MITRE | Center for Technology & National Security

ENGINE SUSTAINMENT STUDY

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Executive Summary

In a future filled with increasingly complex national security challenges, the Department of Defense (DoD) will need to find innovative solutions to solve readiness challenges to provide continued capability to the operator.

Most recently, the 2018 National Defense Strategy (NDS) challenged the DoD to increase readiness in this era of the great power competition.

However, any strategy to recover and maintain readiness levels required by the NDS and current and future DoD leadership must also include long-term cost control conditions. The DoD high operational tempo the past 25+ years has presented many challenges in the sustainment and readiness of weapon systems. One avenue to increased readiness and reduced cost in sustainment is the leveraging of parts that are identical and certified by the Federal Aviation Administration (FAA) under its Parts Manufacturing Approval (PMA) process. This paper captures MITRE's efforts to quantify the benefits as well as impediments to adoption of reverse engineered PMA parts that have not been licensed by the original equipment manufacturer (OEM), and provides recommendations to resolve these impediments. Due to the short timeframe for the study, the team focused on United States Air Force (USAF) commercial derivative engines but the value of PMA parts to both reducing weapon system sustainment (WSS) costs, increasing readiness and reducing supply chain risk expands across all types of parts on all weapon systems including airframe, engines, landing gear, components, and interiors. MITRE conducted a policy and literature review and interviewed multiple leaders across the USAF to gain better insight into their desire to pursue PMA parts approval, and its challenges. The team also interviewed the FAA Military Certification Office and industry to gain a better understanding of PMA processes and certification efforts in the commercial domain. PMA parts are subjected to a rigorous review and qualification process conducted by the FAA predicated on ensuring the new reversed engineered part performs exactly the same, fails the same, and is as safe as the part it is replacing thus ensuring the aircraft continues to operate within the same conditions and type certificate as the original OEM part. Today, all major U.S. air carriers extensively use PMA parts in their fleets to increase competition, reduce costs, and ensure a robust supply chain of parts is readily available. They use small dedicated staffs to evaluate the benefit of the PMA part as well as review technical data generated by the PMA suppliers during the reverse engineering process to ensure the part meets the performance and safety requirements of the original part. These parts are supplied/manufactured from third-party companies focused on PMA using both OEM licensed and unlicensed activities. The result of this study

TODAY, ALL MAJOR U.S. AIR CARRIERS EXTENSIVELY USE PMA PARTS IN THEIR FLEETS TO INCREASE COMPETITION, REDUCE COSTS, AND ENSURE A ROBUST SUPPLY CHAIN OF PARTS IS READILY AVAILABLE.

is a recognition that adoption of PMA parts use by the USAF is not a simple activity, especially since the USAF is its own certifying authority and aircraft operator. In fact, the USAF previously attempted to leverage PMA, but was not successful due to numerous challenges encountered. Since 2012, the USAF has not approved any PMA parts across the USAF according to the Strategic Alternative Sourcing Program Office (SASPO). The findings presented in this paper serve to highlight what the key barriers are and, in turn, the recommendations that will allow the USAF to take advantage of PMA parts. Implementing the recommendations in this paper will allow the USAF the fastest opportunity with the least amount of effort to reduce sustainment costs, increase readiness and reduce supply chain risk. PMA parts developed through reverse engineering and proven to the FAA and commercial airlines that they are comparable "one-for-one" replacements for OEM parts can be quickly integrated into the USAF weapon system sustainment programs with little to no added risk.

MITRE's investigation led to five findings:

1. USAF belief that they cannot use FAA certified parts due to different flight profiles
2. Key DoD policy, regulations, and data complicate use of PMA parts
3. Lack of driving function to pursue PMA parts approval and cost savings
4. Reverse engineered PMA parts do not require OEM data rights
5. Contract language driving lack of competition

SINCE 2012, THE USAF HAS NOT APPROVED ANY PMA PARTS ACROSS THE USAF ACCORDING TO THE STRATEGIC ALTERNATIVE SOURCING PROGRAM OFFICE (SASPO).

To address these findings, MITRE identified five recommendations to help the USAF leverage the benefits of using PMA parts to increase readiness, reduce costs, and drive down cycle time:

1. Increase visibility and importance of PMA parts
2. Establish a dedicated PMA/source alternative repair function/organization
3. Leverage existing FAA PMA process, policy, and guidance
4. Ensure contract language encourages the use of PMA and reverse engineered parts
5. Explore Designated Engineering Representative repairs and Used Serviceable Material

Contents

Motivation for This Study

The 2018 National Defense Strategy (NDS) challenged the Department of Defense (DoD) to increase readiness to build a more lethal force in this era of the great power competition. However, any strategy to recover readiness faster and maintain readiness levels required by the NDS must also include conditions for long-term cost control. In September 2018, then Secretary of Defense Jim Mattis directed the United States Air Force (USAF) and Navy to increase the mission capability rates for the F-16, F-22, F-35, and F-18 above 80%.[1] However, the USAF never achieved the 80% goal and officially abandoned the effort in 2020 in order to "balance near term readiness recovery with investment in long-term combat capability," as stated by then-incoming Chief of Staff of the Air Force, General Charles Q. Brown during his nomination hearing.[2] The MC80 effort did reveal that unless a different approach is taken, today's DoD sustainment enterprise cannot provide the readiness and responsiveness required by the NDS's requirement to "rebuild and alter its posture, capabilities, and processes for this more competitive and dangerous international environment" without some significant changes.[3]

Observing and leveraging the commercial airline industry's best practices to reduce operations and sustainment costs and decrease supply response times may be a key opportunity for the USAF and DoD. The commercial airline industry continuously strives to reduce its sustainment costs by increasing the competitiveness of its supply chain. One strategy that is used to achieve this objective is to leverage non-original equipment manufacturer (OEM) parts certified by the Federal Aviation Administration (FAA) under Parts Manufacturer Approval (PMA). This approach has resulted in significant value to commercial airlines by decreasing costs and improving supply chain response times.

The USAF previously attempted to leverage PMA, but the commitment and success has been disparate across the enterprise. In 2008, the Propulsion Commodity Council established a program to focus on PMA parts approval for engines, but seemingly did not extend the effort beyond one engine, the F103 used by the KC-10. In 2016, RAND published a report that focused on efforts by the Council and KC-10 program office to pursue PMA parts and Designated Engineering Representative (DER) repairs for its commercial-derivative engines by a non-OEM Maintenance, Repair and Overhaul (MRO) contractor.[4]

RAND stated, "During the first 11 months of the contract, 41 engines were delivered with a per engine savings of $1 million when compared to the previous contractor. Approximately $500,000 of the savings is attributable to the use of PMA parts and DER repairs."[5] Using these previous studies as a foundation, MITRE investigated the benefits, risks, and barriers to introducing more competition into the DoD supply chain with emphasis on the USAF commercial derivative engine sustainment and the use of non-OEM parts that were qualified under the FAA PMA process without license from the OEM.

WHILE MAINTAINING ALL OF OUR AGING FLEETS ARE DIFFICULT AND EXPENSIVE, WE CONTINUOUSLY EXAMINE EMERGING TECHNOLOGIES, COMMERCIAL BEST PRACTICES, AND OTHER METHODS TO REDUCE THE SUSTAINMENT COSTS FOR OUR AIR FORCE.

General C.Q. Brown, 22nd CSAF

Understanding the Scope of the Issue

Today's USAF faces a dilemma: It must stay at the forefront of performance while dealing with longer life spans that drive increased weapon systems sustainment requirements and associated costs. The extended life span of a weapon system increases the sustainment burden to keep it safely in the air, with cost-per-flying-hour increasing and reliability decreasing. These weapon systems were not designed for the life spans they are flying and represent huge challenges to the DoD, including aircraft structural integrity challenges, diminishing manufacturing sources and material shortages, increased inspections, non-existent or outdated tech data, modernization requirements to meet new threats or provide new capabilities, parts obsolescence of existing capabilities/systems, and so on. These unforeseen maintenance requirements on aging weapon systems, lack of DoD data rights, and lack of competition in part suppliers, repair, and overhaul contribute to the increasing costs to sustain today's weapon systems.

FIGURE 1. CHALLENGES TO MAINTAINING READINESS [6]

SUSTAINING LEGACY WEAPON SYSTEMS IS A CONTINUED CHALLENGE. FOR EXAMPLE, THE B-52 STRATOFORTRESS, NOW AT ~70 YEARS OF CONTINUOUS SERVICE, IS PLANNED TO REMAIN OPERATIONAL INTO 2050.

