

Despite the 737 Classics being retired in large numbers, there are still more than 2,800 CFM56-3s in operation. These require an extensive support network. The major providers of engine maintenance, component repair, and PMA provisioning are reviewed.

Who's who in the CFM56-3 support market

With more than 1,900 737 Classics built and with a fleet of spare engines to support, the total number of CFM56-3s manufactured will have exceeded 4,400 units. However, the large number of retirements that has taken place in recent years means that the active 737 Classic fleet has diminished to about 1,200 aircraft, and the number of active engines will therefore be in the region of 2,800 units. The 737 Classic fleet is expected to contract still further, and the implications of this are that the surplus of used engines on the market will probably continue to grow. Some aftermarket participants believe that the CFM56-3 could follow a similar aftermarket trend to the JT8D, whereby a market surplus caused a slump in engine values and shop visit activity. Once all time-continued engines in a reasonable condition have been used up, shop-visit activity and engine values will increase again.

For continued support, operators need to be assured of services offered by engine shops, specialist and high-technology repair agencies, and lessors and traders. The capabilities offered by engine shops and component repair agencies are surveyed here. Suppliers of parts manufacturer approved (PMA) parts are also analysed.

CFM56-3 MRO market

Aircraft powered with -3C1 engines are the most numerous and most popular with airlines. These aircraft are likely to remain in service the longest, and the current active fleet numbers more than 560 aircraft, which means an active fleet of about 1,300 -3C1 engines.

The -3B1 fleet is the second largest,

with 440 active aircraft, relying on an active -3B1 fleet of about 1,000 engines. Another 96 aircraft with -3B1 engines are parked, with United and Continental both having retired large numbers of 737-300s in recent years.

There are fewer than 240 -3B2-powered active aircraft, which means an active -3B2 fleet of about 540 engines.

With the CFM56-3 ranging in age from 11 to 25 years, all engines will now have a mature maintenance status. Many, if not all, of the initial production and operational problems will have been resolved, so this means that the maintenance is predominantly related to scheduled or planned shop visits and the replacement of life limited parts (LLPs). The surplus of used engines, however, means that many airlines will be able to avoid the high cost of buying new LLPs by acquiring time-continued parts from used engines instead.

The CFM56-3's maintenance requirements will depend partially on the rate of utilisation by operators, the engine flight hour (EFH) to engine flight cycle (EFC) ratio, and the typical removal and shop visit intervals achieved by the engine. The life of LLPs installed on the engine will also have a bearing on this.

Mature intervals for the lowest rated -3B1s will be 10,000EFC, equal to about 14,000EFH. This will reduce gradually for higher thrust ratings and be about 4,000EFC and 6,000EFH for engines rated at 23,500lbs. Typical rates of utilisation by most operators are in the region of 2,500FH per year.

Engines will therefore require shop visits every two to five years, which suggests that the CFM56-3 market is equivalent to 700-900 shop visits annually. In 2007-2008 the annual global

shop-visit volume was close to 1,000 units. With the implosion of the fleet and a surplus of engines, total shop-visit numbers dropped to 515 in 2009. The market is now showing some signs of recovery, however, as aircraft are changing hands.

Some shops are reported to be offering a guarantee to customers that 100% of the materials used in shop visits will be used. Such a policy will reduce the cost of engine shop visits, make the maintenance market more competitive, and consume parts from time-continued engines at a high rate.

Sourcing maintenance

Many engine shops offer different types of CFM56-3 repair and overhaul capability. These vary from basic disassembly into modules to the most detailed and complex component repairs.

Information relating to the capability of each facility is divided in two parts.

The first part is the main engine level, which can be as simple as disassembly of the engine into modules, disassembly of each module to piece-part level, and complete overhaul of the module.

The engine's six main modules comprise: the fan and low pressure compressor (LPC) assembly; the high pressure compressor (HPC); the high pressure turbine (HPT); the low pressure turbine (LPT); the combustor; and the gearbox.

