Improved Sustainment of U.S. Air Force Aircraft Engines:

'Doing More Without More' With Alternative Parts and Repairs

By Colonel Joe Wilson and Colonel (Ret) Jim Diehl

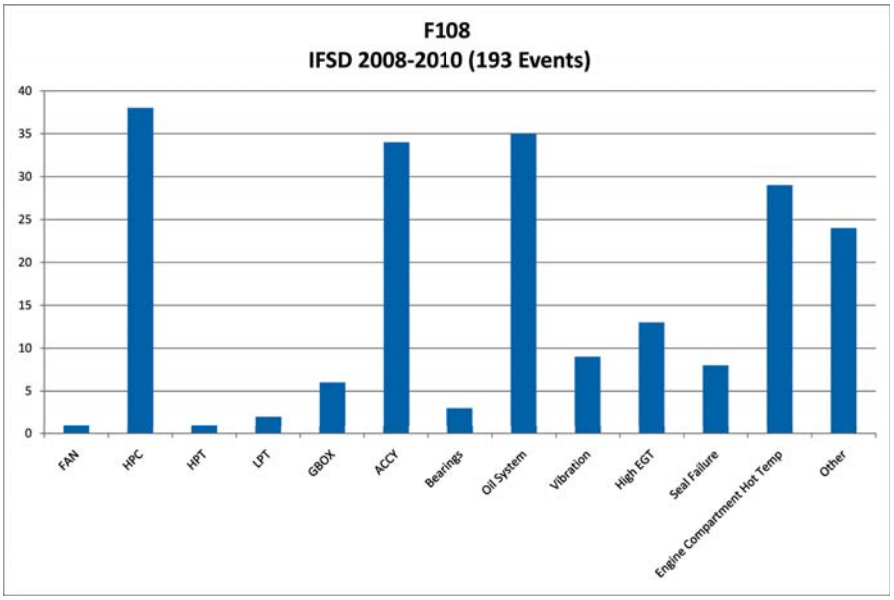
"...we have a continuing responsibility to procure the critical goods and services our forces need in the years ahead, but we will not have ever-increasing budgets to pay for them. We must therefore strive to achieve what economists call productivity growth: in simple terms, to DO MORE WITHOUT MORE."
-Ashton B. Carter, Under Secretary of Defense for Acquisition, Technology, & Logistics (September 14, 2010)

As part of the nation's military strategy to address current and recent conflicts around the world, the U.S. Air Force has been flying combat missions for more than 18 consecutive years. This has accelerated the aging of aircraft engines through significant increases in engine cycles, operating hours and exposure to harsh operating environments. As a result, the Warfighters have experienced dramatic drops in wartime spare levels and a steady decline in overall engine reliability

USS John S. McCain (DDG 56) powered by four LM2500 engines configured with compressors and high pressure turbines common to the US Air Force TF39 engine powering the C-5 aircraft fleet. (Source: US Navy)

and performance. The KC-135 fleet has experienced an increase in F108 engine in-flight shutdowns and failures that have resulted in a struggle during the past two years to achieve minimum Warfighter engine spare levels.

According to Chuck Melton, Deputy National Guard Bureau/A4, the F108 propulsion system is now "ANG's worst for fleet health," with engine spare levels well below wartime requirements. From fiscal year 2008 through fiscal year 2010, the overall KC-135 fleet (Air National Guard and Air Mobility Command) experienced 193 engine failures or shutdowns, as reported to the Air Force Safety Center. Similar patterns across the Air Force fleet have resulted in greater demands for engine maintenance, a severely stressed engine supply chain and engines retaining their position as the Number One sustainment expense within the Air Force Materiel Command.



Wartime flying operations are placing stress on the U.S. Air Force engine fleet. The USAF F108 engine fleet averages 60 engine failures/in-flight shutdowns per year that threaten crew safety and mission readiness. (Source: HQ AFMC/SEF)

A culture change is needed to introduce a "do more without more" ethos and robust new engine sustainment strategy to restore Warfighter confidence and support, in terms of sufficient wartime spares and improved engine performance. In today's fiscally challenging environment, doing more without more also translates to identifying a strategy for controlling engine maintenance and material costs while ensuring the safety, reliability and top performance of power systems.