The DoD invests tens of billions of dollars annually to sustain military assets, including aircraft, ships, and missiles, to ensure they are ready to support today's and tomorrow's mission.[7] Historically, aircraft operation and support (O&S) costs represent 60-75% of an aircraft's total life cycle cost, with the biggest cost driver (nearly a third, according to the Government Accountability Office [GAO]) being maintenance costs.[8] If this statistic continues to hold, then the KC-46's Average Procurement Unit Cost at $239.8M per aircraft will result in a total sustainment cost of $719.4M per aircraft; multiplied across 175 aircraft in the USAF inventory (current expected quantity) the $44B development program will be dwarfed by the $126B+ sustainment bill. Exacerbating this issue is the fact that the USAF operates the majority of its weapon systems well beyond their originally scheduled planned service lives—one example is the B-52 Stratofortress, which is currently at ~70 years of continuous service, and is planned to remain in operational service well into the year 2050.

One strategy to decrease costs is increasing competition. The KC-10 engine enterprise is just one example, realizing a cost savings of nearly $41M over an 11-month period when the USAF outsourced maintenance of its commercial-derivative engine to a non-OEM MRO (per a 2016 RAND study).[9] The

B-52s Arrive at Al Udeid Air Base. Tech. Sgt. Walter, assigned to the 36th Expeditionary Aircraft Maintenance Squadron at Barksdale Air Force Base, La., inspects a B-52 Stratofortress that arrived at Al Udeid Air Base, Qatar, April 9, 2016, to support Operation Inherent Resolve. The 19-nation air coalition consists of numerous precision strike aircraft and the B-52s will bring their unique capabilities to the fight against The Islamic State of Iraq and the Levant. The B-52 is a long-range heavy bomber that can perform a variety of missions including strategic attack, close-air support, air interdiction and maritime operations. (U.S. Air Force photo/Tech. Sgt. Nathan Lipscomb)

KC-10 fleet example referenced above is comprised of approximately 50 aircraft, which is considerably smaller than the KC-135 (~400), C-17 (~200), and incoming KC-46 (~175) fleets; by increasing competition in these larger aircraft programs, even greater cost efficiencies can be achieved and the funding repurposed to support higher priority USAF initiatives. The Services must consistently look for proactive ways to reduce sustainment costs, and focusing on materiel costs is one opportunity area. PMA parts are just one pathway with a proven track record in commercial airlines to drive down sustainment costs.

Finally, in today's environment, the U.S. government is dealing with an economic toll caused by the recent coronavirus pandemic that may negatively impact future DoD budgets. "The Congressional Budget Office recently estimated that the federal budget deficit will be upwards of $3.7 trillion in the current fiscal year and exceed $2 trillion in fiscal year 2021 as a result of spending on COVID-19 response and recovery. There is a history of military cuts when deficits get high."[10] This pandemic serves as another function forcing the USAF to actively look for opportunities to reduce costs across their weapon systems.

Why PMA Parts?

PMA parts were the focus of this study since they could provide "quick wins" across the USAF Enterprise in reducing sustainment costs while increasing supply chain response times contributing to readiness across all Acquisition program life cycles. The fastest opportunity with the least amount of effort that could be quickly integrated into the USAF weapon system sustainment programs are those PMA parts developed through reverse engineering—and proven to the FAA and commercial airlines that they are comparable "one-for-one" replacements for OEM parts. Narrowing the focus to commercial-derivative engine PMA parts allowed MITRE to draw corollaries between the military and commercial domains, but MITRE recognizes there are several avenues to approval for alternate sources. The USAF can leverage the parts already qualified as PMA parts and already flying on commercial aircraft to reduce sustainment costs and increase unit readiness. The USAF flies and sustains numerous commercial-derivative engines that have significant similarity with the engines found on commercial aircraft.

In fact, repair procedures are typically the same across these engines. The USAF can reduce its risks and analysis time for approvals by leveraging the successes achieved by commercial airlines through the focus and approval of PMA parts.

An analogy that helps reinforce this thought process and sets the stage for this paper's analysis is the existence of generic drug industry that is certified by the Food and Drug Administration (FDA). The FDA is responsible for protecting the public health by ensuring safety, efficacy, and security of human drugs and for advancing the public's health by helping to speed innovations that make medical products more effective, safer, and more affordable and by helping the public get the accurate, science-based information they need to use medical products and foods to maintain and improve their health.[11] Drug industries provide lower cost options through the release and approval of generic drugs. The FDA provides guidance, compliance, and regulatory information—thereby certifying that the generic alternative is a safe and effective replacement for the name-brand drug developed by the original pharmaceutical company. Similarly, the FAA certifies that a PMA part is safe and effective for its designed use on a certified aircraft/engine as a suitable replacement for the OEM part or repair process. Both industries use reverse engineering as the method to design, validate, and manufacture the alternative source.

THE USAF CAN LEVERAGE THE PARTS ALREADY QUALIFIED AS PMA PARTS AND ALREADY FLYING ON COMMERCIAL AIRCRAFT TO REDUCE SUSTAINMENT COSTS AND INCREASE UNIT READINESS.

PMA parts can be qualified in two distinct manners: (1) with licensing agreements with the OEM or (2) without licensing agreements with the OEM. As stated in FAA Order 8110.42D, "Applicants must show that the design meets the applicable airworthiness standards by either of the following two ways: (1) Show that the PMA article's design is identical to the design of the article that is covered under a type certificate, or (2) Use test and computation that shows the PMA article's design meets the airworthiness requirements that apply to the affected products."[12] Today, all major U.S. carriers extensively use PMA parts in their own fleets to be more competitive, reduce costs, and ensure a robust supply

A KC-135 Stratotanker prepares to refuel a B-52 Stratofortress Oct. 30, 2016, near Fairchild Air Force Base, Wash. Two B-52s were refueled during the mission. (U.S. Air Force photo/Tech. Sgt. Travis Edwards)

chain of parts is available. Many of these technically compliant PMA parts are also applicable to commercial derivative weapon systems (e.g., KC-10 and KC-46) and commercial derivative engines (e.g., PW2040 engines found on the C-17) used across the USAF.

The next section highlights benefits and potential cost savings that could be realized with these reverse engineered PMA parts. The remainder of this paper will focus on data and findings gleaned from interviews and review of DoD, FAA, and industry documentation that helped the team identify the greatest barriers to adoption of non-OEM licensed PMA parts. The final section of the paper provides five executable recommendations to address these findings and allow for increased cost savings and supply chain responsiveness.

Benefits of PMA Parts

There are multiple benefits to utilizing PMA parts. The first, and most obvious, benefit is the potential for significant financial savings when calculated across the DoD enterprise and across the life cycle of a weapon system. As mentioned earlier in the paper, the DoD maintains its weapon systems far longer than commercial industry. Financial savings can be found in the savings per part-purchase as well as in repair costs realized through competition. Unfortunately, DoD databases do not easily identify or capture those potential cost savings opportunities.

The Defense Systems Management College (DSMC), among others, have computed aircraft O&S costs at upward of 60-75% of an aircraft's total life cycle cost.[13] Nearly a third of that is attributed to maintenance costs, but identifying which portion of maintenance is related to materiel costs has historically been problematic. Detailed engine-specific costs are often difficult to extract from DoD databases due to the way costs are reported and recorded. For example, the traditional work breakdown structure for O&S includes categories such as Intermediate Maintenance, which are not reflected in the USAF Total Ownership Cost database.

Additionally, costs are frequently reported under the "Other Maintenance" category without clearly identifying nomenclature, so engine-specific costs are lumped together with other, unrelated costs.[14] This is one of the reasons the benefits of PMA parts and repairs has not been obvious. Another challenge is having complete insight into part replacement costs when the weapon system is maintained and sustained by the OEM, such as the F117 engine.

Commercial airlines have done a better job at tracking and managing those repair and part costs and have experienced significant savings using reverse

> "COST GROWTH ABOVE INFLATION (CGAI) IN O&S COSTS IN RAW MATERIALS FOR USAF FIXED WING AIRCRAFT APPEAR TO BE APPROXIMATELY 3% YEAR OVER YEAR. IT IS SPECULATED THAT THIS ANNUAL INCREASE MIGHT BE DUE TO REPLACING AIRCRAFT PARTS THAT ARE EITHER BECOMING RARE OR OBSOLETE. THAT IS, THE ACTUAL AGE OF THE AIRCRAFT ITSELF IS NOT CAUSING THIS UNACCOUNTED FOR CGAI, BUT INSTEAD, THE CAUSE APPEARS TO BE THE ESCALATING PRICE OF REPLACING RARE, IF NOT IMPOSSIBLE TO FIND, MDS PARTS ON THE OPEN MARKET."
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> G.J. Ferry, 2013

engineered PMA parts. Therefore, MITRE investigated the commercial MRO's experiences to understand potential benefits for the DoD. According to data from ICF International, one of the leading consulting organizations in the aerospace industry, airlines spent more than $32 billion on OEM new parts in 2015.[15] MITRE understands that commercial aircraft are flown more frequently and fly more hours per year than military aircraft, which in some cases drives increased removal rates, which make PMA parts more cost effective across a single year.

