With 7,500 CFM56-7B engines in operation, and another 3,000 still on order, the maintenance and support market for the CFM56-7B is one of the largest in the industry. The global support providers of engine maintenance and component repairs are summarised.

CFM56-7B maintenance & support market

The CFM56 is now the most successful jetline engine programme. A close relation of the CFM56-5B, which powers the A320 family, the -7B has been just as popular, powering all variants of the 737NG family. The -7B first went into service in 1997, and production rates are still high, with many orders to be fulfilled, despite the orders for the latest 737 family (the 737 Max), and A320 neo.

This makes for a large supply of CFM56-7B engines for the maintenance, repair and overhaul (MRO) market, both now and for the foreseeable future.

The -7B series has six thrust ratings, indicated by two-digit suffix: the -7B18 (19,500lbs thrust), -7B20 (20,600lbs thrust), -7B22 (22,700lbs thrust), -7B24 (24,200lbs thrust), -7B26 (26,300lbs thrust), and -7B27 (27,300lbs thrust).

CFM56-7B engines can be divided into those with the Tech56 modification, and those without it. The thrust ratings and designations for Tech56 modification variants are the same, but with a '/3' suffix, for example, CFM56-7B26/3.

CFM56-7B fleet profile

The CFM56-7B is one of the most numerous engines in the world. There are 7,500 CFM56-7B engines active, with more than 3,000 confirmed orders for more than 1,500 737NGs *(see table, page 38)*.

The most populous engine is the -7B26, operating on 891 active aircraft: 20 737-700s; 835 -800s; and 36 -900s. This gives an active installed fleet of 1,782 -7B26 engines. Only nine aircraft with -7B26 engines have been parked. The world's large fleets are split between Europe (536 engines), Asia Pacific (580) and North America (558), with smaller numbers elsewhere. The largest active fleets of -7B26 engines are with Ryanair (101 aircraft), Continental Airlines (now United; 100), Delta (71), American Airlines (49), China Southern (33), Qantas (33), Turkish Airlines (31) and Air China (29).

The -7B26 with the Tech56 insertion, designated the CFM56-7B/3, is the second most popular engine, with 736 active 737NGs, operating on 10 737-700s, 640 737-800s and 86 737-900ERs. This gives an active fleet of 1,472 -7B26/3 engines, found mainly in the Asia Pacific (600 engines) and Europe (570). Only one aircraft with -7B26/3 engines is parked. Ryanair dominates the active -7B26/3 fleet, with 151 aircraft. Other major operators are Air China (36 aircraft), Norwegian Air Shuttle (35), and Garuda Indonesia (32).

The -7B22 and -7B24 are the next most popular engines, operating on 507 and 476 aircraft respectively, giving 1,014 and 952 active engines of these types. These are found on all 737NG variants, with North America the most popular region for these engines. Southwest Airlines (166 aircraft), WestJet (61), and AirTran Airways (46) are the dominant operators of the -7B22. Southwest Airlines also dominates the -7B24 fleet, with these engines on 136 active aircraft.

The Tech56 insertion variants of these two engines total 61 aircraft (122 engines) for the -7B22/3 and 300 aircraft (600 engines) for the -7B24/3. These are found on 61 737-700s for the -7B22/3. The dominant operators of the -7B22/3 are WestJet (15 aircraft), and KLM (13). Tech56 engines are also found on 80 737-700s and 220 737-800s. The largest fleets of these are split almost equally between the Asia Pacific and North America. Southwest Airlines again dominates this fleet with 136 aircraft with -7B24/3 engines. There are many more smaller operators of this engine type.

Of the lower thrust rating versions of the -7B, there are 118 aircraft with 236 -7B20 engines, comprising 35 737-600s and 83 737-700s. SAS dominates the -7B20 fleet with 28 737-600s with -7B20 engines, and 10 737-700s with -7B20 engines. Several other smaller operators also use this type. Most of these engines are flown in Europe. The Tech56 insertion -7B20/3 engines power only eight aircraft, all 737-700s, with TUIfly (3), Shanghai Airlines (3) and Jetairfly (2).

