The CF6-80C2 is steadily being phased out. There are 460 CF6-80C2-powered aircraft still in operation. This generates annual demand for about 500 shop visits per year. With engines getting old, the priority is to ensure end-of-life maintenance costs are economic for operators.

CF6-80C2 MRO & engineering support

GE's CF6 engine family has been in service for more than 45 years, having entered service in 1971 with the DC-10-10. The CF6-80C2 and CF6-80E1 turbofan engines have a single-fan, two-shaft configuration. Both have a four-stage low pressure compressor (LPC) and a 14-stage high pressure compressor (HPC). They both also have a five-stage low pressure turbine (LPT) and a two-stage high pressure turbine (HPT).

The CF6-80C2's fan diameter is 93 inches, while the CF6-80E1 has a fan diameter of 96.2 inches. Thrust ratings also differ between the two models. The -80C2 is rated at 52,200-62,000lbs thrust, and the -80E1 is rated at 65,800-69,800lbs thrust.

There is a slight difference in overall pressure ratios. The -80C2 is 27.1-31.8, and the -80E1 is 32.4-34.8. The CF6-80C2 powers the A300-600, the 767-300ER, 747-400 and -400ER variants, and the MD-11. It is the predecessor to the CF6-80E1, which powers the A330-200 and A330-300. For this technical support survey, coverage for the CF6-80C2 will be provided.

Mature engine considerations

The CF6-80C2 is a mature engine, so is now powering a declining number of aircraft. Today, the CF6-80C2 still powers about 460 aircraft in service, most of which are 747-400s and 767-300ERs.

"Generally speaking, ageing engines need heavier workscopes which include a higher degree of parts repair, as well as material replacement, especially for life limited parts (LLPs)," says Norbert Moeck, director of engine programmes at MTU Maintenance. "With a growing supply of available surplus material, however, as a cost-effective alternative to both new material, as well as repaired parts, demand for component repairs/replacement has become a factor of surplus availability and price."

As new generation engines enter the fleet, promising greater cost savings and fuel efficiency for owners, operators are inevitably exploring the process of phasing out mature engines. In general, operators will find fuel consumption the biggest overall cost of operating a mature engine.

Other costs to consider can be mitigated. While heavy maintenance events become a more regular requirement for ageing engines, for example, the number of time-continued and serviceable parts and spares available for a mature engine helps to keep costs down. Time-continued and serviceable parts become more widely available as an engine ages, due to the teardown and part-out of retired engines and those that are beyond economic repair (BER).

It is not cost efficient for operators to continue paying maintenance on BER engines, so they will opt to purchase 'green-time' engines instead. Leasing also remains an option for operators on mature engines, because the cost of the lease or finance of a mature engine is low compared to a newer type. "Control of costs is key for all engines, but it is even more crucial for end-of-life engines," says Mike Bezuijen, technical sales director for engines at AFI KLM E&M. "For leased engines it is trying to get the optimum life and quality for the remaining contracted period."

Operators will also find that there is more variety available when choosing which shops to carry out maintenance on an ageing engine. Types like the CF6 family have long been in operation, so a greater mix of maintenance, repair & overhaul (MRO) and technical support facilities licensed to provide services have developed. This is in relation to newer engines, such as the GE90. The trend in today's aftermarket is for OEMs to exercise far greater control on who can perform extensive maintenance on new engine types. In many cases therefore operators and lessors are more or less forced into choosing either an OEM-owned facility, or an OEM-approved service provider, that will commonly work through an agreement with the manufacturer whereby only OEM engine maintenance programmes and repairs are offered. In general, this means that costs are kept fairly high, and the engine aftermarket remains fairly uncompetitive, with little or no third-party service provider options for smaller or start-up operators.