The survey results summarise the capability level of each shop for each of these modules. There is a table for each module, and each shop's capability with respect to that module (*see tables, pages 32 & 34*). Three main levels of capability are listed: minimum (M), refurbishment

CFM56-3 - FAN & LPC MODULES CAPABILITY

Maintenance Provider	Fan and booster	No. 1&2 bearing support	Fan frame assembly
Aerotherm	M/R/O	M/R/O	M/R/O
Aveos Fleet Performance Inc.	M/R/O	M/R/O	M/R/O
Bedek Aviation (Divn of IAI)	M/R/O	M/R/O	M/R/O
Delta TechOps	M/R/O	M/R/O	M/R/O
Central European Engine Services	M/R/O	M/R/O	M/R/O
GE Celma (Brazil)	M/R/O	M/R/O	M/R/O
GE Engine Services - Malaysia	M/R/O	M/R/O	M/R/O
GE Engine Services - Strother	M/R/O	M/R/O	M/R/O
GE Engine Services - Wales	M/R/O	M/R/O	M/R/O
LTQ Maintenance	M/R/O	M/R/O	M/R/O
Lufthansa Airmotive Ireland	M/R/O	M/R/O	M/R/O
Lufthansa Technik	M/R/O	M/R/O	M/R/O
MTU - Vancouver	M/R/O	M/R/O	M/R/O
MTU - Zhuhai	M/R/O	M/R/O	M/R/O
P&W Norway Engine Center	M/R/O	M/R/O	M/R/O
P&W Turkish Engine Center	M/R/O	M/R/O	M/R/O
P&W Shanghai Engine Center	M/R/O	M/R/O	M/R/O
Snecma SSB, Brussels	M/R/O	M/R/O	M/R/O
Snecma SMES, Casablanca	M/R/O	M/R/O	M/R/O
Snecma SAMES, Chengdu	M/R/O	M/R/O	M/R/O
ST Aerospace	M/R/O	M/R/O	M/R/O
TAP Maintenance & Engineering	M/R/O	M/R/O	M/R/O

CFM56-3 - HIGH PRESSURE COMPRESSOR MODULE CAPABILITY

	HPC Rotor assembly	HPC fwd stator	HPC rear stator
Aerotherm	M/R/O	M/R/O	M/R/O
Aveos Fleet Performance Inc.	M/R/O	M/R/O	M/R/O
Bedek Aviation (Divn of IAI)	M/R/O	M/R/O	M/R/O
Delta TechOps	M/R/O	M/R/O	M/R/O
Central European Engine Services	M/R/O	M/R/O	M/R/O
GE Celma (Brazil)	M/R/O	M/R/O	M/R/O
GE Engine Services - Malaysia	M/R/O	M/R/O	M/R/O
GE Engine Services - Strother	M/R/O	M/R/O	M/R/O
GE Engine Services - Wales	M/R/O	M/R/O	M/R/O
LTQ Maintenance	M/R/O	M/R/O	M/R/O
Lufthansa Airmotive Ireland	M/R/O	M/R/O	M/R/O
Lufthansa Technik	M/R/O	M/R/O	M/R/O
MTU - Vancouver	M/R/O	M/R/O	M/R/O
MTU - Zhuhai	M/R/O	M/R/O	M/R/O
P&W Norway Engine Center	M/R/O	M/R/O	M/R/O
P&W Turkish Engine Center	M/R/O	M/R/O	M/R/O
P&W Shanghai Engine Center	M/R/O	M/R/O	M/R/O
Snecma SSB, Brussels	M/R/O	M/R/O	M/R/O
Snecma SMES, Casablanca	M/R/O	M/R/O	M/R/O
Snecma SAMES, Chengdu	M/R/O	M/R/O	M/R/O
ST Aerospace	M/R/O	M/R/O	M/R/O
TAP Maintenance & Engineering	M/R/O	M/R/O	M/R/O

CFM56-3 - HIGH PRESSURE TURBINE MODULE CAPABILITY

	HPT Nozzles & guide vane assembly	HPT rotor assembly
Aerotherm	M/R/O	M/R/O
Aveos Fleet Performance Inc.	M/R/O	M/R/O
Bedek Aviation (Divn of IAI)	M/R/O	M/R/O
Delta TechOps	M/R/O	M/R/O
Central European Engine Services	M/R/O	M/R/O
GE Celma (Brazil)	M/R/O	M/R/O
GE Engine Services - Malaysia	M/R/O	M/R/O
GE Engine Services - Strother	M/R/O	M/R/O
GE Engine Services - Wales	M/R/O	M/R/O
LTQ Maintenance	M/R/O	M/R/O
Lufthansa Airmotive Ireland	M/R/O	M/R/O
Lufthansa Technik	M/R/O	M/R/O
MTU - Vancouver	M/R/O	M/R/O
MTU - Zhuhai	M/R/O	M/R/O
P&W Norway Engine Center	M/R/O	M/R/O
P&W Turkish Engine Center	M/R/O	M/R/O
P&W Shanghai Engine Center	M/R/O	M/R/O
Snecma SSB, Brussels	M/R/O	M/R/O
Snecma SMES, Casablanca	M/R/O	M/R/O
Snecma SAMES, Chengdu	M/R/O	M/R/O
ST aerospace	M/R/O	M/R/O
TAP Maintenance & Engineering	M/R/O	M/R/O