However, the USAF typically flies its aircraft many more years and will see more savings across the entire life cycle of the aircraft. PMA suppliers claim, and there is increasing data to support, savings opportunities of 25-45% per part over what OEMs are charging for their parts. Even on the low end, this translates into $8B of savings potential in the commercial market (in 2015 dollars). The Airline Guide to PMA points to potential savings of $100k per engine shop visit, thanks to PMA parts.[16] One commercial airline documented a $30-40M annual savings just in materiel from utilizing PMA, according to RAND, and the MITRE team heard similar accounts from its industry interviews.[17] Considering the significant similarities shared between many commercial and USAF engines, it is reasonable to assume that similar opportunities exist, especially considering the life cycle of the USAF aircraft/engine.

The USAF has undertaken several initiatives that yielded (and in some cases, still are producing) results on par with commercial experiences. For example, Air Force Materiel Command's (AFMC's) Propulsion Commodity Council documented more than $3M savings annually on parts for the F108 engine—including PMA as well as alternate sources, such as commercially overhauled used parts.

F108 engine parts approved in the 2006-2010 timeframe (and still flying today) have demonstrated their safety and success in generating competition. These parts have saved the DoD up to 54% in comparison to their OEM counterparts in the DoD. The well-documented efforts on the KC-10 engine (F103) is another example, returning $200M in savings over a four-year period.

Chromalloy provided cost data for two specific parts that were reversed engineered (Gas Turbine Engine Nozzle Segments), which both sell for 35% below their OEM equivalent. When these nozzle segments were introduced onto the F108 engine in 2010, the USAF saved $3M (a 48% reduction from the OEM price). Further, the USAF benefited from Chromalloy's high-pressure turbine (HPT) F108 blades, saving an additional $3.6M (a 58% savings over the OEM price). Additionally, Chromalloy carried out over 900 overhauls using non-OEM maintenance practices and commercial parts on the TF39 engines, which saved the USAF over $130M (over five years) from the previous baseline; parts alone accounted for $20M in annual savings.

Through the research, MITRE was able to acquire a list of PMA parts for the PW2040 engine and a Bill of Materials for the derivative F117 engine. In comparing the two parts lists, the MITRE team focused on parts common to both engines. This reduced list of OEM part numbers was then provided to HEICO, a large PMA parts supplier. HEICO provided approximate prices for the PMA versions for most of those parts. While some of the savings opportunities are small—less than a dollar for some of the smallest parts—there are some parts that offer significant savings potential, especially in large quantities.

Focusing in on a few key parts, potential significant savings exist even with low quantity PMA applications. For example, combining the heat shield parts (below) yields almost $19k potential savings per engine build.

The heat shield replacement seems to be an easily attainable goal and $19k in savings is significant enough over time to investigate further. If a typical engine experiences at least four overhauls in its planned 30-year life, that's nearly $80k in savings

Description	Estimated Savings Per Engine Build
LPT Heat Shield	$ 13.7k
LPT Heat Shield	$ 2.7k
Turbine Exhaust Case Heat Shield	$ 1.1k
HPT Heat Shield Stop	$ 1.0k
HPT Heat Shield	$ .5k
Grand Total	$ 19.0k

for a single engine. At the other end of the potential spectrum are much greater savings. It was estimated that the F117 OEM cost for parts where there is a HEICO PMA available is over $432k. If 100% of the available PMA parts were used in an overhaul (which is extremely unlikely), the savings would be over $200k per overhaul.

If the estimated 1300 F117 engines are overhauled approximately every seventh year, then roughly 186 engines are overhauled annually. At that level, the lowest estimated savings (assume the heat shield is the minimum) would be over $3M annually (and on the extreme high end, over $37M annually).

Engine Quantity Inventory	Overhauls Per Year (1/7)	Low Estimate Savings	High Estimate Savings	Low Potential Yearly Savings	Overhauls Per Year (1/7)
1300	186	$18,000	$200,000	$3,348,000	$37,200,000

Unfortunately, the current sustainment arrangement for the F117 engine with the OEM does not allow these savings opportunities without contracting modification, but the potential savings make it worth examining further.

Benefits to Military Readiness

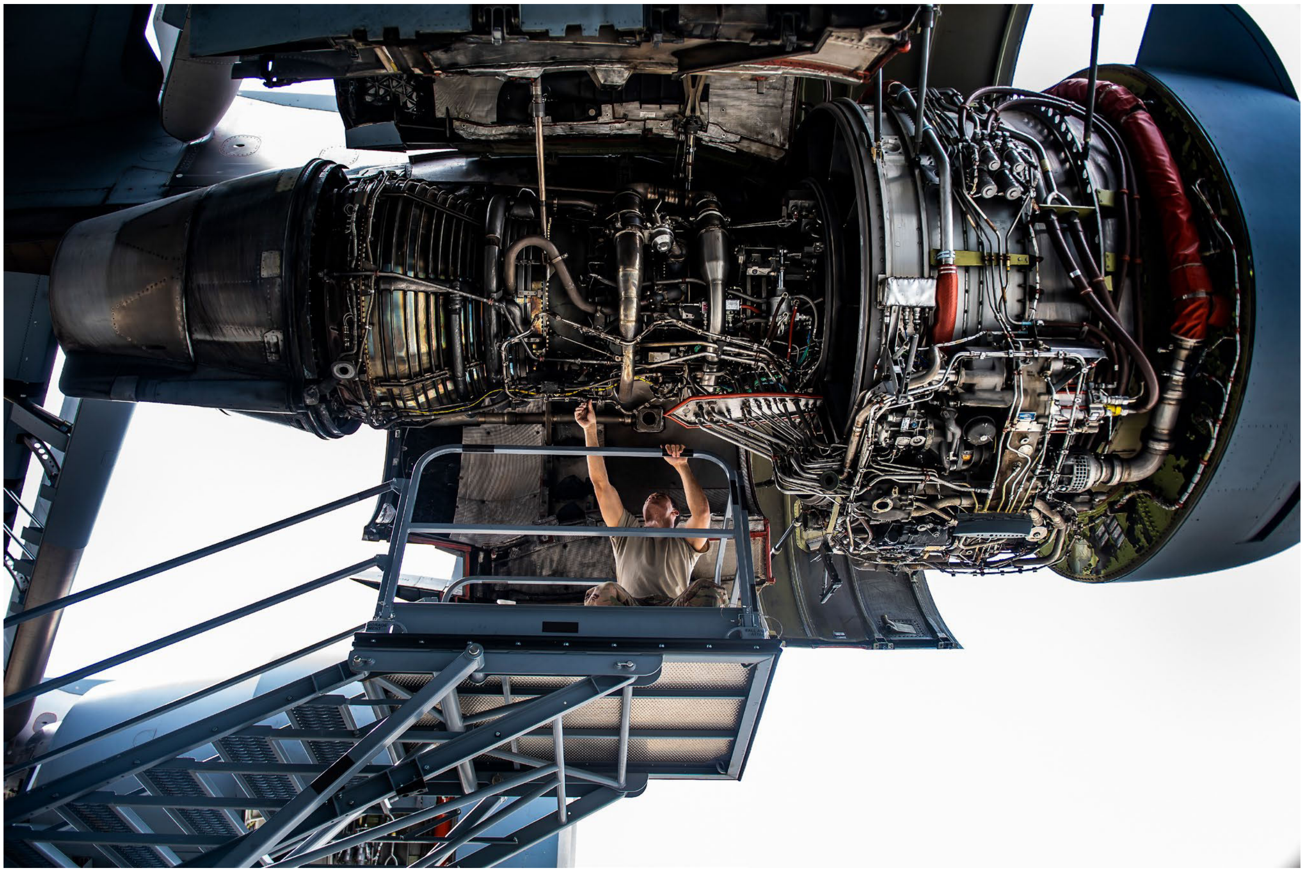
PMA parts can also provide a significant potential benefit to military readiness by ensuring there are multiple suppliers for a part that could increase supply effectiveness rates while also reducing risk to the supply chain. Increasing utilization of PMA parts increases the breadth of the marketplace providing alternative sources of supply. This increases competition, which has been shown to not only drive down prices, but also to increase part availability, making aircraft parts more readily available in the supply chain. During our interviews, the Office of the Secretary of Defense (OSD) leadership shared statistics indicating historically a 20-25% further decrease in prices when there is increased competition from alternate suppliers. This translates into increased readiness with a rapidly repairable and deployable fleet, which also increases overall resilience and viability for a larger market of suppliers—a key component of the NDS.