The remaining option today for new engine types, it should be noted, is to pay for the rights to perform maintenance on an operator's own fleet. This requires access to a manufacturer's proprietary data, and also investment in tooling. The cost of acquiring these capabilities is high, so it is not usually a viable option for small operators. Only the largest heavyweight operators are able to adopt this approach in today's landscape *(see Aircraft Commerce: acquiring maintenance capability for new-generation engine types, issue 98 February/March 2015, page 34).*

Service partners & providers

The CF6-80C2 engine has a global mix of OEM-run and service provider facilities, in addition to independent third-party engine shops. GE's CF6-80 engines are overhauled at GE's Caledonian and Celma facilities, alongside repair services. GE also has a

Over the past 10 years, the fleet of CF6-80C2-powered widebodies has declined from more than 1,200 to a current fleet of about 460 aircraft. These are mainly 747-400s and 767-300ERs.

global network of repair shops, including one in Ohio that specialises in rotating parts and structures for the CF6 engine series. It also has a repair facility in McAllen, Texas that concentrates on CF6 LPT airfoils. GE Component Repair, Hungary repairs all honeycomb and composites.

One of GE's service providers is ATI in Singapore, which focuses on CF6 combustor, HPT, HPC and LPT airfoils. EGAT and KLM are also overhaul providers for the CF6-80C2. Last, repair channel partners include Barnes Aerospace, which repairs CF6 HPT shrouds, and GKN Aerospace, which repairs the CF6 fan blades.

GE's repair technologies for each component in the CF6-80C2 include:

- HPT & LPT airfoils: stripping, FPI, eddy current, x-ray, welding, brazing, grinding, EDM, laser drilling, and coatings (Pl Al, VPA, EBPVD).
- Combustors: waterjet stripping, welding, brazing, coatings, and laser drilling.
- Rotating parts: FPI, eddy current inspection, ultrasonic inspection, metal spray (HVOF), grinding, and machining.

CF6-80C2 maintenance

There are 22 CF6-80C2 MRO providers, of which 14 offer third-party services to outside customers. Delta TechOps is headquartered in Atlanta, Georgia and has been providing MRO and technical services on the CF6-80C2 for several decades. It offers comprehensive maintenance services for the CF6-80C2 engine including full engine overhaul, engine piece-part repair, and engine LRU repair.

"Typical 80C2 engines run for about 30,000 engine flight hours (EFH) between heavy maintenance (HM) checks," outlines Robert Schultz, director of engine maintenance at Delta TechOps. "A hot section restoration is usually only required at the HM visits. Over the past several years, however, the oil manifold in the compressor rear frame has driven a significant number of on-wing events and subsequent shop visits requiring separation of the engine core between HM checks. Delta TechOps has implemented a comprehensive fleet management plan to mitigate the operational and financial impacts associated with this reliability issue. A borescope inspection programme has been developed to detect at-risk engines to schedule them off-wing before experiencing an operational event such as an in-flight shutdown (IFSD). The engines are then inducted into the shop using a highly focused workscope designed to minimise hot section hardware exposure," says Schultz.

One key consideration for operators running a maturing engine is the proximity of various LLPs to their life thresholds. These parts are often expensive to replace, so operators will opt to incorporate an 'LLP reserve' into overall operational costs and engine maintenance budgets. This is often an essential requirement of lessors to ensure that sufficient considerations have been undertaken by lessees regarding the cost of engine maintenance. Because LLPs are hard-timed, it is easy to predict when replacements will be required. "The engine has 22 LLPs, varying in cycle life but most are 15,000 or 20,000EFC," continues Schultz. "The LLPs are usually not removed until they are close to their life limit." Engine overhaul is obviously also a key consideration for operators. The -80C2 is primarily operated on-condition, so the time between overhaul (TBO) can vary.

CTS Engines originates from Fort Lauderdale, Florida. It has provided full overhaul services for the CF6-80C2 since 2010, yet has been performing field service work on the engine since 2002. "We typically see HM visits every 3,500EFC," explains Vesa Paukkeri, president and chief operating officer at CTS Engines. "At least a full performance restoration of the HPC, HPT and compressor rear frame (CRF) will take place at this event, alongside many times overhauls of the HPT and HPC. These are often overhauled because of the LLP replacements.

"Maintenance workscopes for the fan section and LPT vary, but often the LPT is expanded to a performance restoration rather than a minimum or light inspection. The fan mostly stays as repair only depending on its condition."

During hot section inspections, seals and airfoils tend to have the most substantial maintenance requirements. "Airfoils are overhauled, while seals are refurbished during these events," says Paukkeri. "Regarding the LLPs, the life limits are accurate, but of course some LLPs scrap out prematurely due to the inspection findings. One part with a high scrap rate among CF6-80C2 engines has been the stage 2 HPT disk."