In the higher thrust rating, 289 aircraft (578 engines) are powered by the standard -7B27. All of these are 737-800s, except one 737-700. American Airlines (27), Alaska Airlines (26), and Gol Transportes (23) are the largest operators of the -7B27. 116 aircraft have 232 Tech56 insertion -7B27/3s installed on them. Again, these are all 737-800s, except one 737-700 and two 737-900ERs. Gol Transportes Aereos (30), Alaska Airlines (29), and Air India Express (17) are the largest operators.

There are further sub-variants of the -7B with modified take-off power management and exhaust gas temperature (EGT) capabilities. These are classified with an additional suffix of 'B1' and 'B3.' There are 36 aircraft with -7B26/B1 engines All but two aircraft are 737-700BBJs, with many private operators. 79 aircraft have -7B27/B1 engines and comprise special and military variants of the 737-700 and -800. Only 11 aircraft have -7B27/B3 engines, and again all are special or military variants.

The remaining -7B active fleet

CFM56-7B GLOBAL FLEET BREAKDOWN

Engine Model	Africa Active	Africa Parked	Asia Pacific Active	Asia Pacific Parked	Europe Active	Europe Parked	Middle East Active	Middle East Parked	N. America Active	N. America Parked	S. America Active	S. America Parked	Total
CFM56-7B20	0	0	60	2	128	0	0	0	14	2	34	0	240
CFM56-7B20/3	0	0	6	0	10	0	0	0	0	0	0	0	16
CFM56-7B22	44	0	196	0	88	2	4	2	558	0	124	0	1,018
CFM56-7B22/3	6	0	12	0	52	0	0	0	46	0	6	0	122
CFM56-7B22E	0	0	10	0	10	0	0	0	0	0	2	0	22
CFM56-7B24	30	0	302	2	104	0	26	0	400	0	90	0	954
CFM56-7B24/3	10	0	284	0	20	0	0	0	286	0	0	0	600
CFM56-7B24E	2	0	26	0	0	0	0	0	36	0	0	0	64
CFM56-7B26	76	4	580	2	528	8	10	0	558	4	30	0	1,800
CFM56-7B26/2	0	0	0	0	2	0	0	0	0	0	0	0	2
CFM56-7B26/3	62	0	600	0	570	2	58	0	152	0	30	0	1,474
CFM56-7B26/B1	4	2	10	0	8	0	10	0	32	0	8	0	74
CFM56-7B26E	14	0	82	0	34	0	6	0	2	0	12	0	150
CFM56-7B27	66	0	84	2	210	4	4	0	120	0	94	0	584
CFM56-7B27/3	14	0	36	0	50	0	2	0	62	8	68	0	240
CFM56-7B27/B1	6	0	28	2	34	10	40	0	44	4	6	0	174
CFM56-7B27/B3	2	0	6	10	4	6	0	8	10	18	0	0	64
CFM56-7B27E	0	0	0	0	2	0	0	0	0	0	12	0	14
CFM56-7B27E/B3	0	2	0	4	0	0	0	0	0	4	0	0	10
GEO-TOTALS	336	8	2,322	24	1854	32	160	10	2,320	40	516	0	7,622
OVERALL TOTAL	344		2,346		1,886		170		2,360		516		7,622

comprises engines with the suffix 'E.' Eleven aircraft, all 737-700s, are powered by the -7B22E. Nine 737-700s and 23 737-800s have -7B24E engines.

Increasing the thrust rating even further, there are 66 737-800s with -7B26E engines, and nine 737-900ERs; totalling 75 aircraft or 150 engines. Seven 737-800s have -7B27E engines.

The vast majority of confirmed orders are for the Tech56 insertion variants now built as standard for the 737NG family. Orders for the -7B26/3 make up the bulk, with about 700 confirmed aircraft orders (1,400 engines) still outstanding. Orders for the -7B24/3 and -7B27/3 are both over 150 aircraft, or 300 engines. Other engines in the -7B series have a smaller number of outstanding orders.

Shop-visit market

According to statistics from the OEM, there were 672 'engine-caused' shop visits for the 12 months from October 2010. These are planned visits caused by faults in the engine, or planned replacements of life-limited parts (LLPs). Other shop visits can be classified as 'non-engine-caused'. These are unscheduled visits, caused, for example, by foreign object debris (FOD). If non-engine-caused visits are included, then an additional 129 shop visits can be added for the same time period, giving a total of 801 shop visits for the 12 months from October 2010.

