

Many engines are maintained on total care-style programmes to manage engines to a high maintenance standard. These are not required after engines pass an age of about 20 years. New programmes are emerging for older engines to reduce maintenance activity and costs.

Maintenance programmes for ageing engines

For young engines with a long remaining operational life, the normal management focus is on maximising asset value by performing maintenance to keep the engine's maintenance status at a high level. In the case of a fixed rate per engine flight hour (EFH) or engine flight cycle (EFC) total care maintenance and similar style contracts, there is normally a risk transfer to the maintenance provider, which is often an original equipment manufacturer (OEM). The rate paid will, therefore, reflect what is required to perform a high level of maintenance.

For mature and end-of-life engines, with a short remaining operational life, the maintenance management focus shifts to reducing and minimising costs, while maximising extraction of any maintenance and remaining value.

New and developing maintenance programmes and alternative engine shop visit (ESV) worksopes cater to the needs of mature engines, and are aimed at extracting and releasing this residual maintenance asset value during the last few years of an engine's operation. Airlines and operators do not want to pay full reserves to maintenance providers in an engine's last years of operation, when paying for all elements

of maintenance, such as full overhauls and replacement of life-limited parts (LLPs), is or could be unnecessary. The mature aftermarket needs flexibility.

OEMs, engine lessors and maintenance repair and overhaul (MRO) facilities have become more creative in adapting to customer needs to efficiently maintain engines while also reducing, and in some cases eliminating, the costs of the next ESV, before retiring the engine.

Engine management

Traditionally, over a 20- to 25-year average engine life, engine lessors or owners collected maintenance reserves at a particular rate per EFH or per EFC as collateral against all predicted future maintenance requirements at the next ESV. This would ensure the engine asset's maintenance condition was at a full or high level, to operate and remain on-wing for a full shop visit interval, without any restrictions. Such a contract is structured to protect against any default so that maintenance costs were always covered.

By the time an engine reaches 20 years of age, however, operators are trying to scale down maintenance inputs and reduce the costs of maintenance and ESVs by customising worksopes.

The main elements are managing the condition of turbomachinery and components that are maintained on an on-condition basis, and managing LLPs that have lives fixed at a number of EFCs.

Hot and high pressure modules will require on-condition maintenance for a shop input at every ESV. Low pressure and temperature modules will require a shop visit input after every second or third time on-wing (TOW). A full overhaul occurs when most or all of the modules have a shop visit input. Reserves, therefore, have to be accumulated per EFH or EFC over the estimated TOW so that sufficient funds are available to pay for the full ESV for on-condition maintenance, when due.

There is scope for airlines to reduce maintenance costs as an engine enters its last years of operation by scaling back maintenance activity, either through avoiding maintenance on certain modules, or through swapping modules or complete engines with others that have remaining maintenance condition or 'green time', and so can remain on-wing before an ESV is required. It is also possible to increase the portion of turbomachinery parts that are repaired, or replace scrap parts with usable serviceable material (USM).



Quality endures

Engine Services

We are offering more than repair and overhaul but Full Service Solutions tailored to individual customer needs at highest quality levels. Our portfolio comprises MRO services for PW100 series, PW 160 as well as PW 901A APUs and CF 34-series – CF 34-10 is ready to serve as well.

Call up your individual maintenance solution
24/7 +49 (0) 172 620 3500
sales@lthero.com
www.lthero.com

The Fine Art of MRO Services

Lufthansa Technik
AERO Alzoy

All an engine's main modules and component groups do not have to be maintained to a full level after the engine reaches an age of about 20 years. Time-continued modules and LLPs with green time and used serviceable material can be used to reduce maintenance costs in an engine's final years of operation.

LLPs include rotating disks, which sit in the gas path and shafts. These parts are given fixed life limits in EFCs by the OEMs, and are the most critical parts. In most cases, the EFC limits of LLPs are 15,000-30,000EFC.

