Keeping the Battle Phrog Flying

Upgrades add life to airframes that supported troops over decades.

The CH-46 helicopter, introduced in 1964 and known as the "Battle Phrog," has supported a variety of missions over many decades in various capacities. These aircraft continue to be crucial battlefield assets, whether it be inbound flights of food, fuel, or ammunition for the troops on the ground, or outbound flights carrying the wounded to field hospitals or safer ground.

As the Battle Phrog approaches 50 years of service, efforts are underway to reduce operating cost while keeping the platform tactically relevant. In addition to critical engine and avionics/electronics upgrades, considerable effort has focused on replacing worn or corroding metal components with advanced composite components, in an effort to reduce weight and reduce maintenance requirements, while simultaneously increasing the usable payload.

The CH-46E helicopter is also known as "The Battle Phrog."

The National Center for Defense Manufacturing & Machining (NCDMM, Latrobe, PA) recently worked on a joint project with NAVAIRSYSCOM PMA 226 (Cherry Point, NC) to replace the current Stub Wing Upper Access Panel (SWUAP) with a new panel comprised of advanced composite materials. The SWUAPs are located on the stub wing on each side of the CH-46 airframe.

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"The NCDMM was engaged to assess the SWUAP for improved performance and weight reduction," states Jon Winchester, H-46 deputy program manager for airframes, NAVAIRSYSCOM PMA 226. "The internal staff of technical experts and selected Alliance Partners engaged with Manufacturing Alliance Partner VX Aerospace [Morganton, NC] and North Carolina A&T State University [Greensboro, NC] to develop, manufacture, and test the SWUAP panels. The NCDMM team has defined a configuration and supplied a panel that met and exceeded the requirements."

The new design was developed to remedy recurring structural and maintenance problems with the existing composite SWUAP panels. The existing panels have a slight fore-and-aft curvature, and are composed of 50 plies of unidirectional carbon fiber. Four 27-ply unidirectional U-channel stiffeners are spaced along the underside of the SWUAP panel. The panel also includes circular cutouts and metal rings that mate with fuel-cell bladders housed in the stub wing itself.

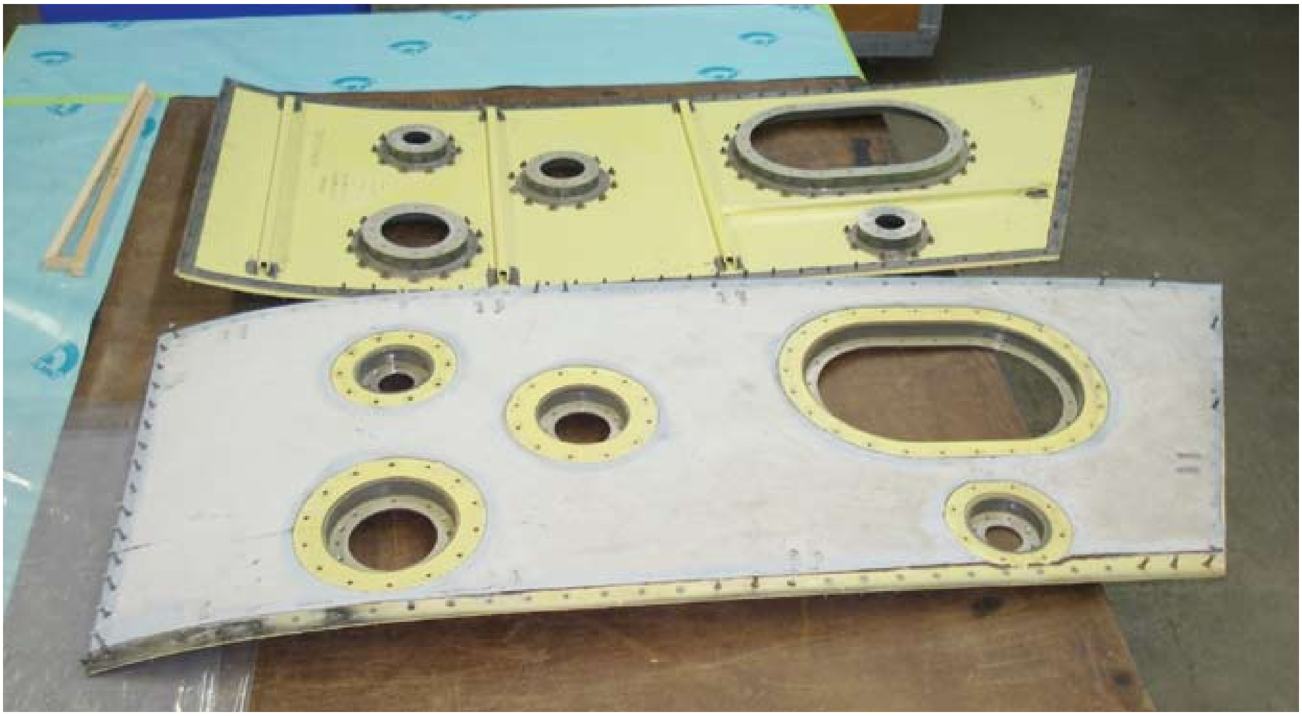
Over the years, it became apparent the U-channel stiffener design itself was deficient because it did not adequately distribute the stresses when impact loading was applied to the top surface. Rather than using the internal steps in the side of the fuselage, some aircraft maintainers jump and occasionally drop heavy items on these panels, or use the panels as a step platform to climb up to the engines to perform maintenance. This typically results in bond failures between the stiffeners and the SWUAP panel itself.