In-house Shop visit levels

M - Minimum

R - Refurbishment

O - Overhaul

S - Module work sub-contracted

(R) and overhaul (O). These are the same workscope levels as defined in the workscope planning guide. A minimum workscope involves a simple external inspection and a borescope.

Refurbishment involves some degree of disassembly and inspection, but the module is not completely disassembled to piece-part level. Some repairs will be carried out. An overhaul involves a complete disassembly of the module to piece-part level, and an inspection of all parts and repairs. If the shop does not have the required capability for an overhaul, it sub-contracts the work. This is denoted by S.

The second part concerns specialist and high-technology repairs of piece-part components. These are discussed in a later section.

Shop module capability

All the main global CFM56-3 engine shops were consulted for this survey, and their module and main engine maintenance capabilities are listed (see tables, this page & page 34).

There are a number of independent shops as well as those connected to airlines, but the majority of shops are owned by, or are joint ventures (JVs) with, the original equipment manufacturers (OEMs) General Electric (GE) and Snecma. Pratt & Whitney (PW) also has capability for the CFM56-3 at several of its engine shops.

The OEM shops generally offer a complete overhaul service with disassembly of all modules to piece-part level, and then complete repair of these parts.

GE in particular is the main maintenance provider for this engine with five facilities, and has a 32% share of annual engine shop-visit activity.

GE is capable of all engine module breakdown and repairs at its relevant facilities, to all three shop-visit levels, with the exception of certain specialist repairs such as airfoils. These are sub-contracted to other shops within the GE network.

Snecma has four shops spread across three continents, and accounts for about 10% of recent shop visits.

The third OEM involved in CFM56-3 maintenance, PW, offers maintenance at three of its engine service centres (see tables, this page & page 34). PW has amassed a market share of just over 5% using three facilities on two continents.

The biggest airline maintenance facility is Lufthansa Technik, due in part to its JVs: Lufthansa Airmotive Ireland, and LTQ Maintenance, a J-V with Qantas. These three shops account for nearly 10% of the global share in recent CFM56-3 shop visits.

MTU Vancouver and MTU Zhuhai

CFM56-3 - LOW PRESSURE TURBINE MODULE CAPABILITY

	LPT Stage 1 Nozzle	LPT stator / rotor assembly	LPT shaft assembly	LPT frame assembly
Aerotruth	M/R/O			
Aveos Fleet Performance Inc.	M/R/O	M/R/O	M/R/O	M/R/O
Bedek Aviation (Divn of IAI)	M/R/O	M/R/O	M/R/O	M/R/O
Delta TechOps	M/R/O	M/R/O	M/R/O	M/R/O
Central European Engine Services	M/R/O	M/R/O	M/R/O	M/R/O
GE Celma (Brazil)	M/R/O	M/R/O	M/R/O	M/R/O
GE Engine Services - Malaysia	M/R/O	M/R/O	M/R/O	M/R/O
GE Engine Services - Strother	M/R/O	M/R/O	M/R/O	M/R/O
GE Engine Services - Wales	M/R/O	M/R/O	M/R/O	M/R/O
LTQ Maintenance	M/R/O	M/R/O	M/R/O	M/R/O
Lufthansa Airmotive Ireland	M/R/O	M/R/O	M/R/O	M/R/O
Lufthansa Technik	M/R/O	M/R/O	M/R/O	M/R/O
MTU - Vancouver	M/R/O	M/R/O	M/R/O	M/R/O
MTU - Zhuhai	M/R/O	M/R/O	M/R/O	M/R/O
P&W Norway Engine Center	M/R/O	M/R/O	M/R/O	M/R/O
P&W Turkish Engine Center	M/R/O	M/R/O	M/R/O	M/R/O
P&W Shanghai Engine Center	M/R/O	M/R/O	M/R/O	M/R/O
Snecma SSB, Brussels	M/R/O	M/R/O	M/R/O	M/R/O
Snecma SMES, Casablanca	M/R/O	M/R/O	M/R/O	M/R/O
Snecma SAMES, Chengdu	M/R/O	M/R/O	M/R/O	M/R/O
ST Aerospace	M/R/O	M/R/O	M/R/O	M/R/O
TAP Maintenance & Engineering	M/R/O	M/R/O	M/R/O	M/R/O

