

A Good Idea Comes to Fruition

The F/A-18 Center Barrel Replacement-Plus Program

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Naval jets live hard. That point is well illustrated by the U.S. Navy's premier fighter/attack aircraft, the F/A-18 Hornet. Achieving initial operating capability in 1984, the Hornet was designed to fly 6,000 hours and accumulate 2,000 arrested landings (landings on board an aircraft carrier where the aircraft is abruptly stopped by the use of a tail hook and arresting cable stretched across the flight deck) and 8,300 total landings. Day after day, the jets are stressed to the edges of the engineering envelope, and the real-world toll of repeated oscillating G-forces isn't easily predicted when the structures are initially designed.

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Such destructive forces have their greatest effect on attach points, where the aircraft's wings and main landing gear join its fuselage frame. Those attach points, along with the surrounding fuselage section, are dubbed the aircraft's center barrel. One expression of the destructive toll is a metric called wing root fatigue life expended (WRFLE), and it is calculated through a complicated engineering analysis that determines each aircraft's remaining structural integrity at the critical wing attach points. Thus, a severely used aircraft can have far fewer flight hours and landings than the stated design limits and still be scrapped as a result of excessive metal fatigue wear and tear.

WRFLE values increase over time at variable rates depending on the aircraft's environment, mission, and operational use. For the F/A-18 C and D models, WRFLE is capped at 0.78 for older aircraft and 1.0 for newer models. The reason for the difference is that engineers learned from the testing of older aircraft and designed newer aircraft to be less susceptible to fuselage fatigue cracks than their predecessors.

Origins from a Crash Landing

The life of naval aircraft is one of repeated controlled crashes. Tasked with landing 25,000 pounds of hardware on a floating airport in the middle of the ocean that may be moving several feet per second laterally and vertically, naval aviators aren't to blame for being a bit decisive when landing. Such decisiveness translates to abrupt forces resonating through the aircraft that contribute to the dreaded increase in WRFLE with each additional carrier landing.

In 1991, a Hornet with low flight hours experienced an excessively hard carrier landing that caused what was considered irreparable damage to the aircraft's center barrel section. Normally, the Navy would rely on one of its two Fleet Readiness Centers (organic depots) to repair the damage. The crippled Hornet was shipped to the Navy's FRC Southwest in San Diego, Calif., for damage assessment. The damage was so severe that it was judged to be beyond even the FRC's capabilities. In the past, this type of damage would remove the aircraft from service to be cannibalized for spare parts—a sad end for an almost-new airplane. After evaluating both the aircraft and their options, the Navy turned to the private sector in hopes of finding a way to repair the low-hour aircraft rather than accepting the traditional outcome.

Industry repair estimates were as high as 50 percent of the original procurement cost, and the time to design and build repair fixtures was forecast at three years. The complicating factor that drove these estimates was that the separation point of the fuselage for this repair was different from the fuselage separation point for the original construction. This eliminated the ability to use existing equipment and meant that everything had to be designed and built from scratch. Hence, they didn't see commercial repair as a viable option. Unwilling to retire a relatively new aircraft, the Navy reassessed its options.

A team of depot engineers, technicians, and logisticians within FRC Southwest rose to the challenge to do what had never been done before. Given the green light to think and act outside the box, they developed the machinery and technology to remove and replace the damaged center barrel. They created a procedure that allowed them to break apart a Hornet where it was never designed to be taken apart in order to replace the crucial center part of the aircraft that supports the wings and landing gear. In the end, FRC Southwest completed the initiative in just 18 months at a cost of approximately \$4 million. More important, they saved a low-flight-hour aircraft from being scrapped.

A Perfect Storm

There were further challenges for the Hornet in the future. The 1997 retirement of the medium-attack bomber, the A-6E Intruder, coupled with the Hornet's participation in three subsequent wars has caused a higher-than-anticipated aircraft utilization rate. Because of those unanticipated circumstances, the Hornet had more tasks to accomplish in a shorter period of time than the designers had anticipated. With every increment of increased demand, the Hornet's calendar life expectancy decreased as a result of the increased number of hours flown and landings, coupled with taking fewer hours to reach WRFLE limits because of the stresses imposed on the aircraft as it flew its training and combat missions.

FRC Southwest's innovations, however, established a process for repair and maintenance that could be improved and adapted to respond to today's requirements.