All LLPs will be replaced at least twice in a 20-year operation for engines accumulating about 2,000EFC per year. Engines on long-haul operations will accumulate less than 1,000EFC per year. A full set will only be replaced once in the first 20 years of operation in the case of most engines. Reserves are often collected to replace all LLPs up to an age of about 20 years.

New LLPs installed at this age will have sufficient EFCs remaining until the engine retires. Reserves for LLPs, therefore, need not be collected as the engine enters its last years of operation.

When LLPs need to be replaced late in an engine's life, costs can be reduced either by using modules or complete engines with green time, or by purchasing LLPs with green time.

While using these techniques means that at the end of service or economic life the engine would be likely to have close to zero maintenance condition and remaining on-wing life, all its residual value would have been extracted or released, leaving only the teardown value. This level of maintenance management suits engines that are being phased out or are at the end of their economic life.

Engine life cycles

In general, the economic and production life cycle or timeline of an engine is broken down into three phases.

Phase one is the period from the first engines being introduced into operational service to their first major performance restoration ESVs. During the first few years of production, modifications, mainly service bulletins (SBs), are introduced to improve the engine's build standard and operational reliability.

All engines are likely to be covered by new engine warranties and OEM support contracts linked to the aircraft at time of purchase for at least part of this phase.

Phase two covers the transition of the engine following the early operational and improvement cycle, and up to the period where the aircraft it supports ceases production. This is often referred to as the engine's 'mid-life' or mature phase. The last engines from the



production line will have a higher technical build and hardware standard than the first-built engines.

Finally, phase three ties in with the fleet passing its maximum number. This is followed by a decline in the fleet due to the removal from service of the aircraft type it powers, and can be referred to as the 'sunset' period. As some engines in the fleet are retired, the supply of engines and modules in the aftermarket will rise. This, therefore, increases the number of engines with 'green time' remaining, which can be used to mitigate or offset the need for full shop visit maintenance.

OEM Mature Engine Options

About 50% of all new aircraft are delivered with engines managed under all-inclusive maintenance and technical support packages. Engines under maintenance oversight by the OEM are overhauled to the latest standards and use approved parts, which is claimed to result in the operators achieving up to 15-20% longer TOW, as well as the engines maintaining a greater market value.

Many such 'point of sale' flight hour agreements (FHA) or complete care packages have support coverage that extends from ESVs to additional services such as: engine health monitoring; engine maintenance management; technical record services; spare engine provisioning; aircraft-on-the-ground (AOG) support; and even foreign object damage (FOD) protection. Perhaps surprisingly, most support programmes exclude reserves for LLP replacement, which have to be paid for separately by the operator when replacement is due.

To follow the maintenance life cycle,

OEMs are now developing maintenance services and contracts to meet the needs of customers that have engines at the end of the initial total care programmes. These new contracts are designed to keep the engine in full maintenance condition for the remaining years of operation, while reducing maintenance actions and costs. These new services and contracts are designed to allow airlines to release engine asset and maintenance value. GE and Rolls-Royce are two OEMs whose programmes are described here.

GE Mature Fleet Solutions

GE has a dedicated Mature Fleet Solutions team to help airlines realise and extract maximum economic value from the engine and address changing needs of engines moving through their lifecycle. A major objective is to work with operators to develop 'highly-customised worksopes for mature engines to match the projected in-service life'.

The team aims to find the best way to address customer needs for CFM56 engines manufactured by the GE and SNECMA of France joint venture CFM International (CFMI).

Scott Brensike, general manager for mature fleet solutions at GE Aviation, states: "We are very enthusiastic about the opportunities in the mature engine space. It is a vibrant part of the market, and there is a lot of innovation taking place. That is great for customers, and it inspires us to work really hard to quickly develop products and services that help customers maximise the remaining economic life of their engines. We are constantly challenging ourselves to work closely with our customers to understand



each customer's unique needs and to offer them a full range of effective solutions.”

