ConnectPress pro e community
For users of Pro/ENGINEER, Windchill, and other PTC affiliated products

One Small Step for FiberSIM® Software, One Giant Leap for Advanced Composites

By Mike Kirsch, NASA

During NASA's development of a Composite Crew Module (CCM), it became obvious that VISTAGY's FiberSIM® composites engineering software was a vital solution that significantly enhanced our team's efforts in everything from design to fabrication. When it was all over, the team of NASA and industry engineers that collaborated on the design and manufacture of the crew module had a hard time imagining how they could have completed the task *without* FiberSIM. We used FiberSIM on just about every part of the CCM that was made of advanced composites.

The composite crew module goals and objectives defined by the NASA Administrator in January 2007

When NASA originally considered employing composites in manned spacecraft, it had conflicting considerations. On the one hand, there were concerns that composites might have an unacceptable leak rate and insufficient damage tolerance. On the other hand, composites potentially offered lots of benefits, including reduced weight and lower lifecycle costs.

The most appealing aspect of applying composites to the crew module primary structure was a potential 10-15 percent reduction in weight on complex shapes compared to its aluminum counterpart. In space travel, where every additional ounce of weight drives costs skyward, a 10-15 percent reduction in the weight of the crew module would have a profound effect on payload capacity and mission expense.

The potential of advanced composites was compelling, so the NASA Engineering and Safety Center (NESC) was charged by Mike Griffin (then NASA administrator) with putting together a team of government and industry structures experts to gain experience in making use of new composite construction and inspection technologies specifically for manned spaceflight structures.

Composites come of age at NASA

One of the primary goals of the program is to determine which composite materials are best suited for future NASA spacecraft. I am convinced that composite spacecraft will play a major role in NASA's future missions. Composites are already being considered for use in structures where weight is critical, including lunar landers, habitation modules and launch vehicles.

Another goal of the project was to gain experience putting together an organizationally flat, collaborative and geographically dispersed team that could work together effectively. The collaborative effort was a success. Nine of the 10 NASA sites around the country contributed to the project as well as a number of significant aerospace companies, including ATK, Lockheed Martin and Northrop Grumman.

The team considered nearly a dozen concepts and decided to make the CCM primary structure a stiffened honeycomb sandwich of carbon fiber. It is composed of upper and lower pressure shells spliced together to help meet the accelerated schedule and keep non-recurring costs under control (a mass produced pressure shell would likely be one-piece using multi-part extractable tooling). Further strengthening the shell are gussets, panels, and various metallic fittings to distribute point loads. The lower shell is stiffened by the floor backbone forming a unified structure which carries pressure and inertial loads via bending.

“Back of the envelope calculations predicted that this concept would reduce the mass of the lower structure by 20 percent over a traditional ring frame pressure head design, ”said Ian Fernandez, lower structure lead at NASA Ames Research Center in Moffett Field, California.” The concept was verified by finite element analysis and we went with it.”

Pictured are fabricators at ATK in Iuka, MS laying up plies of composite material to create the inner honeycomb sandwich skin of the NASA crew module. The plies are being laid up with the assistance of a laser projection system (as indicated by the faint green lines on the top and side of the capsule), which is driven by FiberSIM software. With FiberSIM's Laser Projection module, engineers can automatically generate laser data files from within their CAD system directly from the 3D model of the composite part. This significantly increases engineering and manufacturing productivity, greatly reduces errors and makes updating and maintaining laser projection data easy.

Mr. Fernandez has worked on composite structures for over a decade. He used FiberSIM during the SOFIA (Strategic Observatory for Infrared Astronomy) project and to build a 10 foot aerodynamic aperture surface for a modified 747 commercial aircraft.

"Blown away by FiberSIM"

"I saw FiberSIM for the first time at the SAMPE® Conference (Society for the Advancement of Material and Process Engineering) back in 1998 and was blown away," said Mr. Fernandez. "The aperture was simple compared to the complexities of the crew module, but it didn't make a difference to FiberSIM."

It's a big step to go from what's in Pro/ENGINEER® Wildfire® to the manufacturing floor and then layup. The fidelity between what we saw in Pro/E® and how it translated in terms of wrinkles, ply angle and flat patterns was the true test of FiberSIM. (Editor's Note: FiberSIM is also fully integrated into CATIA V4, CATIA V5 and NX).