Business As Usual Weakens Sustainment

With some of today's engines projected to remain in service past calendar year 2040, it becomes clear that "business as usual" is no longer a viable engine sustainment strategy as we look to the future of U.S. Air Force engine sustainment. Strategists within the organization need to rethink the current approach to sustainment.

Reliance for aftermarket parts and materials historically has been on the aircraft engine Original Equipment Manufacturers (OEM), resulting in an acquisition environment in which more than half of the engine sustainment funding is spent via sole source contracts. The lack of alternative sources for parts and services and lack of competition in negotiating cost makes it difficult for the US Air Force to negotiate substantial price improvements, supply chain reliability and other contract performance concessions.

The other military services are experiencing a similar reliance on sole source engine contracts. Today this long-time Department of Defense practice represents a missed opportunity to utilize the same competitive dynamics of the commercial aircraft marketplace – and to leverage the competition to deliver to the Warfighter's real price, schedule and performance improvements that have been commonplace in commercial aviation for decades.

Lt Gen Don Wetekam, (ret), USAF former U S Air Force Headquarters Deputy Chief of Staff for Installations and Logistics and now President, AAR Aircraft Services)

Commercial Best Practices – Use of Alternative Parts and Repairs

The good news in sustainment is that a new engine strategy is emerging that has been fully time-tested by the commercial aviation industry. The strategy involves the adoption of commercial best practices that utilize non-OEM alternative parts and repairs. For many years commercial aviation debated the use of Federal Aviation Administration certified alternative parts and repairs. While the OEMs actively continued the debate, the airline industry stepped forward, in harmony with the FAA, to utilize the certified alternative parts and repairs.

An overwhelming body of evidence in flight safety, reliability, reduced costs, improved schedules and strong engine performance has convinced many in the commercial aviation industry to view alternative parts and repairs as a best practice. Alternative parts, certified at every step of the design and development process by the FAA, are known within the industry as Part Manufacturer Approval (PMA) parts. Alternative repairs, also certified by the FAA, are known as Designated Engineering Representative (DER) repairs. As observed by Lieutenant General (ret) Donald J. Wetekam, former U S Air Force Headquarters Deputy Chief of Staff for Installations and Logistics and now President, AAR Aircraft Services:

"Commercial aviation has long recognized the benefits of alternative parts and repairs. While the application of commercial standards isn't a panacea, the military could benefit from much wider acceptance and use of PMA/DER. This isn't anything new; it's a tried and true approach that saves money, increases competition and enhances support."

Commercial PMA Parts Started with the Military

PMA parts are FAA-approved replacements for OEM-produced FAA Type Certificate parts. PMA producers must demonstrate

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to the FAA through testing that a part is the same or better than the part it is designed to replace. In a September 2004 white paper titled, "The PMA parts Tsunami: Hype or Reality?" AeroStrategy, an independent industry research company, said the FAA initially adopted rules for the parts in the 1950s in response to the introduction of out-of-production surplus military aircraft into the commercial aviation market. Since that time the FAA has continued to develop procedures to declare airworthy the reverse-engineered parts that support commercial aircraft engines.

The attitude toward PMA parts within the commercial aviation industry was reflected in the remarks of Robert Sullivan, General Manager, Engine Supply Chain, Delta Airlines (Delta Engine Yearbook 2007):

> *"The quality of the PMA parts used by Delta is as good, if not better than those of the OEM. This is essential because we will never sacrifice safety or performance for unit cost savings."*

While the OEMs have claimed that their parts are more reliable than certified alternative equipment and repairs, the fact is that the reliable performance of PMA parts has been increasing substantially, while service failures and non-OEM Airworthiness Directives (AD) have not. The strong safety record of PMA parts has allowed them to become a cost reduction strategy for the aviation industry, delivering a minimum savings of 35% when compared to OEM catalog pricing. The success of the PMA equipment has not gone unnoticed by the OEMs. In fact, one OEM that previously sent letters of concern to the FAA about PMA equipment now offers a product line of PMA parts it developed for a competitor's aircraft engine.