The Mature Fleet Solutions programme offers firm fixed price plus (FFP+) and time and materials (T&M) overhauls. In these, GE eliminates scrap rate exclusions, or scrap material caps set during ESVs for costing certainty, so that the operator gets a fixed shop visit price, regardless of the amount of material that has to be scrapped and replaced.

To further help customers reduce costs, a high USM content is used in T&M overhauls. Other solutions include engine exchanges, module exchanges to match the required LLP life with the forecast removal interval, and green time leases.

Apart from GE's Mature Fleet Solutions, the TRUEngine programme also aids mature engines in service.

TRUEngine

With a focus on engine material content, GE and CFMI introduced the TRUEngine programme in 2008. A TRUEngine title is given to an engine that has been maintained to the appropriate CFM and GE manuals, and operated in approved configurations and within operational parameters. The engines must also contain GE- and CFM-approved LLPs and other critical internal components, and be maintained to a set standard at approved MROs.

The TRUEngine programme now includes the CFM56, CF6, GE90, GENx, and CF34 families in response to a growing industry need to better assure engine material content as assets are evaluated and redistributed. Although not limited to mature engines, the greater

operational assurance and ability to maximise asset value in turn aids the mature engines' marketability. The product is free, with no qualifying cost.

Brensike adds: “Several studies confirm that engines maintained in OEM configuration retain up to 50% higher residual value, compared to engines maintained with parts manufacturing authority (PMA) content and/or designated engineering repairs (DERs). For example, a study by the International Bureau of Aviation (IBA) examined sales for CF6, CF34 and CFM56-3 engines, and found a clear preference in the market for engines maintained to OEM standard, as indicated by higher trading values.”

“The TRUEngine classification has an important role to play in the mature space, where engine trading and USM are most prevalent.” Brensike continues. “For many owners, engine residual value is a critical component of their business model, and the TRUEngine designation is a technically robust, transparent means of quickly identifying engines that have always been maintained to GE or CFMI standards, which maximises engine residual value. As adoption of the TRUEngine designation has accelerated, it has become increasingly common to see engines listed for sale or lease as ‘TRUEngine’ which, combined with rapidly growing enrolment in the programme, is evidence of the value that the market places on the designation.”

More than 10,000 CFMI and GE engines are enrolled in the TRUEngine programme, which has been endorsed by operators and lessors worldwide. More than 140 customers have signed up to the programme, and over a dozen lessors.

Full maintenance reserves should be paid for an engine's maintenance during the early and mature phases of its life. New maintenance programmes allow maintenance activity and costs to be scaled back when the engine enters the ageing phase of its life.

Rolls-Royce TotalCare® Flex®

TotalCare® services were launched by Rolls-Royce in the late 1990s. The company's existing TotalCare services, TotalCare® Life® and TotalCare® Term®, include engineering management and support services tailored for each customer. These services transfer both operational and ESV cost risks back to Rolls-Royce. Rolls-Royce says this results in greater engine reliability and take-off weight (TOW). About 90% of Trent operators choose one of the long-term care agreements. The contract renewal rate is currently at 100%.

In addition, Rolls-Royce has TotalCare® Flex® under development with current customers. TotalCare Flex offers economic management of mature engines up to retirement, with the release or extraction of asset value.

Alex Dulcewicz, head of marketing services for civil large engines at Rolls-Royce, says: “TotalCare Term forecasts the engine's maintenance costs over an agreed time period of several years, and the EFH accumulated in that period, and divides one by the other. This is the basic element of TotalCare. Additional services are EHM, spare engine provisioning, and maintenance management.

“TotalCare Life makes the same forecasts, but the rate per EFH is calculated such that the service fee being paid is attributed to each maintenance event and the TOW preceding it. The rate is calculated for each shop over the engine's life. In effect an engine now has two components of value: the value of the hardware; plus the value or maintenance reserves accrued under the contract. The accrued reserves in the contract can be transferred by engine serial number (S/N) when the customer decides to move the aircraft onto another operator. TotalCare Life has no end date, and can continue for as long as the operator wants.”