CFM56-3 - COMBUSTOR CAPABILITY

	Combustion case assembly	Combustion chamber assembly
Aerotruth	M/R/O	S
Aveos Fleet Performance Inc.	M/R/O	M/S
Bedek Aviation (Divn of IAI)	M/R/O	M/R/O
Delta TechOps	M/R/O	M/R/O
Central European Engine Services	M/R/O	M/R/O
GE Celma (Brazil)	M/R/O	M/R/O
GE Engine Services - Malaysia	M/R/O	M/R/O
GE Engine Services - Strother	M/R/O	M/R/O
GE Engine Services - Wales	M/R/O	M/R/O
LTQ Maintenance	M/R/O	M/R/O
Lufthansa Airmotive Ireland	M/R/O	M/R/O
Lufthansa Technik	M/R/O	M/R/O
MTU - Vancouver	M/R/O	M/S
MTU - Zhuhai	M/R/O	M/R/O
P&W Norway Engine Center	M/R/O	M/R/O
P&W Turkish Engine Center	M/R/O	M/R/O
P&W Shanghai Engine Center	M/R/O	M/R/O
Snecma SSB, Brussels	M/R/O	M/R/O
Snecma SMES, Casablanca	M/R/O	M/R/O
Snecma SAMES, Chengdu	M/R/O	M/R/O
ST Aerospace	M/R/O	M/R/O
TAP Engineering & Maintenance	M/R/O	M/R/O

CFM56-3 - GEARBOX MODULE CAPABILITY

	Inlet gearbox (& No.3 bearing)	Transfer gearbox	Accessory gearbox
Aerotruth	M/S	M/S	M/S
Aveos Fleet Performance Inc.	M/R/O	M/R/O	M/R/O
Bedek Aviation (Divn of IAI)	M/R/O	M/R/O	M/R/O
Delta TechOps	M/R/O	M/R/O	M/R/O
Central European Engine Services	M/R/O	M/R/O	M/R/O
GE Celma (Brazil)	M/R/O	M/R/O	M/R/O
GE Engine Services - Malaysia	M/R/O	M/R/O	M/R/O
GE Engine Services - Strother	M/R/O	M/R/O	M/R/O
GE Engine Services - Wales	M/R/O	M/R/O	M/R/O
LTQ Maintenance	M/R/O	M/R/O	M/R/O
Lufthansa Airmotive Ireland	M/R/O	M/R/O	M/R/O
Lufthansa Technik	M/R/O	M/R/O	M/R/O
MTU - Vancouver	M/R/O	M/R/O	M/R/O
MTU - Zhuhai	M/R/O	M/R/O	M/R/O
P&W Norway Engine Center	M/R/O	M/R/O	M/R/O
P&W Turkish Engine Center	M/R/O	M/R/O	M/R/O
P&W Shanghai Engine Center	M/R/O	M/R/O	M/R/O
Snecma SSB, Brussels	M/R/O	M/R/O	M/R/O
Snecma SMES, Casablanca	M/R/O	M/R/O	M/R/O
Snecma SAMES, Chengdu	M/R/O	M/R/O	M/R/O
ST Aerospace	M/R/O	M/R/O	M/R/O
TAP Maintenance & Engineering	M/R/O	M/R/O	M/R/O

In-house Shop visit levels

- M** - Minimum
- R** - Refurbishment
- O** - Overhaul
- S** - Module work sub-contracted

are another two large providers, accounting for about 11% of the market. This makes them the most active independent maintenance providers.

There are many smaller maintenance providers, both airline-connected and independent. As the size of the fleet has diminished and the number of first-tier customers has declined, several shops have left the CFM56-3 market. In Europe these include MTU Maintenance and Air France Industries.