Lufthansa Technik (LHT) is headquartered in Hamburg, Germany. It has been providing overall maintenance for the CF6-80C2 engine since 1987. Repair services have been gradually implemented since that time. "The N1 system and the HPCs are overhauled every second shop visit, roughly every 7,000FC," explains Claus Bauer, vice president of engine services overhaul at Lufthansa Technik.

"In our experience, while many engines are monitored on an on-condition basis, shop visits for some engine types

CF6-80C2 LLP LIMITS

Module	LLP	LLP Limit (FC)
Fan	Shaft forward fan	15,000 or 20,000
	Disk stage 1	15,000 or 20,000
	Spool fan RTR	15,000 or 20,000
	Shaft Mid Fan	15,000 or 20,000
HPC	Disk stage 1	15,000 or 20,000
	Disk stage 2	15,000 or 20,000
	Spool stage 3-9	15,000 or 20,000
Shaft/spool	Stage 10-14	15,000 or 20,000
HPT	Disk stage 1	9,000 - 15,000
	DIsk stage 2	9,000 - 15,000
	Spacer Impeller	9,000 - 15,000
	Vane ring	9,000 - 15,000
LPT	Disk stage 1	20,000
	Disk stage 2	20,000
	Disk stage 3	20,000
	Disk Stage 4	20,000
	Disk stage 5	20,000
	Shaft	20,000

are triggered by the expiry of LLP lives. On-condition findings that can trigger an HM event for the CF6-80C2 include panel cracks in the combustor. This can force an engine overhaul," continues Bauer. "Also, cracks in the trailing and leading edge for the 1st stage nozzle guide vanes (NGVs) and cracks in the HPT's 1st stage blades and 1st stage shrouds can cause the engine to be removed and overhauled. The HPT components are the most expensive parts in the engine, and can cost several thousand US dollars per piece to replace."

Air France KLM Engineering and Maintenance (AFI KLM E&M) operates out of several service centres across Europe, including Paris Charles de Gaulle Airport, and Amsterdam Schiphol. The MRO has enabled substantial capabilities in the widebody engine maintenance and technical services that can be provided. "Since introduction of the CF6-80C2-powered aircraft within our fleet, we are supporting the related type by means of in-house capability," says Mike Bezuijen, technical sales director for engines at AFI KLM E&M. "We have had this capability since the early 1990s, when we introduced the 747-400 equipped with the FADEC CF6-80C2s to our portfolio."

"Maintenance on CF6-80C2 engines is based on 'soft-time' thresholds of the individual engine modules," further explains Michel Nollet, KLM E&M powerplant and testcell engineer. "By performing maintenance tasks at the recommended threshold, it would be expected that subject modules will perform reliably with good performance until the next shop visit or beyond.

"Regular heavy maintenance checks typically include performance restoration (or overhaul) of the core engine (HP compressor/combustor/HPT)," continues Nollet. "Besides that, additional maintenance can be performed on LPC/gearboxes/LPT, all depending on individual soft-time thresholds, required modifications, or if additional EGT margin is required. In general, we find that a CF6-80C2 never comes in the shop just for a scheduled hot section refurbishment unless there is a problem in the HPT."

Similarly, the removal of an LLP should not take place outside anything other than a routine shop visit, due to the relative ease with which its removal can be forecast by maintenance planners.

LLP replacement is done during the shop visit based on remaining cycles and the expected time on-wing, both financially and technically. In the event that engines have to be taken off-wing for LLP replacement, it means that the engine has reached or even exceeded its build goal, both financially and technically. With the growing reliability of the engines it can be necessary to stagger shop visits if too many are planned for removal in the same time frame.

"The LLP should not be an unscheduled removal reason, since LLP replacement can be planned during regular shop visits based on expected/required on-wing time," says Nollet. "It might be, however, that additional engine modules must be disassembled to remove an LLP with low cycles remaining, although the subject module has not reached its soft-time maintenance threshold yet.

"The life limit is based on calculations of the OEM (GE) and the Federal Aviation Administration (FAA). The operator does not have any influence on these numbers. Of course, an operator would like to see the highest possible life limits."