According to an Air Force Times article, "of the 5,413 or so aircraft in the fleet, the percentage that are able to fly at any given time has decreased steadily each year since at least fiscal 2013, when 77% of the aircraft were deemed flyable. By fiscal 2017, that metric had plunged to 71.3%, and it dipped further to 69.97% in 2018."[18] The increasing age of the USAF's fleet is a contributing factor to this decline.

Many of these aging aircraft have supply chain issues due to lack of parts in the supply chain, which was exacerbated by the COVID-19 pandemic. Impacts from the COVID-19 pandemic produced long-term, non-recoverable shortages to the defense supply chain. One of the lessons learned from this pandemic is the importance of having multiple suppliers available to reduce risk to the supply chain and readiness. PMA parts are a proven strategy that could help the DoD mitigate future supply chain risk and increase resiliency across the DoD supply chain, helping to increase aircraft mission-capable rates.

Challenges in Acceptance of PMA Parts

The primary MITRE team for this study, with more than 100 years combined in USAF acquisition, engineering, logistics, and cost accounting experience across the acquisition life cycle began this study by reviewing all DoD, USAF, and FAA policy and guidance associated with approval of alternate sources of supply, specifically related to PMA parts. The team subsequently followed up its research with numerous in-depth interviews across DoD, USAF, FAA, and industry partners to gain a broader perspective of the literature reviewed and the policies/processes implemented. The findings and associated recommendations to address the barriers to successfully implement PMA parts and increase competition identified from this study are summarized as key findings and recommendations



High level inspection: Staff Sgt. Andre Rivera, 911th Maintenance Squadron jet propulsion technician, inspects a C-17 Globemaster III engine during a Home Station Check inspection at the Pittsburgh International Airport Air Reserve Station, Pa., May 18, 2020. Due to the travel restrictions put in place because of COVID-19, Airmen are performing HSC inspections on the airport's flightline while the new hangar is under construction. (U.S. Air Force photo by Joshua J. Seybert)

Findings

Finding 1: USAF Belief That They Cannot Use FAA Certified Parts Due to Different Flight Profiles.

There were several recurring barriers identified to the MITRE team during the multiple interviews. However, the one heard most often was that the DoD cannot use FAA certified parts without further study and investigation due to variations between military aircraft and commercial airline flight profiles. The interview participants stated that PMA parts cannot be held to the same policies, regulations, and standards developed under civilian airworthiness certification per Title 10 of the United States Code, and amplified by Department of Defense Directive (DODD) 5030.61. However, the intent of 5030.61[19] is to provide the DoD the leeway necessary to "conduct missions while employing prudent risk mitigation…where timely airworthiness assessment is not feasible."[20] Contrary to these statements is the guidance provided in MIL-HDBK-516C that states:

> *The FAA Title 14, Code of Federal Regulations (CFR) Part (for example, 23, 25, 27, 29) referenced is dependent on aircraft type and must be consistent with aircraft size and usage. The list shown is not all inclusive and the user is cautioned to look at the reference material only as a guide and not for purposes of citing requirements. The user is also advised to use additional FAA Advisory Circulars or other FAA Policy documents, such as Orders and Notices that may be found on the FAA website, to assist in understanding the FAA's implementation of the regulatory requirements.*[21]

DUE TO A RIGOROUS QUALIFICATION PROCESS, PMA PARTS FIT THE SAME, PERFORM THE SAME, AND FAIL THE SAME AS THE ORIGINAL OEM PART.

MITRE agrees that the FAA certification is not valid on a DoD aircraft, but reverse engineered PMA parts should be given credit for the rigorous qualification process conducted by the FAA. PMA parts are subjected to a rigorous review process conducted by the FAA predicated on ensuring the new reversed engineered part performs exactly the same, fails with the same modes, and is as safe as the part it is replacing. In addition, the PMA process ensures the engine or airframe receiving the PMA part continues to operate within the same conditions and type certificate as the original OEM part.

In other words, the PMA part fits the same, performs the same, and fails the same as the original OEM part. Even though the DoD flies different mission profiles, the majority of the engine parts are the same between the commercial and the commercial-derivative engine. Typically, different inspection and replacement intervals are required to account for the difference in flight profiles. Therefore, if a PMA part is qualified to the exact same performance, specification, and manufacturing requirements as the original OEM part, the part will perform the same in the commercial-derivative engine as the OEM part.

When commercial engines are selected for DoD aircraft, they are subsequently assessed to determine if the mission profiles flown by the DoD aircraft differ significantly enough to warrant additional inspection intervals or repair and replacement sooner than their commercial aircraft cousins. This is effectively a “derating” of the commercial engine and can be determined through test or analysis to minimize the level of risk. This risk assessment may then drive changes in inspection intervals/requirements and/or changes in replacement cycles to the original engine requirements and is aimed at reducing engine failure risk in flight due to the DoD mission variation.

Therefore, the parts that are the exact same in the commercial engine and commercial-derivative engine, then the PMA part that operates the same as the original OEM part should not require further in-depth analysis to verify safety beyond the rigorous testing and qualification required by the FAA. The USAF already takes into account different requirements for inspection and repair intervals for its engine and engine parts. From a risk assessment perspective, no additional risk should be seen to the platform as long as the PMA part maintains its original form, fit, and function requirements, which are validated as part of the FAA PMA certification process. MITRE does agree that the DoD (similar to commercial MROs) should still do its own due diligence to ensure the PMA parts being proposed perform the same as the OEM part through a review of the technical data package generated during the PMA part provider’s reverse engineering process.

One example, the C-17 Globemaster III is powered by four Pratt & Whitney (PW) F117-PW-100 turbofan engines. These engines are commercial derivatives of the PW2040 engine, which is currently used on the Boeing 757 aircraft. The C-17 obtained a military airworthiness certification based upon the slight variations between the F117 and PW2040. Therefore, the engine is “derated” through changes in inspection requirements and repair frequencies based on the variance between its USAF mission profiles and its civilian mission/operating profiles, but the engines retain over 95% of the same parts and repair processes as the commercial engine. For the most part the derating of the commercial derivative engine accounts for the varied use from the commercial environment and mitigates the risk of accepting PMA parts without further in-depth analysis. This should expedite the DoD’s acceptance of PMA parts, and establish a level of familiarity and confidence associated with the PMA data package submitted to the FAA and USAF.

Another interesting fact to debunk this perceived barrier is the proven track record of the thousands of PMA parts currently being flown by commercial air carriers. The FAA conducted a study, known as the Aviation Safety, Repair, Alteration and Fabrication Study, into the safety of PMA parts and reviewed its own internal PMA qualification process to ensure continued operational safety. This study confirmed that since commercial air carriers started flying PMA parts, no adverse effects have been documented on operational reliability. The performance of the PMA part is exactly the same as the original OEM part. In its report, the FAA concluded that PMA parts are safe and equivalent to OEM parts.[22] Therefore, a PMA part would carry the same risk as the OEM part that was originally approved for use on a military aircraft as a commercial-derivative engine. The operation of the engine would not be affected and therefore the airworthiness risk assessment to the platform should occur relatively quickly.

Finding 2: Key DoD Policy, Regulations, and Data Complicate Use of PMA Parts

The interviews with the USAF engineering and logistic organizations repeatedly pointed toward Air Force Material Command Instruction (AFMCI) 23-113 as the guiding document for source alternative repairs (SAR) and the qualification of PMA parts.[23] The SAR process accounts for all part types/alternate sources ranging from simple, non-safety critical assemblies to complex, unique critical components for jet engines. AFMCI 23-113 defines the internal SAR process across the USAF sustainment enterprise, and points to the standard Manufacturing Qualification Requirement for further defined requirements.[24]

This Qualification Requirement (QR) allows for PMA parts developed by similarity (e.g., under license with the OEM) by a third-party vendor; however, non-licensed PMA parts (e.g., reverse engineered) are excluded in this QR. MITRE understands the challenges associated with providing clear guidance for reverse engineered parts. Although the intent of the USAF is to address reverse engineering parts on a case-by-case basis since each type of part has different requirements, this sends mixed signals to the part supplier community. This approach relies on the engineering support activity (ESA) to develop its own requirements for substantiation data, which could be different from the rigorous FAA requirements, which may drive additional burden, testing, and cost to the suppliers and DoD.