DER Repairs – Benefits Too Substantial To Ignore

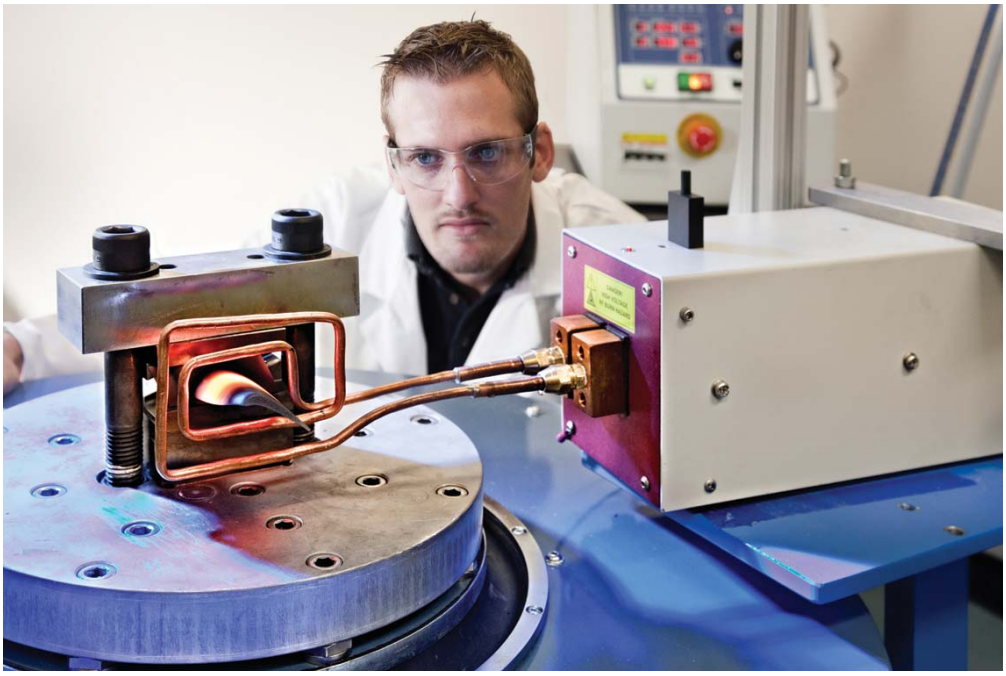
As with PMA parts, DER repairs also are certified and fully approved by the FAA. At a minimum, DER parts must be returned to their original condition of form, fit and function. DER repairs cannot have any detrimental effect on engine performance or durability. Interestingly, certain FAA-approved DER repairs have demonstrated improved performance and durability over OEM equipment due to tighter tolerances through the application of technological advances, including improved coatings on the components, more advanced repair and machining processes, and other features. DER repairs are now accepted on a global basis and can be found on virtually all commercial aircraft engine types. With more airlines utilizing PMA parts and DER repairs than ever before, the benefits are too substantial to ignore.

At a time of weak revenue growth the global aerospace industry has continued to utilize innovative cost containment strategies. Maintenance, which ranks second behind fuel as the largest cost line item for airlines, has huge potential for cost savings. Much of the savings is captured through the use of the comparable and less expensive PMA parts and DER repairs. Significant savings are also being realized by aircraft operators because PMA parts and DER repairs introduce competition where there once was none. In one example, PMA parts and DER repairs for the commercial CFM56-7 gas path engine components have resulted in savings of $500,000 per engine shop visit, or more than 50% off the typical OEM catalogue pricing.

PMA and DER: Are They Safe ... Are They Reliable?

Every day major carriers including American, Delta and United demonstrate their trust in the safety and reliability of alternative PMA parts and DER repairs, as do those in the industry and regulatory agencies who fly these airlines. A compelling and related case study on turbine engine component safety and reliability with DER repairs was published in 2010 by the US Navy regarding its fleet of LM2500 ship engines. The LM2500 engine has a common compressor and high pressure turbine with the US Air Force TF39 engine powering the C-5 aircraft fleet. During the June 2010 ASME Turbo Expo 2010: Power for Land, Sea and Air industry gathering in Glasgow, United Kingdom, the Navy reported on 10 years of experience with repaired LM2500 High Pressure Turbine blades.