"One of FiberSIM's strengths is defining individual segments of plies, often referred to as flags," said Mr. Fernandez. "It calculates how big and what shape the flags can be before they become too difficult to conform to the tool."

FiberSIM can display important features of a ply, such as splices, darts, boundaries, local coordinates, warp angle, etc. to help engineers build the best possible part.

"We paid special attention to minimizing overlaps in fit-up critical areas to prevent any issues down the road during assembly," said Mr. Fernandez.

Shown is the composite crew module during the assembly splice operation at ATK in Iuka, MS., prior to the installation of graphite epoxy doublers. FiberSIM software helped NASA capitalize on the potential of composite materials by reducing risk, design and manufacturing costs as well as complexity and cycle times. The software has proven in production to increase engineering productivity and reduce development time, material waste, design revisions and tooling costs.

FiberSIM then calculates what shape the flat pattern needs to be and exports that data to manufacturing for the NC cutting machine. Another critical FiberSIM capability is generating data to drive accurate laser projections of the flag boundary.

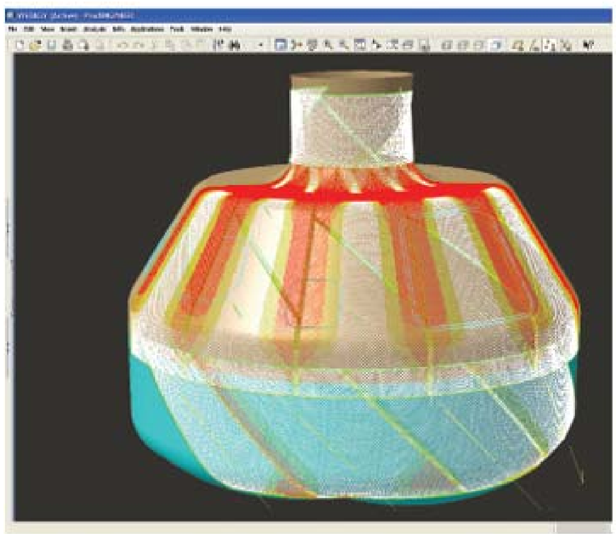
"Without this boundary projection on the tool, determining the location of the flags would be a painfully slow process and quality would be degraded," said Mr. Fernandez.

FiberSIM was also used to produce laser projection files to help locate and trim the core (in place on the tool) and also to create an inspection grid on the skins.

Determining if composites have the 'Right Stuff'

I don't think it would be economical to construct something like the crew module without FiberSIM. You could build a simplified version for the same price, but mass and quality would take a big hit, driving operational costs way up. For state-of-the-art applications like this where every aspect is critical, FiberSIM was the perfect solution.”

How will NASA decide if the CCM meets expectations? It will give it the old shake test. Testing will be performed on a static test rig that will apply force to critical parts of the CCM, simulating the stresses encountered during a mission.



Pictured is a simulation generated by FiberSIM showing how fibers deviate from the specified orientation as a ply of composite material is draped over a tool for making the NASA composite crew module. The areas highlighted in white indicate fibers whose orientations fall within an acceptable range from specification while the yellow and red areas indicate where fibers mildly (yellow) or significantly (red) deviate. FiberSIM enables users to understand the behavior of continuous fiber reinforced composite materials as they conform to complex curvature, ensuring that stiffness and strength requirements are met and validating that the manufactured part matches the design intent.

If the results of the CCM project are positive, it is likely that there will be a composite manned spacecraft taking off sometime in the future. In fact, the project has already paid dividends: The developers of NASA’s Orion crew module (who are also using FiberSIM) are applying lessons learned from the NESC CCM to composite aspects of their craft. The Orion structure is comprised of 40 percent composites by mass. The main difference is that Orion’s pressure module is metallic while the NESC's pressure module is composite.

Our hope at NESC is that one day someone will be sitting in that module heading into space.

Don't bet against it.

Mr. Kirsch is the NASA Engineering and Safety Center Principal Engineer and Project Manager of the Composite Crew Module Program chain. VISTAGY solutions help customers deliver robust products on time and on budget by increasing productivity, improving communication throughout the product lifecycle and enabling better-informed decision-making early in the design process. The company's customers include over 200 of the world's leading manufacturers in the aerospace, automotive, transportation interiors and wind energy industries. VISTAGY is headquartered in Waltham, Massachusetts, USA and can be reached at +1.781.250.6800 or by visiting www.vistagy.com.