeng.com

Grantec Engineering Consultants, Inc.
Hammonds Plains, Nova Scotia
grantec.ca

Livermore Software Technology Corporation
Livermore, CA
lstc.com

Noran Engineering Inc.
Westminster, CA
nenastran.com

Simulayt Ltd.
Brookwood, Woking, Surrey, UK
simulayt.com

Simulia, Inc. /Abaqus
Providence, RI
simulia.com

UGS/Siemens
Plano TX
ugs.com

Vistagy, Inc.
Waltham, MA
vistagy.com

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MATERIALS
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apsci.com

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margins of safety based on different criteria.

Many Players, Many Angles

Knowledge and resources for making the most efficient use of composites also come from users across the manufacturing spectrum. Software such as FiberSIM from Vistagy captures the nuances of the actual composite lay-up approach to help manufacturing teams translate a CAD design into real parts more rapidly, efficiently, and accurately. And suppliers such as Specialty Materials (formerly part of Textron Systems) deliver the real goods with such offerings as titanium metal matrix composite (MMC) preimpregnated sheets.

Just remember, for technology that seems heavy on verbiage, it's actually very light stuff, and for many applications, it's the right stuff, too. ■

Contributing Editor **Pamela J. Waterman** *is an electrical engineer and freelance technical writer based in Arizona. You can contact her about this article via e-mail sent to DE-Editors@deskeng.com.*

The Adam Aircraft A500 is a pressurized centerline-mounted twin-engine plane with a carbon-fiber composite skin designed with NX and Solid Edge software from UGS. *(Image courtesy UGS)*

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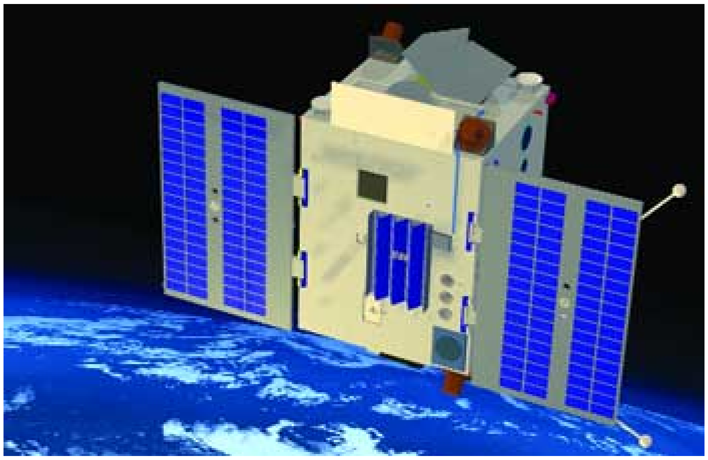

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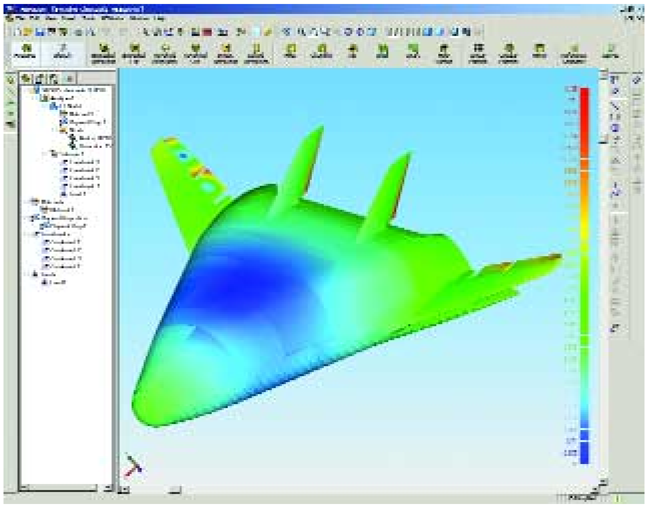

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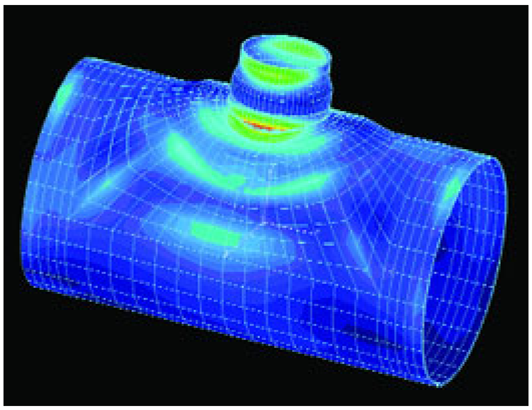

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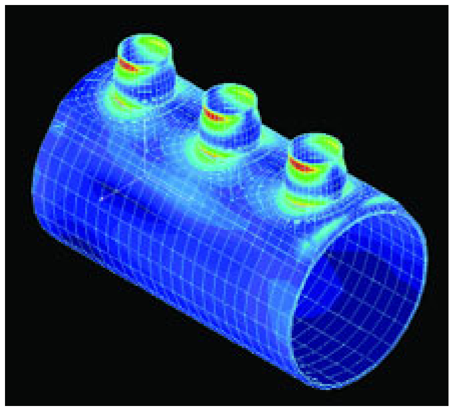

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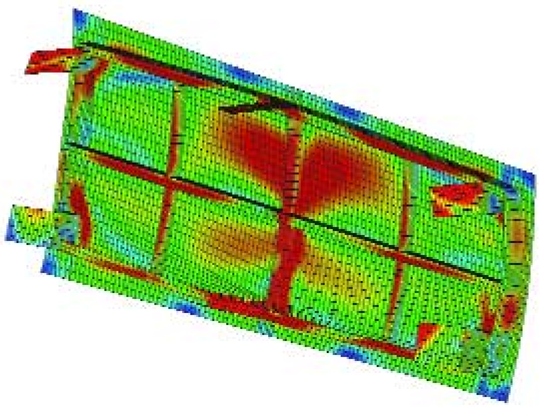

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More Information

Altair Engineering, Inc.
Troy, MI
altair.com

ANSYS
Canonsburg, PA
ansys.com

Componeering Inc.
(Convergent Mechanical Solutions)
Seattle, WA
bconverged.com

COSMOS, the Analysis
Division of SolidWorks
Santa Monica, CA
cosmosm.com

ESG Engineering
Tempe AZ

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Applied Sciences Inc.
apsci.com

W.L. Gore & Associates
gore.com

Specialty Materials, Inc.
specmaterials.com

Yokohama Aerospace America, Inc.
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Contributing Editor Pamela J. Waterman is an electrical engineer and freelance technical writer based in Arizona. You can contact her about this article via e-mail here.

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