The approach being pursued today by the USAF is to send out Requests for Proposal (RFPs) on a part-by-part need basis; specific guidance is then captured in individual qualification requirements packages associated with each SAR solicitation. Numerous suppliers indicated that their impression/belief was the USAF is trying to stay away from PMA parts that were qualified through reverse engineering, as the RFP typically requires a licensing agreement with the OEM. This approach does not provide industry with clear guidance on how to submit and qualify parts for consideration as an alternate source supplier using reverse engineering methodologies.

AFMCI 23-113 references and heavily leverages the Joint Aviation Source Approval and Management Handbook,[25] which states:

1. *"Sources proposing to supply items based upon reverse engineering, Parts Manufacturer Approval (PMA) test and computation, or similar techniques must be approved by the cognizant Service ESA regardless of criticality to ensure that the alternate proposed design is validated."*[26]
2. *Handbook section 3.5.2.1.4 points to section 1.9, and clearly states, "FAA PMA items approved under 'test & computation' fall under this category [SAR Category IV: Alternate Item] as the new design must be verified."*
3. *Section 1.9 states that "reverse engineering may be considered if … (1) there is an overwhelming readiness need and all other methods of support are unavailable or prohibitive, (2) a Business Case Analysis demonstrates cost savings commensurate with potential safety or performance risk, and (3) the government must be in possession of sufficient data or be provided sufficient data to perform a risk assessment or assess the reverse engineered design."*

Therefore, the PMA supplier is not guaranteed the requirements for substantiation data established by the ESA will be the same as those clearly defined in the FAA PMA guidance. This additional DoD requirement could drive additional burden, testing, and cost to the suppliers, and subsequent "no-bid" solicitations. In short there is too much uncertainty with the requirements for a PMA parts supplier to approach the DoD with a potentially significantly lower cost part or part that could improve readiness by increasing supply chain availability. Finally, MITRE has not found any documentation or requirements that would drive the USAF to require different qualification requirements/testing than the FAA's requirements for similar parts.

By comparison, the FAA PMA process is defined in multiple publications, including FAA Order 8110.42D, Advisory Circular (AC) 21.303-4, AC 33-8 for "engine specific" PMA parts, and AC 33-9 for PMA repairs guidance. The ACs' guidance does not provide specific requirements to submit a PMA part for consideration but does provide clear recommendations to industry for developing the substantiating data to support a PMA design approval. The FAA PMA certification process is extremely rigorous from original design and manufacturing phases to repair and overhaul phases of a part's life cycle.

The FAA maintains regional aircraft certification offices (ACOs), with some offices specializing in certain aspects of the airworthiness certification process. The Boston ACO contains the Engine Certification Office (ECO) and may establish special test requirements to ensure PMA parts meet all airworthiness requirements. For example, the ECO required a PMA applicant to conduct costly whole engine testing to validate the safety of the PMA part.[27]

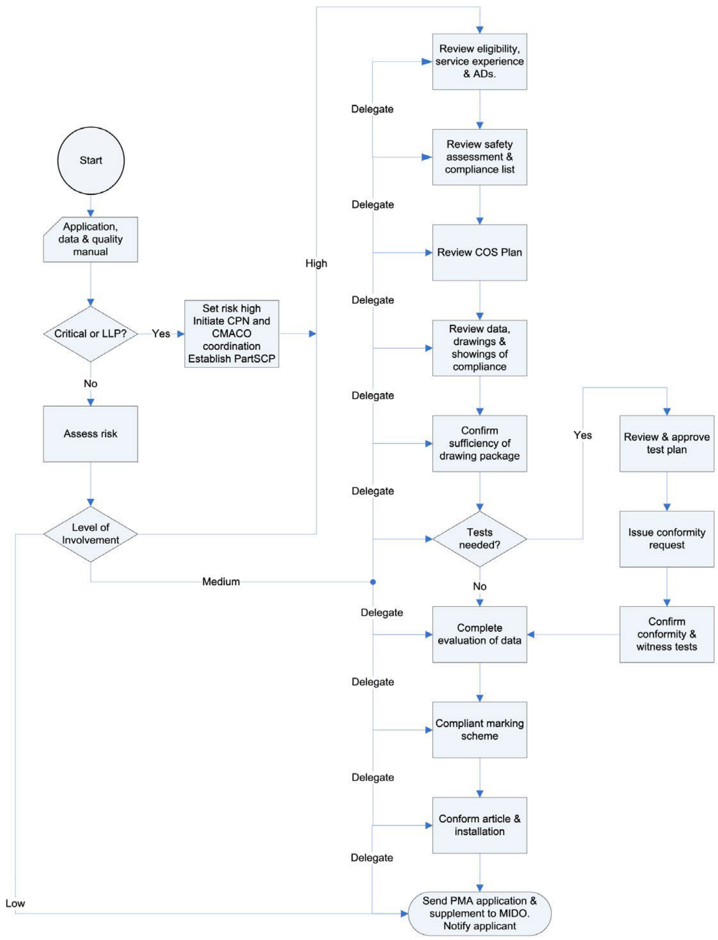


FIGURE 2. FAA PMA TEST AND COMPUTATION PROCESS DIAGRAM (FAAO 8110.42D, APPENDIX A)

The bottom line is that the certification standards for the PMA part are the same as for the original OEM part, and thus the PMA part has no more technical risk than the equivalent part provided by the OEM. The DoD and USAF should leverage the FAA's experience and guidance to reduce the level of effort required by the DoD to qualify PMA parts through "test and computation certification."[28]

Finding 3: Lack of Driving Function to Pursue PMA Parts Approval and Cost Savings

In 2004, the USAF approved F108 (CFM56) HPT Blade, as a PMA approved part.[29] The estimated savings from this one part was $3.2M in Fiscal Year 2007/2008. It was a common part with the U.S. Navy, though not approved at that time. In 2006-2007, the USAF's goal was to increase the number of PMA parts approved/used. According to a briefing given by the Propulsion Commodity Council Director, the USAF was interested in establishing a strong PMA program across the USAF.[30] The USAF realized that there was a potential of over 1,500 parts that could be leveraged using PMA with an average annual forecast of $46.8M from the Defense Logistics Agency (DLA) and $3.6M from USAF managed contracts.

The USAF was looking for improved performance and reliability, increased part availability, and lower sustainment costs. Across engines, 65% of the cost of maintenance was attributed to materiel cost. According to this briefing, market research indicated a potential savings of 36% prior to USAF purchase price. The briefing indicated 12 USAF PMA approvals to date with an annual savings of $1.2M realizing a 40% price discount from the OEM part. There were an additional 39 PMAs under review for an additional projected annual savings between $3.2M and $5.1M. It was evident that the USAF understood the benefits of PMA parts. The briefing indicated that they established a USAF PMA part approval strategy and developed a detailed document checklist. The USAF planned to utilize the Propulsion Commodity Council and the Propulsion Senior Leadership to drive PMA approvals while maintaining the "safety without compromise" approach.

Fast forward 13 years to 2020: The USAF has not made substantial progress with increasing the quantity of approved PMA parts. According to the Strategic Alternative Sourcing Program Office (SASPO), no new PMA parts have been approved within the USAF since 2012. What happened to this priority? When and where did the USAF focus shift, and what were the roadblocks/challenges they encountered?

From MITRE's observations, one factor could have been the new AFMC organizational structure in 2012 that established five centers. The five-center reorganization aligned all weapon system program offices (both acquisition and sustainment) under the Life Cycle Management Center and aligned these program offices under a Program Executive Office (PEO). The reorganization gave the PEO true life cycle responsibility of the weapon system. During the reorganization, efforts and priorities shifted to meet new demands, increasing operations tempo, and increasing sustainment challenges. Further demonstrating the absence of top-down drive for PMA parts, the AFI 63-101 Life Cycle Sustainment Plan makes no reference to PMA parts as a potential source of cost savings and improved readiness to the supply chain.[31]

THE USAF WAS LOOKING FOR IMPROVED PERFORMANCE AND RELIABILITY, INCREASED PART AVAILABILITY, AND LOWER SUSTAINMENT COSTS.

In addition, MITRE discovered the USAF ran into challenges with contracting laws within the DoD that require competing alternative part requests through formal RFPs. As a result, once an approved PMA source was identified and an RFP for procurement was issued, OEMs would compete for the alternative sourced parts and under-bid the PMA offeror(s). This effectively improved the cost position of the materiel but did little to improve competition across the supply chain by providing alternative suppliers.

The USAF also experienced situations where suppliers were proactively submitting part proposals, but when the time came to review the proposal in depth, the supplier lacked the necessary technical data package. This drove additional burden to both the supply chain and engineers to review proposals that in the end were not valid. These suppliers were not typical suppliers that specialized in PMA, but due to contracting regulations the USAF could not exclude companies from bidding. Finally, the USAF also had concerns that some PMA suppliers may have had insight into OEM design requirements under an earlier contract with the OEM as an approved supplier. If the USAF approved the PMA supplier, it was concerned with potential future litigation from OEMs on the use of previous access to OEM intellectual property (IP). In these cases, the USAF would request proof that previous OEM IP was not used in the reverse engineering process, and unfortunately many suppliers could not validate that they did not use their previous knowledge during the reverse engineering processes.