Navy program managers described how the OEM recommended they "…not consider HPT blade refurbishment due to the inherent risk associated with using repaired versus new production parts during the overhaul cycle." The Navy ignored the recommendation and began having the engine HPT blades overhauled. Once installed, the Navy reported it could not tell the difference between the repaired and new production blades "installed side by side in the same engine room aboard ship." The Navy also addressed the reliability of the blades, acknowledging that from 1975 to 1999 it had a 0.38 engine failure rate/year caused by or linked to failures of OEM newly manufactured High Pressure Turbine blades. Although Navy program managers are gathering more data to address all concerns on the service life of repaired blades, they "can point to no data which support an increase in HPT blade failures" on the



BELAC LLC Testing a High Pressure Turbine PMA Blade.

repaired blades. What they can point to is the $81M in accrued saving, thanks to the Navy's 1999 decision to repair High Pressure Turbine blades.

Stringent manufacturer testing and FAA airworthiness evaluations have contributed to the noteworthy safety record of engine PMA parts. (Source: Chromalloy)

Setting the Record Straight

It is not surprising that OEM parts manufacturers view PMA parts and DER repairs for the aircraft engine as a challenge to their dominant position in the lucrative aftermarket. To maintain their competitive positions they have threatened reduced support for commercial customers that elect to use PMA equipment, for example. And they have continued to foster an atmosphere of distrust within commercial and military aviation for the demonstrated quality, safety and performance of the certified parts. In 2008, the FAA released Special Airworthiness Information Bulletin (SAIB) NE-08-40 on August 8, 2008 intending to address concerns that commercial statements by OEMs were inappropriately undermining public confidence in PMA parts.

CFM56-3 PMA High Pressure Turbine Blade Purchased by the USAF for the F108 engine. Establishment of a second source of supply introduces competition where there is none, resulting in better Warfighter support at significantly lower cost. (Source: Chromalloy)

Within the Department of Defense there remains a culture favoring OEM engine parts and repairs despite the positive experiences of commercial aviation – with noteworthy exceptions that include the Navy utilization described earlier and importantly, the US Air Force.

In 1999 the US Air Force initiated adoption of alternative DER repairs during the transition of TF39 engines from the Air Force organic depot support to a commercial maintenance provider. Over time the Air Force has approved a variety of TF39 alternative repairs originally developed for commercial CF6-6, LM2500 and other turbine engines. As a result, the TF39 engine fleet has seen a 126% improvement in Exhaust Gas Temperature margin – the test cell indication of engine performance – and a 60% reduction in flying hour cost. For the Warfighter this translates to greater time on-wing at much lower cost.

In 2007 the US Air Force began a focused effort that resulted in acceptance and utilization of PMA parts and DER repairs (termed "Commercial Derivative Repairs"). One major success was the approval of a second source for newly-manufactured F108 engine High Pressure Turbine blades. The FAA-approved PMA blades are used by many air carriers on the commercial CFM56 engine fleet. The first competitive PMA solicitation by the US Air Force for a F108 High Pressure Turbine blade resulted in the OEM still winning the contract – but at a price that was 49% lower than its previous sole source price. And since that initial review where a PMA parts bid was reviewed and competed, the US Air Force has purchased the alternative blades for their engine fleet, at a cost that is 58% lower than the sole source cost. The latter competition generated savings of $11M on 3,426 High Pressure Turbine engine blades.

Another savings and alternative source utilization milestone was the abandonment of the 100-percent condemnation of four stages of compressor blades. Instead, the US Air Force awarded a five-year DER repair contract to a commercial supplier – an action that will save $23M. The repair contract has already saved sufficient funding to pay the repair contractor for the remaining four years of the contract. This is one of 18 engine component repair contacts entered into by the US Air Force with a non-OEM provider, generating an overall cost avoidance of $863M .

There was further indication in 2010 of the move toward a new culture of equally reviewing the aftermarket services provided by alternative engine parts and repairs suppliers. This occurred when the US Air Force awarded a KC-10 Aircraft Contract Logistics Support Contract that gave blanket approval of the use of FAA approved CF6-50 engine PMA parts and DER repairs during overhaul and maintenance of the tanker engine fleet. This new approach also permitted the use of previously used commercial parts repaired to FAA standards.