Other than the stage 2 HPT disk referenced earlier, the other LLPs present in the CF6-80C2 are summarised *(see table, this page)*.

In addition to LLP limitations, other hard-timed thresholds may take place during routine HM events. "Another influence is airworthiness directives (ADs)," continues Nollet. "Normally, during regular engine maintenance, any open AD notes (that could limit engine on-wing time in any way) are closed and LLPs with low stub life are replaced to make sure that the engine will meet its required on-wing time. Besides the above (scheduled) maintenance, however, engine life can be restricted by unexpected damage or hardware failure during operation. In general, for the CF6-80C2, the on-wing life expectation would be more than 28,000EFC, with an average of 7-9EFH per EFC between heavy maintenance events."

Contracts for ageing engines

Engine management agreements are sought by operators from MRO providers to maximise the transparency of maintenance costs for a mature engine. Various factors will affect which type of programme best fits the customer. "The requirements vary greatly depending on customer fleet size and condition," says Schultz at Delta. Typical agreements offered by maintenance providers include time and material (T&M), power-by-the-hour (PBH), fixed-rate, and not-to-exceed (NTE) *(see: PW4000 technical support survey, Aircraft Commerce, issue 104 February/March, page 55)*. "All of these types of contract are requested by customers, and CTS is able to provide any of those independent of the OEM. Due to the fairly mature fleet, however, most common agreements are done on a T&M basis with an NTE cap," outlines Paukkeri.

"We offer all kind of programmes ranging from a basic T&M to a complex PBH concept," outlines Bezuijen at AFI KLM E&M. "For mature engines nearing the end of their lifes, however, we definitely see a preference for an NTE or

The annual market for CF6-80C2 shop visits has steadily been declining, and is at about 500 shop visit events per year. This has temporarily stabilised, but will naturally decline as more aircraft retire and the number of used engines increases.

fixed-price contract in the market." This is presumably so that customers have a clear indication in advance of the cost implications arising from each routine maintenance event.

"Lufthansa Technik is not part of the OEM network, so all of our customers come to us direct, without involvement from GE," says Bauer. "Alongside third-party customers, we, of course, have fleet maintenance from Lufthansa airline and cargo subsidiaries. The split is currently about 50:50 between the two types on the CF6. The third-party ratio of other engine types is 75% or higher.

"As such, we offer all of the standard engine maintenance contracts, including flat rates, single shop visits (that are popular for smaller CF6 operators on a one-by-one basis where they tender single quotes) and mobile services," continues Bauer. "If a defect is raised ahead of a regular shop visit interval we can also investigate performing an endoscopic fix by focusing on the part of the engine concerning the fault. By accessing it without completely disassembling the engine, we are able to preserve and not waste the remaining FC ahead of the engine's next overhaul." This can be done for different types of problems.

"There is no clear indication or trend towards any price model for the CF6-80C2," continues Bauer. "I estimate that about half, for maximum planning stability, will opt for a flat rate, such as PBH. The other half may choose T&M, with an NTE cap on the contract. This is because they sometimes like to contribute used serviceable material (USM) material from their own stock. If a contract spans four years, for example, and an operator knows the fleet will be retired, then the availability of surplus material will inevitably increase. If a flat rate agreement is signed, one has planning stability, but the T&M with NTE cap provides more flexibility. Ultimately, you are hedging bets on part availability," says Bauer.

"Our fly-by-the-hour contracts are offered both as a traditional rate paid up-front, as well as on a restored rate basis (payment per event) due at the time of overhaul," explains Moeck. "In both cases the hourly or cycle-based rate is pre-agreed with the customer."

Engine management

Engine management through an agreement with a service provider is key to helping operators minimise and regulate costs for a mature engine.

Delta TechOps provides a full range of engine maintenance management services. "Independently, Delta TechOps provides engine condition monitoring (ECM) services for the CF6-80C2, in addition to a wide variety of other engine types," outlines Schultz. "Delta TechOps provides its ECM customers with automated alerts, performance trending, and expert technical analysis.

"Delta TechOps also provides removal forecasting, maintenance planning, workscoping, and technical assistance as required by customers," adds Schultz. "Engine workscopes may follow OEM recommendations, or be customised to the customer's requirements."