All engine shops surveyed anticipated growth in their shop-visit numbers. The overall market in 2012 is forecast to be a total of 950 engine- and non-engine-caused shop visits, rising to 1,200 shop visits in 2016 and 1,700 in 2021.

Engine removals

The maintenance requirements for the CFM56-7B will be mainly related to planned shop visits and LLP replacement. Other factors include the engine's rate of utilisation by operators, and its engine flight hour (EFH) to engine flight cycle (EFC) ratio (the average number of flight hours for each cycle flown).

The main removal causes vary by the thrust rating of the engine. According to Claus Bullenkamp, senior manager engine programmes at MTU Maintenance Hannover: "The low-thrust removal driver is typically the first LLP, and the high-thrust removal driver is typically loss of performance." Other factors can cause engine removal, however. "Removals may be due to operational characteristics, such as: geographical operational area; flight hour to flight cycle ratio; percentage derate; engine hardware configuration; customer maintenance programmes (for example, quick turn programmes); and lease return requirements," says Dion Verbocht, customer support engineer with Air France Industries KLM Engineering & Maintenance (AFI KLM E&M). "Harsh environmental conditions drive the shop visits by compressor erosion and/or hot section distress."

Other engine removal causes include: high-pressure turbine (HPT) blade failures/management; preventative high-pressure compressor (HPC) rotor stator contact; HPC J-hook wear; low-pressure turbine (LPT) nozzle distress; variable stator vane (VSV) bushing replacement; performance restoration; hot section degradation; and harsh environments, leading to combustor distress.

Shop visits

In general, the shop-visit interval decreases as thrust rating increases. MTU Maintenance says the shop-visit intervals for -7B20 and -7B22 variants are around 20,000EFC, changing to cycles of 16,000-20,000EFC for the -7B24, 12,000-17,000EFC for the -7B26 and 10,000-12,000EFC for the high-thrust rating -7B27.

The -7B27 engines are assumed to be operated at a higher EFH:EFC ratio of 2.5:1.

Shop-visit intervals depend on both the geographic region and operational characteristics of each particular engine. Engines with high annual utilisation, and operated in a harsh environment will have a lower shop-visit interval than a lower-utilisation engine operated in a more favourable environment.

"Taking these geographic and operational characteristics into account," says Verbocht, "a low-thrust operator based in Northern Europe, with a ratio of 1.4:1, may have a shop-visit interval of 24,000EFH, whereas an eastern-China-based low-thrust 1.7:1 ratio operator may have an interval of 26,000EFH." Further highlighting the differences between regions and operators, Verbocht adds: "A Middle-East-based, high-thrust 1.3:1 ratio operator can have a shop-visit interval of only 10,000EFH."

"In terms of the shop-visit pattern, low-thrust engines will see core performance shop visits with LLPs, with some operators replacing all LLPs to achieve another full run. High-thrust engines will typically have a core performance workscope, with the LLP