Africa

Africa only accounts for 5% of the global fleet. EgyptAir Maintenance & Engineering and Snecma Morocco Engine Services are the only facilities with engine shop capability, and Snecma Morocco has secured much of the African fleet for its shop.

Asia Pacific

The third largest fleet is in the Asia Pacific. There are independent maintenance, repair & overhaul (MRO) facilities and JVs with OEMs and airline maintenance & engineering departments, including Lufthansa Technik, GE, LTQ Maintenance (a JV between Lufthansa Technik and Qantas), PW Shanghai (a JV between PW and China Eastern Airlines), and Philippine Airlines. The main independent is ST Aerospace, but MTU Zhuhai has a 5% share of the global market.

GE's shop in Malaysia is the most prolific shop. This has over 6.5% of the global market, and a number of local and international contracts.

Europe

At least a quarter of recent shop-visit activity has been completed in European shops. All three OEMs and MRO facilities have large operations in Europe, with the capabilities of some shops growing.

Lufthansa Technik (LHT) works on a large number of these engines around Europe, taking a share of at least 8% of recent global shop visits. LHT has two shops in Europe: its Hamburg engine shop and Lufthansa Airmotive Ireland, Dublin.

GE, Snecma and PW also have a large presence in Europe. PW has one of its main engine centres in Norway, as well as a new JV with Turkish Technic in Istanbul. Both of these facilities account for about 5.5% of the market, although this could change as P&W Turkish Technic Engine Maintenance develops its capabilities.

GE has two European shops. The main shop is GE Engine Services, Wales, while the second is a JV with LOT Polish

The annual volume of CFM56-3 shop visits has declined from about 1,000 per year two or three years ago to about 500. This is mainly due to a surplus of time-continued engines on the market.

Airlines called Central European Engine Services.

Snecma's main MRO Division is in France, but it also has a facility in Brussels. These two facilities have nearly 7% of the global shop-visit market.

The remaining European CFM56-3 engine shops are connected to national carriers. These are JAT Tehnika (formally the maintenance department of JAT Airways) and TAP Maintenance & Engineering (TAP Air Portugal).

Middle East

Although only 1% of the global CFM56-3 fleet is located in the Middle East, Bedek Aviation in Israel accounts for about 3% of global shop visits. It undertakes work for operators from the UK, China, Kenya, Tanzania, Japan, Belgium and Turkey. Bedek Aviation has carried out about 400 shop visits, which is equivalent to about 40 shop visits annually.

North America

The North American fleet accounts for 30% of the global CFM56-3 fleet. The most popular model is the CFM56-3B1, which makes up half the fleet. However, 36% of the North American fleet is currently parked, which could lead to a reduction in maintenance capacity in the region.

The main North American shops are GE Strother, Kansas, as well as a few connected to major airlines. Strother is the market leader, with a 22% share of the market.

The major airline maintenance departments that provide third-party engine shop capabilities are: Delta TechOps in Atlanta, Georgia; United Services in Chicago, Illinois; and Aveos Fleet Performance Inc. in Montreal, Canada.

MTU again has a presence in North America, with an engine shop in Canada. Other independents include Aerothrust in Miami, Florida.

South America

There is only one major engine shop for the CFM56-3 in South America, which is provided by GE's Celma Engine Services shop located in Brazil. This is also one of South America's main engine shops, accounting for less than 1% of the



worldwide market share of engine shop visits.

Overview

With an ageing aircraft it is likely that more 737 Classics will be retired or change ownership. Many of the aircraft could move from North America and Europe to developing economic regions, which could see a corresponding shift in engine shop-visit activity.

It is clear that the GE and SNECMA shops have the largest market share and, despite the geographical distances, could be the shops to retain their numbers of engine shop visits, while other shops lose market share.

Component repairs

There is a large number of specialist repair providers for the CFM56-3. To examine the services that are provided by these companies, the different modules, sub-structures and main components of the engine are taken into consideration.

There are, however, a few providers that offer repairs for virtually all components on the engine. The OEMs GE and Snecma both have large parts repair capabilities.

GE has extensive capability for repairing the ATA Chapter 72 components of the core engine, including all blades and vanes, nozzles, seals, combustors, frames, cases, LLPs, and other components. GE has seven shops for repairing these components in: Cincinnati, Ohio; McAllen, Texas; Tri-Reman, Indianapolis; two in Singapore; one in Hungary; and one in Japan. One of its Singapore shops was previously AirFoil Technologies, which GE acquired

in 2009.