MTU Maintenance performs its CF6-80C2 maintenance services in Hannover, Germany. The company has been maintaining CF6-80C2 engines for over 25 years, exceeding 1,600 shop visits on the engine. Operating outside the OEM network, it offers full MRO services as an independent provider. It serves about 25 airlines, as well as almost 40 lessors, parts traders and MROs. Major customers include Atlas Air, Air Canada and Asiana Airlines. "Customers continue to demand lower operating costs, and in the case of mature engines this implies cost-effective solutions for engines with shorter shop visit intervals, as well as high material usage," explains Moeck.

As an independent provider, MTU has launched two new service offerings tailored to the specific needs of mature engines. These agreements include:

- MTUPlus Mature Engines Solutions

"Directly aimed at operators of older engines, this programme offers cost-effective MRO solutions, as well as alternative services to cut down engine operating costs," highlights Moeck. "Possibilities range from 'Instant Power' options, such as leasing and engine exchange, through to 'Smart Repair' solutions that combine customised workscoping and material salvation, such as for re-use in the customers' own engines."

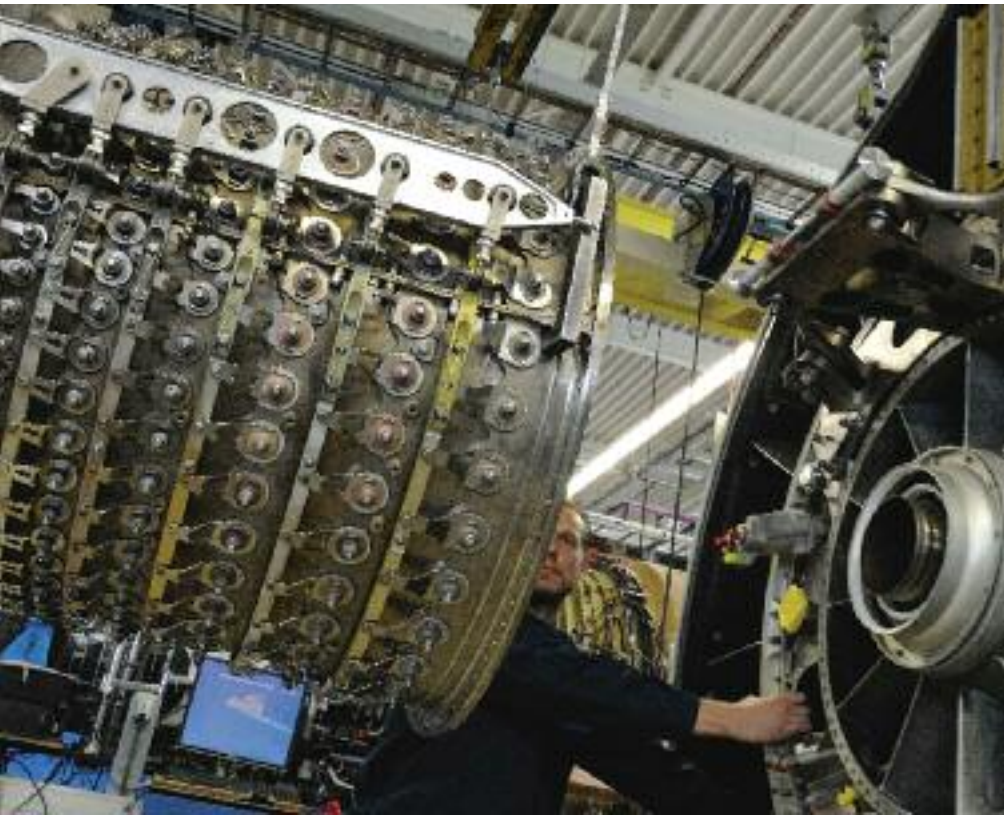
- MTUPlus Asset Value Maximization

Is a solution that instead focusses on the lessors and asset managers, seeking a return of investment for their end-of-life engines. "This programme either optimises the engine's usage if it can still be operated, or maximises the material value through the remarketing of its individual parts," says Moeck. The service is also available for surplus parts.