The MITRE team met with United Tech Ops and Delta Tech Ops personnel to understand if and why their organization focused on PMA parts, their PMA business processes, and how they executed the use of PMA parts, and to leverage their best practices. Currently, both organizations typically approve over 200 PMA parts a year. The extensive use of PMA parts across their fleets is a key component of their competitive edge, which is why they have been focusing on qualifying PMA parts for more than 15 years. Their organizations conduct business case analyses focusing on factors such as cost, usage, quality, turnaround time, and part operational history to determine which parts provide the highest value opportunities for their organizations before engineering analysis occurs.

The typical cost savings the airlines realize is between 25-45% of the OEM part cost, equating to millions of dollars in savings per year. Both organizations achieve these savings with small, dedicated PMA staffs (~4 engineers and ~2-3 business/supply analysts) whose sole job is to identify, review, and potentially approve PMA parts for their MRO operations. This dedicated PMA staff relies heavily on PMA suppliers' technical data package for approvals, which typically takes between two and four weeks to review and approve the part, depending on the criticality of the part. Senior leaders across both organizations understand the value of PMA parts to their business outcomes.

Another critical point made by both organizations was the fact that they never had "quality" issues with PMA parts that were in service—if there was an issue with the OEM part, they usually encountered similar issues with the PMA parts since the PMA parts mimic OEM performance (good and bad), but this did not lead to an adverse effect on operational reliability.

While both organizations focused primarily on non-critical parts, they did have critical PMA parts approved/flying. Most PMA parts they approved were expendable/consumable piece parts of the Next Higher Assembly and were not tracked via serial numbers by the MROs. As a result, they did not maintain specific reliability metrics on these PMA parts, but the same strategy also applies to the

original OEM parts. The metric used to assess these consumable parts is simply a percentage replaced as part of an overhaul maintenance action. On the other hand, the PMA part suppliers maintain detailed reliability metrics on their parts and they indicated they would be willing to share that data with the USAF.

Finding 4: Reverse Engineered PMA Parts Do Not Require OEM Data Rights

Data rights or access to OEM IP was stated numerous times over various interviews as a barrier to the USAF being able to leverage PMA parts. Data access includes rights to the data and the delivery of that data. Data rights are normally established at program initiation, but lack of DoD IP lawyers, limited budgets, and assertions/claims by the OEM that the sustainment contracts were largely derived from IP/technical data created with internal research and development funds create a barrier to securing the data rights/drawings required to take an engine component and hand it over to a third-party vendor to fabricate. Unlimited data rights are also traditionally cost prohibitive but provide the government rights to use, disclose, and reproduce in any manner and for any purpose, and to have or permit others to do so.

However, throughout MITRE's research into PMA parts, interviews demonstrated that while OEM data is value-added for parts comparison, it is not an absolute necessity. There is a large contingent of PMA part suppliers that do not have licensed rights to OEM's technical data but can analyze the OEM's parts to develop their own detailed design packages through reverse engineering processes. Reverse engineering is a critical step in FAA approval of a PMA applicant's substantiation that the PMA part's design meets the airworthiness requirements of the OEM part per 14 CFR 21.303–Parts Manufacturer Approvals.[32]

The MITRE study team met with two leading PMA suppliers: Chromalloy and HEICO. The team wanted to gain insight into their in-house reverse engineering, testing, manufacturing, and qualification processes used to design, manufacture, and obtain FAA PMA certification on parts. Today, thousands of PMA proven parts are available from numerous PMA suppliers. Both PMA suppliers perform intensive reverse engineering processes. They established Engineering Centers of Excellence in reverse engineering where they perform in-house design, computational modeling, destructive and non-destructive testing, and the analysis needed to validate that the parts operate the same as the original OEM part. Both organizations work closely with the FAA for approvals and utilize the airworthiness advisory circulars (such as AC 33-8 for engine parts and 33-9 for engine repairs) to ensure they follow the required testing to obtain PMA approval. Each supplier tests new and failed OEM parts to gain more knowledge of the part dimensions and metallurgy. As a result of FAA sampling requirements of the PMA supplier's reverse engineering process, the PMA parts are manufactured to tolerances tighter than the OEM's original part.

After the design, testing, and qualification is complete, the part should be identical in form, fit, and function as the original OEM part and perform/fail in the same manner. PMA suppliers build their own technical data and digital drawings necessary to qualify the part for the FAA PMA as well as provide the technical data necessary for the commercial airline MRO review and approval. The PMA suppliers are required by the FAA to prove how the requirements of the original OEM part are the same as the new reverse engineered PMA part.

THE AIRLINES TYPICALLY HAVE ACCESS TO TECHNICAL DATA ABOUT THE AIRCRAFT THAT MRO-SPECIFIC VENDORS MAY NOT BE PRIVY TO FROM THE OEM.

More interesting is that United and Delta Airlines both operate significant MRO business units to maintain their own aircraft. Therefore, the airlines typically have access to technical data about the aircraft that MRO-specific vendors may not be privy to from the OEM. When each MRO was asked about how it leverages the technical data it has, they both indicated that they do not have access to the data specified for operational use by the airline as agreed to with the OEMs. In addition, when they do have access to data, whether OEM or developed in house, they do not share data with the PMA suppliers and rely on the PMA suppliers to submit a complete technical data package. This demonstrates that the MRO can approve parts without access to OEM data. Therefore, a lack of data rights should not be a deterrent or barrier for not pursuing PMA parts.

Finding 5: Contract Language Driving Lack of Competition

Another barrier to PMA includes contract language that is often restricting/prescriptive resulting in higher costs, lack of competition, and a reduced supply chain industrial base. In discussions with the SASPO, many times the contract language requires third-party PMA vendors to provide licensed OEM technical data. This often results in SASPO receiving "no-bids" from vendors on parts when it releases an RFP.

In 2017, the Institute for Defense Analysis conducted a research study titled "Department of Defense Access to Intellectual Property for Weapon Systems Sustainment." This study specifically noted that lack of access to IP data inhibits the DoD's ability to use competitive contracting for repair parts, maintenance, and follow-on production, and likely translates into higher long-term sustainment costs. This issue mainly affects programs initiated before 2008, due to new regulations requiring IP rights to be addressed. These regulations recommended Services maximize use of data provided for FAA-certified aircraft under FAA regulations to facilitate competition for maintenance and supply of parts for systems/components.

One example MITRE found that validated that contract language can decrease competition is the "sources sought" for the repair of PW4062-3/F139 engines for the new KC-46. The RFI read:

"The interested concern should have capability to repair/test engines … The source must possess any necessary license agreements with OEM to obtain rights to all required data including MILSPEC mods. At this time, the government is unable to provide an unlimited data package to any third party."[33]

This restrictive language can unknowingly lead to long-term supply chain restrictions and effectively makes the OEM (or suppliers to the OEM) the only possible vendor that can meet the RFP requirements. Many suppliers to the OEM are prohibited through their contract language with the OEM to directly support/supply the DoD. The OEMs are locking in their competitive advantage for future sustainment work with the DoD. The USAF and the United States Navy (USN) overcame this restriction on F108 repairs by mandating vendor use of commercial CFM56-2A/B repair manuals in work offloaded to commercial vendors. This precedent could also work for PW4062-3/F139 upon verification that the OEM F139 manuals and commercial PW4062-3 manuals are equivalent, as well as for other USAF commercial derivative engines.

Therefore, contract language is key. The USAF should consider including incentives to bidders to utilize/leverage PMA parts to the greatest extent possible in the repair and sustainment of any weapon systems and consider allowing bidders to include reverse engineered parts in their proposal as long as the reverse engineering technical data is provided to validate the part. PMA contract language or language to increase competition should also be considered during all phases of the life cycle.

Recommendations

Recommendation 1: Increase Visibility and Importance of PMA Parts

As annotated in our analysis and subsequent findings, there is a lack of importance and visibility driving the use of PMA parts across the USAF. MITRE did not find any policy, language, or senior level metrics/goals driving increased usage or oversight of PMA part approvals across the USAF. During interviews, most leaders had a knowledge of PMA parts and the potential benefits, but they did not have insight or visibility into how widely the USAF currently leveraged these parts.