GE does not repair all accessories or parts related to the quick engine change (QEC) kit. These are manufactured by other OEMs, and GE only repairs some of these components. Some accessories are repaired in the backshops of their engine facilities, such as its shop in Wales for example.

Snecma provides maintenance for the CFM56-3 at its shops in Brussels, Casablanca and Chengdu. Each of these shops has full component repair capability on the engine, either in backshops at these facilities, or through various centres of excellence.

Pratt & Whitney is the third OEM to offer extensive capability for the engine. It has a number of component repair shops that include: PW Aircraft Repair International; East Hartford Repair Operations; Connecticut Airfoil Repair Operations; Dallas Airfoil Repair Operations; International Aerospace Tubes; Turbine Overhaul Services; Asian Compressor Technology Services; Combustor Airmotive Services; Japan Turbine Technologies; and Singapore Part Repair Operations.

Besides the OEMs, Lufthansa Technik is the airline maintenance & engineering organisation with the largest engine component repair capability. It has its main engine shop at Hamburg, but also has Lufthansa Technik Airmotive Ireland in Dublin for engine disassembly and module maintenance.

Component repairs are sent to various divisions in Lufthansa Technik. The first of these is Engine Parts and Accessories Repair (EPAR), based in Hamburg, Germany. There is also Lufthansa Technik Turbine Services in Shannon, Ireland, its engine shop in Berlin,



Germany, and Airfoil Services (ASSB) in Kuala Lumpur, Malaysia, which is a JV with MTU Maintenance.

Overall, Lufthansa Technik carries out up to 100 CFM56-3 shop visits per year.

Engine modules

PAS Technologies, based in Kansas City, Missouri, is one of four companies that overhaul fan blades in the fan module. It utilises a fully OEM-approved forming process, which uses a controlled forming process to achieve optimum airfoil shape. Mark Greene, vice president of sales and marketing for the Americas, claims that it only costs \$20,000 to repair a shipset of fan blades. This compares to a list price of about \$15,000 for a new blade.

The main LPC components are blades and vanes or stators. Chromalloy is one of the market leaders in blade and vane repairs, having developed capability for the CFM56-3 since it entered service. It provides repairs for all blades and vanes in all CFM56-3 modules with the exception of the fan. Chromalloy has extensive capability throughout the CFM56-3, and has up to 20 facilities in various locations around the world. Rob Church, regional sales director for the Americas at Chromalloy, estimates that repairs for blades and vanes typically cost about 10% of the list price of new components.

Blades and vanes are the main components in the HPC module. Chromalloy again is one of the major providers for this module. Airfoil Services (ASSB), a JV between MTU Maintenance and Lufthansa Technik, based in Kuala Lumpur, Malaysia is another provider of

HPC blade repairs.

The main components of combustion chambers are combustion cans and fuel nozzles. Chromalloy is also a major provider of repairs for combustion cans. Other repair facilities include Bedek Aviation, a division of Israel Aircraft Industries; Jet Aviation Specialists, based in Miami, Florida; and Twin Manufacturing, based in Connecticut. The combustor assembly requires specialised repair, and this is the main activity of Jet Aviation Specialists. Besides Chromalloy, it also competes with Lufthansa Technik, GE, and Snecma Services Brussels.

Woodward Aircraft Engine Systems, based in Prestwick, Scotland, is a specialist provider of fuel nozzle repairs for all major engine types. It is also the only company to manufacture parts as well as provide repairs. It is estimated that a new fuel nozzle has a list price of \$4,000-5,000, which compares to a repair cost of \$1,000. Jet Aviation Specialists also provides fuel nozzle repairs.

The HPT module requires some of the most expensive and advanced repairs. Repairs for HPT blades and nozzle guide vanes use laser drilling, for example, and major providers of these are GE, Snecma, Lufthansa Technik and Chromalloy.

Chromalloy and Airfoil Services are two of the providers of repairs for LPT blades and vanes. GE and Snecma also offer repairs, while Chromalloy, GE, Lufthansa Technik and Snecma also provide repairs for LLP stators.

Turbine Controls Inc (TCI), based in Connecticut, specialises in repairing LPT rotating airseals for all four stages. This is one of the many repairs it offers for a wide range of components on the

The fall in CFM56-3 shop visit activity has led to several engine shops leaving the market. The OEMs have the largest share of the CFM56-3 market.