TotalCare Flex is being developed to facilitate the extraction of an asset's maintenance and financial value towards the end of an engine's life, where planning cycles are usually much shorter. It is ideal for engines during their last four to five years before retirement. “For engines entering service for the first time, customers value the risk transfer that TotalCare offers”, adds Dulcewicz. “As



an engine enters the mid-point of the lifecycle, customers are shifting their focus to ease of transition or portability of the engine to the next operator. The focus for the customer toward the end of an engine's lifecycle shifts from maximising TOW performance and portability of the product, to optimising the asset's value and maintenance status with its remaining life.

"Flex provides an adapted/flexed structure to facilitate asset value release of mature engines," continues Dulcewicz. "If you go back 20 years the focus was on risk transfer. The customer base is more sophisticated now, and owners and lessors have different needs. If you take the Trent 700, released in 1995, and still in production today, this has variations in support requirements. We recognise the importance of green life for those engines that will retire with the aircraft. The Flex programme extracts the engine's agreed value over a customer-defined period of time through a \$/EFH reduction and the engine remains the property of RR. That is, the reduced rate includes the purchase of the engine from the operator."

The Rolls-Royce aftermarket can also offer simpler 'Fixed Price' and 'Time and Material' shop visit and overhaul options.

The fixed price overhaul or shop visit allows for a partial transfer of the risks of maintenance costs from the operator to the OEM, and delivers a fixed workscope

at a fixed price.

The T&M option is for customers that want to define the workscope according to market pressures and their future operational needs. Both these services can be referred to by Rolls-Royce as event-based services, and can be adapted for the needs of mature engines.

Dulcewicz notes: "There is a perception that OEMs are tying up MRO capability. Rolls-Royce has recognised the concern and is looking to provide more choice. Only one Trent MRO is entirely owned by Rolls-Royce: AR&O in Derby. Other Trent shops are joint ventures or independent, which is comparable to our competitors. The market has real opportunity for independents to put forward a business case for Trent overhauls, since there is a limit to our capacity. After all, an asset flying is fundamentally good for everyone."

MROs

Independent and joint venture (JV) MROs also offer mature engine support options. As long as the OEM technical manuals are obtained through JV partnerships or licence approvals, there is a growing market in customising workscopes and utilising USM to support the ageing engines.

Full overhauls, restoration shop visits, and even teardowns can all be adapted to

Core modules are more likely to be maintained at a high level when an engine is in its last few years of operation. The engine may be able to continue operating with fan and LPT modules from other engines that have green time remaining.

suit not only individual engine needs, but an operator's fleets with a mix of leasing, engine and module exchanges, and salvation of USM.

MTU Maintenance and Air France Industries KLM Engineering and Maintenance (AFI KLM E&M) are just two of many MROs that are able to assist with mature engine maintenance, as well as leases and operational support.

MTU Maintenance solutions

MTU Maintenance, a worldwide leader in MRO services with over 15,000 completed engine shop visits, operates a mature engine programme called 'MTUplus - Mature Engine Solutions.' This combines alternative MRO solutions and unique complementary services that may save operators the cost of a complete engine overhaul.

MTUplus Mature Engine Solutions comprises two major options as a starting point: Instant Power, focusing on leasing or exchanging engines; and Smart Repair, combining customised work scoping for ESV with material salvaging solutions.

These two products are designed with a modular selection of services: lease, exchange, maintenance and salvation. These support the 'instant power versus smart repair' approach needed by maturing and end-of-life operators.

MTU Maintenance's mature engine portfolio consists of CF6, CF34, CFM56, PW2000, and V2500 engines. Martin Friis-Petersen, managing director of MTU Maintenance Lease Services, notes: "MTU Maintenance offers a one-stop solution of MRO, and alternatives to MRO options. The idea is to enter into an early dialogue with the operator to find the most economic solution that matches operational fleet planning."