To increase competition, reduce sustainment costs, and proactively decrease supply chain cycle time and risk, MITRE recommends four areas to increase visibility and importance of PMA parts:

1. *Service Acquisition Offices should emphasize the importance of leveraging and increasing PMA parts approval by establishing policy with associated goals/metrics.*
2. *PEOs should be held accountable to achieve goals/metrics to decrease sustainment costs and leverage PMA parts where applicable and value-added.*
3. *Within the USAF, the Acquisition Divisions for Science, Technology & Engineering and the Logistics and Product Support Division should work collaboratively to educate and train their communities on the benefits of PMA parts and FAA processes used during the qualification, update policies, and establish repeatable processes across all weapon system program offices.*
4. *The Defense Acquisition University (DAU) should ensure that the importance of leveraging PMA parts is incorporated into acquisition training.*

The first recommendation focuses on the importance of DoD senior leaders communicating priorities and establishing goals and associated metrics across their Services. This recommendation should start with the OSD and flow down to each Service Acquisition Office. MITRE specifically recommends that all Service Acquisition Directors communicate the importance of PMA parts to reduce weapon system sustainment costs and increase supply chain resilience. MITRE recommends the Service Acquisition Offices establish policy that includes leveraging PMA parts and encourages reverse engineered parts with clear goals/metrics. Possible metrics include number of PMA applications submitted, number of PMA parts approved, and cost savings realized.

However, the most important metric should be the business case behind pursuing a particular PMA part, such as cost savings, readiness improvements, or reduced risk to the supply chain. PEOs should help champion the effort to achieve the goals and metrics by ensuring each program office within their portfolios are contributing to achieving the goals. These metrics should be incorporated into business processes and briefed at acquisition decision points/Milestone Reviews and at the bi-annual PEO board meetings to ensure PEOs are leveraging all possible tools to reduce costs over the life cycle of the program.

Also, the Acquisition Divisions for Science, Technology & Engineering and the Logistics and Product Support Division should work collaboratively to educate the program management, engineering, and sustainment communities; update policies; and establish repeatable processes across weapon system program offices. Finally, this information should be coordinated with DAU and the acquisition community should be trained on it, to emphasize the importance of planning for sustainment early in the acquisition process and innovative ways to increase competition to reduce costs such as leveraging PMA parts.

Recommendation 2: Establish a Dedicated PMA/SAR Function/Organization

Leveraging best practices from both Delta Tech Ops and United Tech Ops, MITRE recommends the USAF establish a dedicated PMA/SAR organization that focuses on identifying the "right" candidate parts (with a business case), reviewing supplier technical data, and assessing risk to the platform per airworthiness requirements in MIL-HDBK-516C. MITRE recommends the organization include at least two business analysts (one from Air Force Sustainment Center [AFSC] supply chain and one from AFSC Logistics) in the organization to help identify the right candidate parts that either address a readiness challenge or reduce weapon system sustainment/working capital fund costs before engineering reviews the part.

MITRE also recommends the organization contain at least four dedicated engineers: two from Air Force Life Cycle Management Center, Engineering Directorate (AFLCMC/EN); one from the Propulsion Directorate (AFLCMC/LP); and one from AFSC/EN. The dedicated PMA/

MITRE RECOMMENDS THE USAF ESTABLISH A DEDICATED PMA/SAR ORGANIZATION THAT FOCUSES ON IDENTIFYING THE "RIGHT" CANDIDATE PARTS (WITH A BUSINESS CASE), REVIEWING SUPPLIER TECHNICAL DATA, AND ASSESSING RISK TO THE PLATFORM PER AIRWORTHINESS REQUIREMENTS.

SAR organization should coordinate across AFLCMC/AFSC Technical Directors (subject matter experts) depending on the type of part and the cognizant engineering authority for the part. The dedicated organization should initially leverage proven PMA parts (with a flying history) and start with low risk, simple design parts to build confidence in the process.

Knowledge of PMA parts including FAA process requirements, utilizing checklists, and visiting suppliers' facilities to better understand their processes and capabilities will increase the probability of success. The USAF should garner lessons learned from the commercial MROs, challenge false perceptions, educate the broader engineering community, and gain support from senior technical leaders as they establish their own internal processes. This deliberate approach to grow incrementally and expand into other areas beyond commercial-derivative engines will build experience and technical confidence in the newly dedicated PMA/SAR organization's skills and capabilities.

MITRE recommends the USAF take a deliberate approach to increase technical knowledge and skills required to design and approve reverse engineered parts. MITRE recommends that the Product Support Engineering Division within AFLCMC/EN develop and deliver multiple focus week courses to increase the knowledge and skills required to reverse engineer parts required for source alternative repairs. This technical skill will be necessary as new technologies and manufacturing processes are leveraged and will ensure USAF engineers have a solid foundation needed for re-engineering parts.

Recommendation 3: Leverage FAA PMA Process Policy and Guidance

AFMCI 23-113 is the USAF's guiding document for SAR and the qualification of PMA parts. The SAR process outlined in AFMCI 23-113 accounts for all part types/alternate sources ranging from simple, non-safety critical assemblies to complex, unique critical components for jet engines. AFMCI 23-113 defines the internal SAR process to the USAF sustainment enterprise; however, it does not provide industry with clear guidance on how to submit reverse engineered parts for consideration as an alternate source supplier. Today, this guidance is captured in individual QR packages associated with each SAR solicitation, which is time consuming and inefficient for increasing the number of PMA parts reviewed and approved.

MITRE recommends AFMC/A4 revise AFMCI 23-113 to include references to FAA Order 8110.42D, AC 21.303-4, AC 33-8 for "engine specific" PMA parts, and AC 33-9 for engine repairs guidance.[34] The ACs' guidance does not provide specific requirements to submit a PMA part for consideration but does provide clear recommendations to industry for developing the substantiating data to support a PMA design approval. The FAA PMA certification process is extremely rigorous from original design and manufacturing phases to repair and overhaul phases in a part's life cycle. Leveraging the proven FAA certification process allows industry to clearly understand the requirements needed for approval and qualification for military applications and allows for the data package submitted to the FAA to be submitted to the USAF. Based on the criticality of the part, MITRE recommends the USAF utilize the same requirements as outlined by the FAA for non-critical, low risk parts. A good starting point for the dedicated PMA office would be to review the PMA parts listing published by the FAA to determine if parts with a business case already have a PMA replacement.

Commercial MROs have proven that full data rights are not required to leverage the benefits from using PMA parts across their fleets. The FAA provided clear guidance to industry regarding the requirements to test and qualify a part that has been reverse engineered. Numerous suppliers have proven their ability to reverse engineer parts that perform the same as the original part and add no additional risk to the aircraft. The Aircraft Guide to PMA parts requires "current design drawings must be available to manufacturing and inspection personnel when leveraging test and computation."[35]

Recommendation 4: Ensure Contract Language Encourages the Use of PMA and Reverse Engineered Parts

MITRE recommends updating contract language to include PMA and reverse engineered parts to maintain an adequate supply of specific parts, to reduce costs of parts, and to ensure competition. MITRE recommends the USAF re-evaluate contract language for the sustainment of the F117 engine as well as all commercial-derivative engines to incentivize the use of PMA parts that will drive down costs and reduce supply chain risk even if the OEM sustains and maintains the engine. Both the acquisition and sustainment contracts should direct the contractor (even OEM) to annually perform an analysis to identify those engine parts to be considered for substitution with PMA parts that either drive down costs or reduce supply chain risk and/or decrease cycle time.

The USAF should require contractors to provide this information as an annual deliverable to the program office. This contract delivery requirements list should include specific OEM part number/nomenclature, part criticality, part failure rate, part cost (unburdened), potential PMA vendor(s) for part/s, estimated savings with PMA part substitution, supply chain risk management plan (to ensure counterfeit parts do not enter supply chain), final list of parts recommended for government consideration, and schedule/transition plan for integrating PMA parts. These results should be provided to the government and readdressed at all milestone reviews and Acquisition Strategy Panels, and the data provided to a dedicated PMA/SAR organization.

Recommendation 5: Explore DER Repairs and Used Serviceable Material (USM)

This study was purposefully limited in scope to focus on the USAF barriers to broader adoption and use of PMA parts not developed under license from an OEM. As a result, MITRE recommends an additional study be commissioned to review aftermarket DER repairs and the use of serviceable used parts (USM) on USAF commercial derivative engines. In addition, this study should incorporate commercial maintenance practices in accordance with AC 33-9 Developing Data for Major Repairs of Turbine Engine Parts that are intended to increase mission availability, reduce cost, and extend engine life in an effort to reduce sustainment cost and improve readiness.[36] This is an activity that could be undertaken by the dedicated PMA/SAR organization once it is confident with acquiring PMA parts.