CFM56-3, with the exception of blades and vanes.

Honeycomb & knife-edge seals

Honeycomb seals are the non-rotating component of seals in the LPT. PAS Technologies and Bedek Aviation are two main providers of repairs to honeycomb seals.

Knife-edge seals are the rotating component of seals in the LPT and other parts of the engine. Major repair providers include Bedek Aviation, Turbine Controls and Twin Manufacturing.

These seals are also repaired by the main OEMs: GE, Snecma and PW.

LLPs

LLPs can broadly be divided into three categories: shafts, discs and rotating airseals.

Component Repair Technologies in Mentor, Ohio is just one provider of repairs to engine shafts. Using thermal spray techniques, including high velocity oxygen fuel (HVOF), new coatings can be applied to shafts to restore locating diameters.

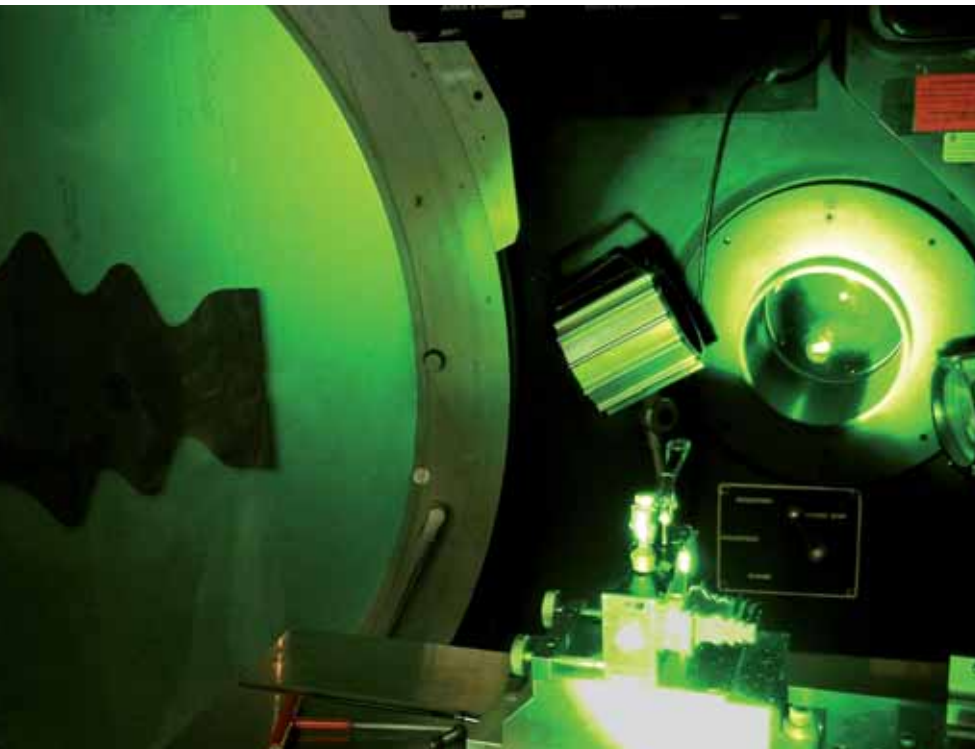
Turbine Controls is another provider of LLP repairs. The company offers repairs for most LLPs in the CFM56-3. These include the stage 1 disc in the HPT, front outer rotating airseal, the HPT rotor shaft, the LPT shaft, LPT discs, the CDP seal, the spools in the HPC, and LPC booster spool.

Jet Aviation Specialists also offer LLP repairs, while Air Concept Repairs offers the repair of blade and vane roots on discs.

Cases & frames

Cases and frames are some of the simplest parts, being non-rotating and having no moving parts. Chromalloy repairs all types of cases for the CFM56-3, as does Air Concept Repair Technologies and Component Repair Technologies. The repair of stationary parts is the speciality of Component Repair Technologies. Twin Manufacturing and Turbine Controls also repair cases on some modules.

In addition to cases, there are also a few other stationary and non-complex parts. Jet Aviation Specialists repairs fan and rear spinner cones, for example.



Bearings & seals

There are five bearing units in the CFM56-3. The main parts or sub-components of bearings are bearing supports, bearing cases and ball bearings.