Acceptance of FAA-approved parts and repairs for the commercial CF6-50 engine fleet over the last 40 years allowed the contractor to deliver significant cost and engine performance benefits beginning with the very first engine serviced under the contract. Since the PMA parts and DER repairs were already developed and in service on other aircraft engines, the US Air Force was not required to expend scarce Component Improvement Program funding. During the first 11 months of the contract, 41 engines were delivered with a per engine savings of $1M when compared to the previous contractor. Approximately $500,000 of the savings is attributable to the use of PMA parts and DER repairs. Interestingly, savings to the US Air Force from the introduction of just two PMA parts (High Pressure Turbine blades and nozzles) during the overhaul of 10 engines means, in essence, the 11th engine overhaul is free … a classic example of "doing more without more."

Under this same contract the US Air Force also benefits from commercial best practices in the reassembly of aircraft engines at the conclusion of maintenance events. All of the proprietary techniques and processes developed over more than 40 years in support of commercial CF6-50 engines are incorporated into the assembly of the US Air Force engines. The engine "build" practices are a major contributor to the delivery of engines with improvements in Exhaust Gas Temperature margins that will result in reduced fuel consumption, which the USAF predicts will save $14M over the Five-Year Defense Program.

To be sure, adoption of FAA-certified and proven alternative "build" practices also represent an alternative to the Department of Defense past practices of seeking engine performance improvements via long-term investments in the development and testing of newly designed parts. By utilizing commercial best practices developed and utilized under the auspices of the FAA, the Department of Defense can avoid the investment costs – and begin capturing immediate savings.

Time to "Do More Without More"

In looking to a new model for Warfighter engine sustainment, the US Air Force has taken important steps in the pursuit of applying commercial best practices and solutions to its strategy that ensure the safety, reliability and top performance of propulsion systems. Utilization of alternative parts and repairs has yet to result in broad acceptance within

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Use of FAA approved parts and repairs are saving $1 million per KC-10 engine overhaul and contributing to improved engine performance. (Source: U.S. Air Force)

the US Air Force engine community or within the Department of Defense, however. Use of sole source engine support contracts continues to be the dominant approach despite an established track record of proven benefits using alternative parts and repairs.

In today's cautionary budget environment, the Department of Defense needs to take full advantage of the alternative PMA parts and DER repairs for its engines that have commercial equivalents. For military engines with no commercial equivalents, they should still consider application of the commercial proven technology for development of alternative parts and repairs to improve competition for military unique engines. When it does, cost savings in the 35 to 50 percent range and measurable, significant gains in engine availability and performance efficiencies will become the norm – and the new benchmark.

Business as usual and sole source OEM-only practices cannot coexist in a "doing more without more" environment. They can and should no longer be acceptable within the Department of Defense engine aftermarket community. Over time, strict adherence to legacy engine sustainment practices place US Air Force fleets outside the mainstream and outside of what others in the commercial aviation industry – the world's commercial airlines – practice as good business. CMSgt Mark Berens, ANG Advisor to the OC-ALC Commander, said the US Air Force F108 engines are "unique antiques" because they have not kept pace with commercial industry standards.

Next Steps Toward a New Strategy

What are the next steps for the Department of Defense if it decides to adopt commercial best practices for engine parts and repairs? It can begin by uniformly permitting FAA-certified and approved parts and repairs (to include commercially repaired parts) for use on US Air Force engines with a commercial equivalent (i.e., the F108/CFM56-2, F117/PW2000, TF34/CF34, and others.). In addition, it is critical for the Department of Defense to obtain undisputed ownership of all technical data for the engines it operates. Obtaining undisputed ownership of all technical data removes the pretext that the Department of Defense does not have the technical data to provide to potential third-party manufacturers as a step in gaining the freedom to compete all engine support contracts. And, when viewed through the lens of history, the cost of obtaining technical data will be considered minor compared to the cost of continuing the existing approach acquiring parts and repairs in a sole source environment for the remaining life of their engines.

Improving the sustainment of military aircraft engines through the use of FAA-certified PMA parts and DER repairs will not take years of work and millions of dollars for research and testing. The technology has already been developed, approved and used as a standard airline industry practice. Commercial best practices are readily available and encouraging a new sustainment strategy will enable "doing more without more."

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