For operators with no time remaining on their engine, the two 'instant power' options of lease or exchange provide a quick solution with minimal or no disruption to service. The lease option, for example for a CF6, is aimed at operators that typically have short-term needs of up to 1,100EFC, and the exchange option at those looking with medium-term needs of 1,100-2,000EFC.

MTU Maintenance supplies customers with lease and exchange engines, and makes sure that replacement engines meet an operator's needs in terms of correct configuration and remaining green time. On-wing exchanges can be

made, and sale-and-leaseback options are also available.

The exchange option can be used as an alternative to standard engine maintenance when workscoping, and the associated MRO costs, are becoming disproportionately high relative to required remaining operational EFH. MTU Maintenance also offers to buy the run-out engines at current market value. Financing solutions are also available.

The two 'Smart Repair' options are maintenance and salvation. The maintenance option is aimed at operators with long-term needs, typically over 2,000EFC, for a required operation. The salvation option is for operators looking for engine teardown services.

The maintenance option provides customers with individual planned workscoping to match operational life expectations. USM usage, including module swaps, is carefully investigated on an individual basis to reduce costs where possible. This could also include the consumption of used material from customer-owned teardown engines as part of the salvation module. MTUPlus Mature Engine Solutions offers full warranties for engines undergoing maintenance in its programme.

The salvation option, due to the modular set-up of MTUPlus Mature Engine Services, allows salvation services to be combined with other options such as lease, exchange and maintenance for larger fleets. Salvation offers a solution to maximise residual value of the asset at the end of its life cycle. Parts can be stored or re-marketed by MTU Maintenance.

MTU's smart repair and lease exchange options play a part in the conceptual 'optimised phase-out plan' that uses alternative solutions to offer substantial cost reductions over an engine fleet maintenance costs. This could be done by using the customer's own USM from their own teardown events over a series of fleet ESVs. The USM would be used to maximise the release of value from the supplied teardown engines. With the use of short-term leases and exchanges as the engines approach retirement, up to 60% savings could be made compared to classic full overhaul shop visit worksopes. The MTUPlus Mature Engine solution process allows customers to combine services they need in a way that works best for them.

AFI KLM E&M

Air France Industries KLM Engineering and Maintenance (AFI KLM E&M) has the advantages of the airline-MRO partnership when dealing with the mature engine leasing and overhaul market, resulting in a customer portfolio that includes major OEMs and MROs.

"As an airline-MRO, Air France

KLM Group benefits from a combined approach. As an operator, we have knowledge of the engine's financial and operational constraints, while as an MRO, we have technical knowledge of the engine," says Tristan Bavière, manager of business development in the engines department at AFI KLM E&M. "AFI KLM E&M benefits from the engine fleet phase-out programme managed by Air France and KLM. As such, AFI KLM E&M has access to USM

(following teardown) and to green-time engines. The teams involved in supporting our customers are aware of the global management of such programmes through constant feedback from our mother companies. This combined experience allows AFI KLM E&M to better anticipate the customer's needs and offer a just-in-time solution."

"AFI KLM E&M supports the customer in analysing the best operational and economic solution,"

**EMPOWERING
BETTER
SOLUTIONS.**

HARCO and **Semco** have joined forces; broadening engineering capability to empower the MRO market with even better solutions for the harshest environments.

Visit HarcoSemco.com to learn more.

HARCO

Semco
INSTRUMENTS, INC.

Connecticut • 203.483.3700

California • 661.257.2000



continues Bavière. “The CFM56-5A, CFM56-5C, CF6-80C2 and PW4000-94 are the main engines supported by AFI KLM E&M under mature/ageing engine programmes. It is important to note that green-time engines do not have to be dedicated to mature/ageing engine programmes, but can also be offered to customers that need a spare engine to cover ‘regular’ engine shop visits.