Bearing support repairs are another speciality of Component Repair Technologies, the parts being stationary within the engine. Repair of bearing cases is offered by Turbine Controls and Twin Manufacturing.

Air Concept Repair Technologies repairs bearings, as does Bearing Inspection.

Accessories & LRUs

The main components mounted on the outside of the engine can be divided between accessories and QEC components. The main accessories include the main engine control (MEC), fuel pump, pneumatic starter motor, variable stator vane actuators, sensors and lubricant units.

Woodward Aircraft Engine Systems is one of the world's major providers of repair and overhaul for the MEC for the CFM56-3, as well as many other engine types. A new MEC unit has a list price in the region of \$200,000, so repair is clearly the cheaper option.

Jet Technology Centre in Dublin, Ireland has repair capability for several engine accessory components. These include fuel pumps and the oil system, actuators, and hydraulic and pneumatic components.

Bedek Aviation has the capability to overhaul all bare engine accessories, and about 80% of the QEC accessories.

Nacelles & thrust reversers

Repair of nacelles, cowls and thrust reversers is a specialist capability. The nacelle and thrust reverser was built by Goodrich during the aircraft's production run.

Thrust reversers are maintained on-condition, and average intervals are estimated to be as high as 35,000 flight hours.

Goodrich offers repair and overhaul of nacelles and thrust reversers for the CFM56-3, but Triumph Airborne Structures now provides the OEM support for the reverser. That is, all spare parts for nacelles and reversers are built by Triumph Airborne Structures in Hot Springs, Arkansas.

Goodrich is the largest provider of repair and overhaul for thrust reverser and nacelle systems. It has four facilities located in Foley, Alabama; Prestwick, Scotland; Singapore; and Dubai, United Arab Emirates. Nordam also provides nacelle and thrust reverser repair capability through its facilities in Tulsa, Oklahoma, Wales in the United Kingdom, and Singapore.

PMA parts

There are five major suppliers of PMA parts for the CFM56-3.

Chromalloy has been developing engine PMAs for the past 10 years, during which time it has bought Belac, a JV between Chromalloy and Lufthansa Technik, which has been manufacturing HPT blades on the CFM56-3 since 2002. Belac's HPT blade replaces CFM's part number 1475M35P02. Belac estimates that its HPT list prices can be up to 40%

Chromalloy and Belac both repair and manufacture blades and vanes for the CFM56-3. It is estimated that savings of up to \$500,000 per shop visit are possible through the use of PMAs.


cheaper than the list price of the OEM's parts.

Chromalloy makes nozzle guide vanes for the CFM56-3. Chromalloy estimates that the list prices of its vanes are 60-70% cheaper than the OEMs', and its blades have list prices 40% lower than the OEMs'.

The advantage of PMAs is clear, with list prices of HPT blades being less than half the price of OEM blades. In the case of other types of blade and vane, PMA parts have list prices that are 40-75% of the OEMs' prices.

HEICO is a second major provider of PMAs for the CFM56-3, manufacturing HPC blades. It also manufactures fuel pump gears, turbine shrouds, compressor blades, bearings and shafts, and a wide range of expendables for the CFM56-3, and other engines in the CFM56 family. HEICO estimates that a saving of up to \$130,000 is possible for each shop visit through use of HEICO's PMAs. Its list prices are 20-40% lower than the OEMs'. "If the DER repairs and turbine blades offered by Chromalloy are included, then the savings per engine event can be as much as \$500,000," says Kate Schaefer, senior vice president of business development and marketing at HEICO Parts Group.

Wencor provides more than 100 PMA parts for the CFM56-3. These are used both in the internal engine, and on the external components, and include the gearbox, engine starter and fuel pump. Examples of components include seals, shafts, vanes, shrouds, bushings and bearings. Wencor does not only distribute its own parts through its own channels, but also through other PMA suppliers for whom Wencor also distributes parts. Wencor estimates that its catalogue prices are 40-60% lower than the prices of OEM parts.

PW has also developed alternative parts for the CFM56-3, although they are not strictly PMAs. PW provides 19 LLPs and 11 gas path components that it has developed with its own supplemental type certificates. The gas path components are four stages of LPT blades, four stages of LPT vanes, the HPT blade, HPT vane, and HPT shroud. These are therefore alternatives to the blades offered by Belac. 

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