Expanding an Innovative Process

Techniques developed by the FRC Southwest team from this incident transformed the Hornet community's views of the impact of WRFLE on an aircraft's serviceability and gave DoD valuable breathing space in developing a successor platform for the Hornet. FRC Southwest, along with its sister depot FRC Southeast in Jacksonville, Fla., now performs F/A-18 center-barrel repairs on a repetitive basis.

The process, named the Center Barrel Replacement-Plus (CBR+) Program, has morphed to add additional repairs that extend to other aspects of the F/A-18's structural life. By detecting, removing, and replacing corroded parts, the process eliminates much of the effort that would have been required to inspect over 200 hot spots inside the aircraft's center barrel section—previously accomplished during scheduled maintenance—then design and analyze repairs for each instance of corrosion or other damage found. The CBR+ process also includes the removal and replacement of portions of the aircraft's spine (the dorsal deck) and analysis of any local modifications that may be required to fit the new CBR module at fuselage interfaces, including crack initiation life analysis (the time it takes to generate a fatigue crack in a new part under fatigue test and/or service loads), and crack growth analysis (the time it takes a crack to grow from

crack initiation to a size that will cause the part to fail under maximum service loads).

As it has evolved, CBR+ has come under the management of the Naval Air Systems Command's F/A-18 Program Office (PMA 265). CBR+ kits are funded and procured through Northrop Grumman (the prime contractor) and installed by the two FRCs. Attaining the formal recognition as Engineering Change Proposal 904, CBR+ is now slated for F/A-18s whose fatigue life reaches WRFLE level of 0.78 or catapult/arrested landing limits as described elsewhere in this article. Installing the Engineering Change Proposal requires about 14,000 man-hours per Hornet—a lot of time and money, but given the alternatives, well worth the investment. The cost for the CBR+ replacement is now approximately \$2.5 million as cost reductions have been realized since the first replacement was done.

The fixture and tooling designed at FRCSW for the CBR+ process is a story unto itself. Three aluminum work stands, standing over 16 feet high, were designed and constructed to enable the depot technicians to work from both above and below the aircraft. The stands are able to handle the specialized tooling used by sheet metal mechanics and have trimmed off about 2,000 manhours per CBR+ event. Furthermore, the stands ensure that the interface alignment between the replacement center-barrel and remaining fuselage sections is maintained to factory tolerances. In other words, the aircraft isn't misaligned when the process is complete—no small feat when working with parts the size of small automobiles.

CBR+ dramatically reduces engineering requirements, labor costs, and processing time (which equates to out-of-service time as well) by replacing the entire center barrel module at splice joints versus completely disassembling the core of the airframe, replacing dozens of worn-out components, installing major modifications to dozens more, and reassembling the airframe. According to Rick DeVore, the FRCSW engineer credited with leading the CBR+ innovation process and co-author of this article, "The CBR+ process allowed us to extend the service life of the aircraft and minimize much of the analysis that will be required during the planned service-life extension program."

A Best Business Practice

The CBR+ program has substantially extended the service life of the F/A-18 and provided an economical alternative to procuring new airframes. Program manager for PMA265 and co-author of this article, Navy Capt. Mark Darrah, observed, "The CBR+ program

has provided PMA265 with a lot of capability that otherwise would not be possible. It cannot be overestimated how these types of initiatives can act as an enabler to leverage greater capability from our limited resources."

Navy Capt. Fred Hepler, the F/A-18 deputy program manager and co-author of this article, had a similar comment when he stated, "The CBR+ program is a great illustration of the type of innovation possible at any level of an organization. There are a lot of great people with a lot of great ideas. Weapons systems program offices cannot afford to miss any opportunity to further enhance their program's efficiency in terms of performance, cost, or schedule."

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Those assessments, by any definition, place CBR+ firmly in the realm of a best business practice. Since 2001, more than 110 CBR+ procedures have been completed at the FRC facilities in California and Florida. Currently, there are more than 30 aircraft per year scheduled to complete the procedure through 2017.

CBR+ has enabled the naval aviation enterprise to address its air combat readiness requirements while maintaining a more balanced, cost-effective readiness approach toward extending the service life of the Navy's fleet of Hornet aircraft. Rear Adm. Mark Skinner, program executive officer for Tactical Air Programs and co-author of this article, remarked that, "With resources under increasing scrutiny, initiatives like the CBR+ program are critical to the continued readiness of naval aviation. Programs will continue to be asked to seek out-of-the-box solutions to problems. I think the CBR+ program is a great illustration of how the acquisition community can work together to benefit not only our naval aviators but our taxpayers as well."

Given its grass-roots evolution and CBR+'s impact on naval aviation readiness, it's hard to argue with these points.

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