“In fact, it is important not to focus on a specific solution,” emphasises Bavière. “It is key to adapt to the customer’s specificities and to find the accurate combination of all the solutions which will meet the customer’s needs.”

For mature and end-of-life engines, AFI KLM E&M support services include engine monitoring, warranty control, line maintenance support and AOG support. When ESVs are needed, optimised engine removal planning along with customised shop visit worksopes help to keep costs down. Green-time engines are available, if needed, to avoid shop visits.

AFI KLM E&M engine parts repair has been organised as a Centre of Excellence. It assures a pro-active repairs development policy to avoid scrap replacement. This represents another important way to reduce engine material costs. AFI KLM E&M’s OEM partnership means that OEM repairs and alternatives through DER or DOA approvals are available.

Through development of its global network, AFI KLM E&M integrates a wide portfolio of solutions, which helps to solve the sunset engines equation. New partnerships include the USA-based JV Bonus Tech, which specialises in engine teardown, allowing AFI KLM E&M a

direct access to USM. Another AFI KLM E&M JV Tradewinds, also USA-based, is a world leader in engine parts trading. To add to its network, AFI KLM E&M’s Paris and Amsterdam engine shops, with CF6-80C2 and CFM56-5A/C capability, have developed a PW4000 capability in its Miami-based Bonus Tech JV.

Mature engine USM market

A good supply of USM is important for OEMs and MROs to provide options and cost reductions during ESV.

GE is a pioneer in the USM business and it is the largest USM distributor of its own material. Through programmes like TRUEngine, GE can use the increased value of OEM USM to secure a higher engine and engine part market value.

“Overall, there is a healthy market for good quality USM, and GE and CFMI are both active in the USM market,” says Brensike. “We sell more than \$700 million of USM per year, and we see USM as a critical component of our strategy of offering customers the broadest range of services and materials solutions. Since we accept only fully traceable and OEM-approved repairs, our USM reduces unknowns and ensures a fully-supportable configuration. With extensive inventory at state-of-the-art distribution facilities in the Americas, Europe and Asia, we provide fast and accurate fulfilment for all GE and CFMI product lines anywhere in the world.”

Bavière adds that: “From a MRO point of view, the current activities in the mature engine market allow us to optimise the stock of used serviceable parts. Indeed, many shop visits on

Independent engine MROs have developed and evolved maintenance programmes for mature and ageing engines. MTU Maintenance’s portfolio of programmes for ageing engines includes the V2500, as well as the CF6 family, CF34, CFM56 family and PW2000.

mature/ageing engines require rebuilding the engine with low remaining EFCs to avoid losing life potential. As such, this is an opportunity for the MRO to propose USM parts which were of no interest before. The issue is to find the most accurate parts to meet the customer needs. It requires the AFI KLM E&M purchase department to be reactive to customer expectations.”

Friis-Petersen also notes: “Due to MTU Maintenance’s close relationship with our customer base, proactive material planning is key to support engine and module exchanges as well as securing access to USM. This was one of the prime reasons for us to establish an engine asset management company with Sumitomo Corporation from Japan. We are based in Amsterdam and offer tailored engine material solutions.”

Summary

The mature engine market is growing in options for maximising the benefits of green life usage in conjunction with known cost of continued operation.

The airlines and lessors, through combined material solutions and optimised worksopes, are able to free themselves from outright spare engine ownership in favour of leasing options. This is with the understanding that mature engines need more frequent performance restoration shop visits and have high material usage, especially the replacement of expired LLPs.

Mature engines tend to give a good view of value performance over time, as they are more likely to be impacted harder by any financial or environmental events that affect the aerospace and travel industries. Customisation has become the tool to maximising benefits, because there is no solution that fits all engines and operators. Measures to defer or even avoid engine shop visits are now firmly in place covering ‘repair versus replace’, or even exchange options to prevent MRO costs from becoming disproportionately high relative to required remaining operation hours. [AC](#)

To download 100s of articles like this, visit:
www.aircraft-commerce.com