In general, operators have a wide range of options available for mature engine maintenance and engine phase-out. "To make the most of the options available to them," continues Moeck, "it helps if airlines have in-depth experience in buying services on a single event or T&M basis, so they have full understanding when comparing the cost of the various solutions offered."

"There is a lot of flexibility for operators," agrees Paukkeri at CTS. "Operators have cost-effective options from piece part level (where used serviceable material is a popular solution) to full engine exchanges.

"Engine fleet managers are presented with an increasing diversity of options for maintaining their mature engines," agrees



The main providers of CF6-80C2 maintenance and technical support include General Electric, Lufthansa Technik, Delta Tech Ops, CTS Engines, MTU Maintenance, and Air France KLM Engineering and Maintenance.

Schultz at Delta. "Generally, for older engine types, such as the CF6-80C2, there is a higher availability of (USM) than there is earlier in the engine's life cycle. Provided it is properly sourced and inspected, such material does not adversely affect engine reliability.

"As a result, engine fleet managers can opt to minimise shop visit costs by installing USM instead of new material. There may also be some availability of surplus engines in a serviceable condition and with LLP life remaining, commonly known as green-time engines. Engine fleet managers may, therefore, also have the option to forgo engine shop visits by replacing engines with these," says Schultz.

"It is essential to take advantage of USM wherever possible, to maximise the economy of an ageing engine," elaborates Bauer. "This philosophy also applies to LLPs. It is also worthwhile for operators to consider using used-but-serviceable complete modules to replace existing engine modules, rather than incurring the cost of a shop visit. Green-time engines tend to best suit operators that actually own rather than lease the engine, and are willing to fly the asset out completely at a planned retirement date. The proximity to the phase-out date will also influence the decision to buy a green-time engine."

LHT has developed a fleet management agreement called 'Smart Life' to optimise the end-of-life utilisation for operators. "Smart life is more than an overhaul agreement," comments Bauer. "LHT will advise the customer which engines to swap, what mobile services to use and at what time, and when to use green-time engines. We have also developed an IT system that interfaces with customers' fleet information."

Wider services

In addition to standard MRO services, maintenance shops have expanded capabilities to remain competitive, extending services to include AOG support, spare engines, and parts repair and provision. CTS engines, AFI KLM E&M, LHT, MTU Maintenance and Delta TechOps are each able to offer these extended capabilities.

LHT has forged a strong presence in the parts provision (and USM) market by buying phased-out 747-400s to tear down. "We have access to a large amount of material through which we can service our own airline fleet alongside third-party customers," says Bauer.

MTU Maintenance exercises these wider services through a global network of facilities for the CF6-80C2. These include:

- Engine MRO: Hannover
- HPC/LPT airfoil repairs: Airfoil Services, Kuala Lumpur
- Other high-tech repairs: Hannover
- Accessory repair/LRU management: Vancouver and Hannover
- On-site/-wing and AOG services: Dallas and Hannover
- Leasing & asset management: MTU Maintenance Lease Services, Amsterdam

"We offer a range of services besides the shop visit itself," says Nollet at AFI KLM E&M. "We consider the on-wing support as one of our most valuable services, for both the customer and MRO. We therefore always assign to our customers a dedicated specialist, who can solve the problem remotely. If necessary, we can also send a team of specialists worldwide to our customers 24 hours a day, seven days a week. It is often more convenient to fix a problem on-site than to remove an engine and send it to the shop.

"Despite the mature type we still have significant contracted volume CF6-80C2's, and are still investing in unique repairs in order save mostly expensive parts," says Nollet. "Repairing a part is still more economic than replacing it. Despite the maturity of the CF6-80C2, we are still investing in new repair techniques to avoid scrapping a part. Examples include the E-beam welding technique, which now makes it possible to repair turbine rear frames in-house against reasonable costs."

Delta TechOps also provides the full range of maintenance and fleet management services for the CF6-80C2, including: on-wing maintenance services, field team support, spare engine sourcing, spare part and component sourcing, engine repair and overhaul, engine testing, ECM; removal forecasting, maintenance planning; workscoping, and technical assistance.