The stiffener bond failures require significant rework time to repair, and without spare SWUAP panels in the supply system, mission readiness is greatly reduced. Moreover, the current panels have been repaired repeatedly, and the repair kits are no longer available.

Tasked to resolve the current SWUAP panel issues, the NCDMM partnered with VX Aerospace and NC A&T University to design, develop, and produce a new lighter, stronger, and more durable SWUAP panel. VX Aerospace was then asked to develop the improved design. To accomplish this, VX Aerospace worked with NC A&T University to replace the discrete U-channel stiffeners with Rohacell core "islands" spaced between the various metal fittings.

NC A&T University designed and analyzed various SWUAP panel concepts for load patterns, and developed a composite ply lay-up configuration to satisfy the enhanced performance requirements. The panel was modeled as fixed-fixed beam with a length of 20.34" (0.5 m), and subjected to a point load of 400 lb (180 kg), worst scenario, compared to an equivalent patch load of 400 lb.

The new composite lay-up configuration comprises an outer copper mesh layer (for lightning-strike protection), a fiberglass barrier layer, eight layers of carbon fiber, the Rohacell core, and eight more layers of carbon fiber. The resulting SWUAP panel is stronger, more durable, and 10% lighter (27.1 lb [12.2 kg] for the new design compared to 29.8 lb [13.41 kg] for the existing design). More importantly, the



The existing SWUAP panels have a slight fore-and-aft curvature, and are composed of 50 plies of unidirectional carbon fiber.

Rohacell core islands and the advanced carbon fiber materials combine to provide superior load dissipation capabilities to eliminate the existing stiffener bond failure mode when under load. These islands provide greater surface area than the existing stiffeners, and result in much lower stress concentrations to greatly reduce, if not eliminate, the current bond failure mechanism.

In addition, out-of-autoclave materials were specified for the project, to ensure cost-effectiveness for the composite materials and the composite lay-up process. Once the composite panels were manufactured by VX Aerospace using an out-of-autoclave lay-up and curing process, the NCDMM developed and implemented new machining techniques using advanced cutting-tool technologies and programming techniques to reduce cutting times and reduce scrap.

In typical short-run machining operations for composite structures, manufacturers use hand-held pneumatic drills and routers to conduct simple machining operations, such as drilling and edge-of-part trimming. Basic trim fixtures are also developed to assist in trimming the structures to final shape and size. These types of techniques are common throughout the industry when quantities do not justify the purchase of machining centers. However, there are drawbacks to these techniques, including fraying of the material, delamination, and splintering of the composite material.

When hand tools are used, cutting forces applied to the material will inevitably vary, thereby inducing delamination. To forestall delamination and reduce scrap, new cutting tools were integrated into the trim/drill processes by the NCDMM. The tools, drills and end mills, were designed to reduce the thrust that panels are subjected to during the drilling operation, as well as reduce the pulling action on the material when trimming the edges of the panel. Delamination and splintering were eliminated. The geometry of the cutting tools and suitable fixturing are also important attributes when machining composites, and should be fully investigated. Different composite materials (carbon fiber, fiberglass, Kevlar, etc.) machine differently, just like different metals machine differently.

"Engaging with the NCDMM on this project provided us with broad access to new machining technologies, among them several we were unaware of, lending credence to the old maxim, 'You don't know what you don't know,'" says Raymond Jones, VX Aerospace CEO. "However, the NCDMM's technical assistance and attention to manufacturing details throughout the project helped us provide SWUAP panels that exceeded program objectives."

With the new SWUAP panels, the CH-46 helicopter program benefits in several ways, including having a reliable source of supply for the SWUAP panels, elimination of stiffener repair rework and maintenance, and reduced turnaround time during depot availabilities. All this leads to greater aircraft operational availability.

Spearheaded by the NCDMM, this project designed and implemented a solution that reduces or eliminates the repair/rework of SWUAP panels by utilizing lighter, stronger, and more durable out-of-autoclave composite materials, combined with an efficient and cost-effective composite manufacturing process.

The systematic approach to the design of the new SWUAP panel encompassed:

- Selecting out-of-autoclave advanced composite materials and lightweight Rohacell core materials used within the panel;
- Implementing core "islands" as part of the ply schedule to add additional load dissipation area;
- Implementing out-of autoclave manufacturing and curing processes to reduce manufacturing costs;
- Employing advanced cutting tools to increase productivity, eliminate delamination, improve quality, and reduce scrap; and
- Conducting structural verification testing on the SWUAP panel to ensure performance enhancements.

All the advanced processes and tooling technologies utilized in this project provided a cost effective, yet superior solution to return the Battle Phrog to service as quickly as possible to support our warfighters.✈

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