Summary

The intent of this MITRE study is to help reduce the barriers and challenges that have impeded significant and consistent pursuit of reverse engineered PMA parts by the USAF and DoD. As proven in past PMA studies, there is significant opportunity for sustainment cost savings and increases in readiness because of leveraging PMA parts. To do this, the five recommendations identified in this paper must be addressed: increasing visibility and importance of PMA parts; establishing a dedicated PMA/SAR organization; leveraging existing FAA PMA process, policy, and guidance; and ensuring contract language encourages use of PMA and reverse engineered parts. To further increase mission availability, reduce cost, decrease supply chain risk additional opportunities to increase competition such as DER repairs and used serviceable material outlined in recommendation 5 should be pursued

MITRE recommends the USAF increase the visibility and importance of approving reverse engineered PMA parts that have a positive business case. This will require the establishment of a dedicated PMA/SAR organization that focuses on developing a PMA/SAR part business case, establishing PMA qualification requirements that leverage the FAA process, and reviewing the PMA/SAR submittals for approval in collaboration with the cognizant engineering authority.

In addition, while MITRE commends the USAF for capturing all SAR guidance in AFMCI 23-113, it would be more advantageous that in the case of PMA parts the guidance provided by FAA Orders and ACs be followed and only modified on an exception basis. Finally, the recommendation to establish a USAF PMA/SAR office should increase the awareness and understanding of FAA PMA parts across the USAF Acquisition community to include their benefits and limitations that will encourage competition and the pursuit of less expensive qualified sources of supply.

MITRE realizes there are numerous challenges the DoD/USAF must overcome to increase competition across the supply chain and repair. Innovative contracting methodologies including Other Transaction Authority, multiple contract awards should continue to be pursued. However, by leveraging the work already done through the FAA's PMA program, there could be some quick wins. The key to success in this area is leadership engagement and commitment, advocacy, and monitoring.

These three areas should start with the top senior DoD leaders and flow down through the PEOs and to program managers, chief engineers, and product support managers. The commitment must be cross-functional, there must be advocacy at all levels, and the monitoring and associated visibility must occur across the entire life cycle of the weapon system. With senior leadership advocacy and a dedicated PMA/SAR organization properly resourced and focused on identifying the most beneficial PMA parts to pursue that are low risk, the USAF can begin leveraging PMA parts and significantly reduce weapon system sustainment costs. Eventually this organization could pursue SAR efforts for military unique engines and aircraft parts as it gets more confident with establishing technical data package requirements for these efforts that do not have a commercial certification basis.

Document Number	Document Name	Date
AFI 62-601	USAF Airworthiness	11 June 2010
AFI 63-101	Integrated Life Cycle Management	30 June 2020
JACG PR#: 11-514	Joint Aviation Source Approval and Management Handbook	16 March 2011
JSSG-2007A	DoD Joint Service Specification Guide–Engines, Aircraft, Turbine	29 January 2004
PCOE BP-99-06 Rev E	Aircraft Gas Turbine Engine Flight Safety Risk Management Process	1 March 2016
AFMCI 63-1201	Implementing Operational Safety, Suitability and Effectiveness (OSS&E) And Life Cycle Systems Engineering (LCSE)	12 September 2018
AFMCI 23-113	Pre-Award Qualification of New or Additional Parts Sources and the Use of the Source Approval Request (SAR)	31 March 2020
FAA Order 8110.101A	Type Certification Procedures for Military Commercial Derivative Aircraft	25 February 2015
FAA Order 8110.42D, Chg 1	Part Manufacturer Approval Procedures	15 September 2017
AC 21.303-4	Application for Parts Manufacturer Approval Via Tests and Computations or Identicality	21 March 2014
AC 33-8	Guidance for Parts Manufacturer Approval of Turbine Engine and Auxiliary Power Unit Parts under Test and Computation	19 August 2009
AC 33-9	Developing Data for Major Repairs of Turbine Engine Parts	30 April 2010
AWB-004A	Development of an Airworthiness Certification Basis	17 June 2011
AWB-215	Change Notices for MIL-HDBK-516C	23 July 2018
AWB-330A	Propulsion System Type Certification	17 April 2018

TABLE 1. KEY DOCUMENTS REVIEWED

Person Interviewed	Organization Symbol	Date
Lisa Disbrow	Former Under Secretary of the Air Force	13 May 2020
		7 July 2020
Tom Fisher et al.	AFLCMC/EN Technical Airworthiness Authority	14 May 2020
	Deputy EN-EZ	
	SL Systems Engineer	
	Airworthiness Office Chief, Technical Director	
	Director of Engineering for Propulsion	
Jamie Gilbert	848 SCMG/EN (Chief Engineer)	14 May 2020
Charles Darnell et al.	AFLCMC/LPS (C-17 and F117 Engine Team)	15 May 2020
		14 September 2020
Mike Schneider et al.	B-52 CERP Chief Engineer	15 May 2020
Jerry Zamoa et al.	Strategic Alternate Sourcing Program Office (SASPO)	18 May 2020
Angie Tymofichuk	SAF/AQD	22 May 2020
		3 September 2020
Zach Sayre	AFLCMC/FMC	26 May 2020
Jeff Vaughn	B-1 Chief Engineer	27 May 2020
Russ Alford	C-5 Chief Engineer (Retired)	28 May 2020
Pat Kumashiro	OSD F-35 Sustainment	2 June 2020
Paul Waugh	PEO Agile Combat Support	3 June 2020
Col Ekstrom	C-17 Material Leader	4 June 2020
		27 May 2020
Frank Finelli	The Carlyle Group	5 June 2020
Mike Irmen et al.	United Technical Operations	18 June 2020
David Linebaugh et al.	Delta Technical Operations	23 June 2020
Alex Ledesma at al.	HEICO	23 June 2020
Sam Malone et al.	Chromalloy	4 June 2020
		12 June 2020
		Additional dates
Jason Brys et al.	FAA MCO	8 June 2020
David Linebaugh et al.	Delta Tech Ops	23 June 2020
Jody LaChance et al.	Delta Tech Ops Leadership	14 July 2020
Steve Gray	Director, 948th SCMG	28 July 2020
Melanie Jonason	Chief Engineer, AFLCMC/LPS	19 August 2020
Loren Lutz	Chief Engineer, AFLCMC/LPS	19 August 2020
Kristin Baldwin	SAF/AQR	24 September 2020

TABLE 2. ORGANIZATIONS AND INDIVIDUALS INTERVIEWED

Footnotes

1. https://www.defensenews.com/air/2018/10/09/mattis-orders-fighter-jet-readiness-to-jump-to-80-percent-in-one-year/.
2. https://www.defensenews.com/air/2020/05/07/the-air-force-bails-on-mattis-era-fighter-jet-readiness-goal/.
3. Department of Defense, "2018 National Defense Strategy, Sharpening the American Military's Competitive Edge" Washington DC: Government Printing Office, 19 Jan 2018.
4. RAND, Applying Best Practices to Military Commercial-Derivative Aircraft Engine Sustainment, 2016 (RAND RR1020z1).
5. RAND, Applying Best Practices to Military Commercial-Derivative Aircraft Engine Sustainment, 2016 (RAND RR1020z1).
6. MITRE, originally generated.
7. GAO Small Businesses Participate in Reverse Engineering of Spare Parts; GAO-19-586: Published: 31 Jul 2019. Publicly Released: 31 Jul 2019.
8. Defense Systems Management College, "Acquisition Logistics Guide," 1997. [Online]. Available: www.dtic.mil/get-tr-doc/pdf?AD=ADA368108. [Accessed 2020]; Jones, G., White, E., Ryan, E. T., & Ritschel, J. D. (2014). Investigation into the ratio of operating and support costs to life-cycle costs for DoD weapon systems. Defense Acquisition Research Journal, 21(1), 442–464; Government Accountability Office. (2010). DoD needs better information and guidance to more effectively manage and reduce operating and support costs of major weapon systems (Report No. GAO-10-717). Washington, DC: U.S. Government Printing Office.
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Senior Airman Taylor Lancaster, a 5th Aircraft Maintenance Squadron aircraft crew chief, guides a B-52H Stratofortress on Minot Air Force Base, N.D., Jan. 9, 2015. Lancaster's main duty is to ensure his jet is fixed and prepared to take off before its flight time. (U.S. Air Force photo/Airman 1st Class Sahara L. Fales)

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Cover photo:

A B-52 Stratofortress breaks away from a KC-135 Stratotanker from the 100th Air Refueling Wing, RAF Mildenhall, United Kingdom, after receiving fuel during a strategic bomber mission, May 7, 2020. Strategic bomber missions enable crews to maintain a high state of readiness and proficiency, and validate the always-ready global strike capability. (U.S. Air Force photo by Tech. Sgt. Emerson Nuñez)

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