Airworthiness directives

Airworthiness directives (ADs) can have a significant impact on maintenance costs and part availability. They are also difficult to predict and foresee; often resulting in a pattern of defects arising in a fleet over a period of time, reporting to the OEM and consequently the regulatory authorities. "Several ADs have had an impact on MRO processes," commences Nollet. "Most of them have a 'must be completed before' interval so that forced removal is not necessary.

"Higher maintenance costs, however, are a reality, due to the AD coming into effect before reaching the maintenance threshold. The most recent example is the AD relating to the LPT casing rework. This required the LPT to be disassembled fully, in order to modify the casing."

Specifically, three main ADs have impacted processes, describes Schultz.

The variety of maintenance support contracts that are used by operators of older engine types include time and material, power-by-the-hour, and not-to-exceed. The large number of used engines on the market also means that savings can be realised through the use of USM.

These three ADs are:

AD 2008-21-11, that relates to LPT Case Doublers (due in Nov 2016).

AD 2012-03-12, which requires a No. 3 Bearing packing Inspection.

AD 2014-21-01, which outlines a new fuel manifold configuration.

"There is also AD 2009-14-08, that refers to the reduction of life limit for spoolshafts 11-14," says Moeck.

Summary

As the CF6-80C2 is gradually being retired, it might be reasonable to assume that providers are starting to see a decline in demand in services for the engine. It seems, however, that requirements are still very much present in the industry, which remains on the cusp of an implosion. "There has not really been a decline in volume yet. Instead there has been a slight shift of fleet from big airlines to smaller operators," describes Paukkeri. "This has actually increased opportunities and overall business for CTS."

The overall need for component replacement, however, is rising. "Scrap rates are getting a bit higher, but many times it is because there is a more cost-efficient option available in the market," says Paukkeri. "It has become cheaper to replace a part than perform an expensive repair in many cases."

"We see a mix of business opportunities still evident in the market," says Nollet. "On the one hand we are asked to assist customers with low-cost shop visits for their lease return shop visits or phase-out engines. The costs for lease return shop visits have to be as low as possible because the engine is not the operator's asset. For that reason they do not want to invest in a costly shop visit for an engine that will return to the owner, since the owner would then be the long-term beneficiary of this investment. The engine must meet the lease return conditions, nothing more, nothing less, but of course we will not compromise on safety and quality. Shop visits for engines that are shielded for phase-out will be as limited and cost effective as possible. Large investments (for example, new LLPs) will not pay off in the remaining flight time.

"On the other hand we have signed recent long-term contracts for start-up operators, mostly in the cargo environment. For those examples, the related shop visit requires a different approach, so LLP management and the related build standard will be key to ensuring a good balance between acceptable time on-wing and cost of ownership for many years and several shop visits.

"Each engine that is getting older requires more maintenance," continues Nollet. "It is obvious that some parts just cannot be repaired a large number of times. And some parts, such as the HPT blades, have a limited number of repairs. We also see that this is causing higher scrap rates, and therefore cost, during shop visits. One must also consider that multiple modifications have been issued by the OEM, designed to increase engine (module) reliability and on-wing time. This has an influence on the (off-wing) maintenance programme, resulting in increased soft-time thresholds and life expectations."

"Last," says Nollet, "LRU and component repairs are an important portion of the total costs of an engine. Even though there are many used parts available on the market, it still can be worth having them repaired. We see different conditions of the parts installed on an engine during the shop visit. It very much depends on the LRU, and the customer's component repair philosophy."

"According to OEM statistics, about 500 shop visits were performed globally in 2015," summarises Moeck at MTU. "This compares to close to 700 visits per year five years ago. The decline in demand, however, has reduced and may have stabilised for now. We have even seen a revival in demand for CF6-80C2 services since the start of this year. Because of low fuel prices, it looks like the phase-out process of CF6-80C2s has slowed down, and some of our customers now seem to be flying their assets for longer.

"What remains to be seen, however, is whether this trend will ultimately lead to a pick-up on MRO work in the medium to longer term," continues Moeck, "or whether MRO demand can be met by instant power solutions, such as engine exchange or leasing as an alternative. We will need to wait and see.

"Last year we carried out about 60 CF6-80C2 heavy shop visits, as well as the same amount of smaller events and checks. The number of visits is fairly stable for now, with a similar number of visits done in 2014, and originally planned for 2016, which might now end up on a higher level." AC