FACILITIES WITH CFM56-7B REPAIR CONTRACTS

Facility	Engine O/H	HSI	Acc. drive gearbox	Elec. system	Fuel system	LRU	Lubrication system	Thrust reverser
Africa								
Ethiopian Airlines	Y	Y						
SNECMA Morocco Engine Services	Y	Y						
Asia Pacific								
Air India	Y	Y						
Airfoil Services Sdn Bhd						Y		
ANA Engine Services Co Ltd	Y	Y						
China Airlines	Y	Y						
Fuel Acc Srvcs Technologies					Y			
Gameco			Y	Y	Y	Y	Y	Y
IHI Corporation	Y	Y						
Korean Air	Y	Y						
LTQ Engineering	Y	Y						
Lufthansa Technik Shenzhen			Y			Y		Y
MTU Maintenance Zhuhai	Y	Y						
PW Shanghai Engine Center	Y	Y						
SIA Engineering Company Ltd	Y	Y						
Sichuan Svs Aero-Eng Maint	Y	Y	Y	Y	Y	Y	Y	
ST Aerospace Engines	Y	Y	Y	Y	Y		Y	
ST Aerospace Systems				Y	Y		Y	
Triumph Aviation Services Asia			Y	Y	Y	Y	Y	Y
Europe								
1-Source Aero Services S.A.				Y	Y	Y	Y	
Airframe Components Europe								Y
Auxitrol S.A.				Y		Y		
Avio S.p.A.	Y	Y	Y	Y	Y	Y	Y	Y
Beagle Aerospace								Y
Chromalloy Holland					Y	Y	Y	
GE Engine Services -Wales	Y	Y	Y	Y	Y	Y	Y	Y
Goodrich (Prestwick)								Y
Iberia	Y	Y						
Jet Technology Center Ltd					Y	Y		
KLM Engineering & Maintenance	Y	Y	Y	Y	Y	Y	Y	
Lufthansa Tech Airmotive Ire	Y	Y	Y	Y	Y	Y	Y	Y
Lufthansa Technik AG	Y	Y	Y	Y	Y	Y	Y	Y
Lufthansa Technik Intercoat					Y		Y	
MTU Aero Engines Polska						Y		
MTU Maintenance Hannover	Y	Y	Y	Y	Y	Y	Y	
Nordam Europe Ltd								Y
PW Norway Engine Center	Y	Y						
PW Turkish Technic Eng Maint	Y	Y						
SNECMA (MRO Division)			Y	Y	Y	Y	Y	Y
SNECMA Services Brussels	Y	Y						
SR Technics	Y	Y	Y	Y	Y	Y	Y	Y
ST Aerospace Solutions A/S								Y
TAP Maintenance & Engineering	Y	Y	Y	Y	Y	Y	Y	Y
Woodward Aircraft Engine Sys					Y			
Middle East								
AMES						Y		Y
Bedek Aviation (Divn of IAI)	Y	Y						
El Al Tech				Y	Y	Y	Y	
Jordan Aeronautical Systems Co		Y						
North America								
AA-MRO	Y	Y						
Accel Aviation Accessories				Y	Y	Y		
Aerothrust	Y	Y	Y	Y	Y	Y	Y	Y
Aircraft Ducting Repair				Y			Y	Y
Ascent Aviation Services Corp						Y		
Chromalloy Dallas						Y		
Chromalloy Texas						Y		
Chromalloy Windsor						Y		
Component Repair Technologies						Y		
CTS Engines	Y	Y						
Delta TechOps	Y	Y	Y	Y	Y	Y	Y	
Eaton Aerospace					Y	Y		
First Wave MRO Inc								Y
Fokker Aerotron				Y	Y	Y		Y
GE Engine Services -Strother	Y	Y	Y	Y	Y	Y	Y	Y
GKN Aerospace Chem-Tronics						Y		
Goodrich (Foley)								Y
Goodrich Aerostructures								Y
Hawker Pacific Aerospace (LAX)					Y			
Honeywell Canada (PEI)					Y			
ITR-Turborreactores			Y	Y	Y		Y	Y
JFJ Industries						Y		
Middle River Aircraft Systems								Y
MTU Maintenance Canada Ltd	Y	Y						
Nordam Repair Division								Y
PW Autoair						Y		
PW Dallas Airfoil Repair						Y		
PAS Technologies Inc		Y				Y		
Patriot Aviation Services	Y	Y						
Propulsion Technologies Intl						Y		
Spirit Aerosystems								Y
StandardAero (Winnipeg)	Y	Y						
TCI					Y	Y		
The Fuel Cell					Y			
Triumph Acc Svcs Grand Prairie				Y	Y	Y		
Triumph Airborne Structures								Y
Twin Manufacturing			Y			Y		
Westfield Gage Company O&R						Y		
Wood Group Fuel Systems Inc					Y			
Woodward Governor Co					Y	Y		
South America								
GE Engine Services -Celma	Y	Y	Y	Y	Y	Y	Y	Y
Seman-Peru		Y						

Source: ACAS and directly from maintenance facilities

replacement due to the operator's policy," says Bullenkamp.

Other important factors in the shop-visit pattern are financial, related to the cost of the engine's ownership. This will generally define the workscope of the first shop visit. "The workscope of the first shop visit will take into account the engine's future utilisation, availability of funding to support the shop visit, and short-term versus long-term economic prospects," says Verbocht. "This workscope also determines the amount of available post-shop-visit, on-wing time.

The workscope of an engine that will be in the current operator's fleet for several years will include: core module and LPT overhaul, including installation of new rotating LLPs; and extension of the fan disk and booster spool life to match the fan shaft's life limit life. This provides an engine that can stay on-wing for up to 30,000EFC," continues Verbocht. Comparing this to an engine soon to be returned to a lessor or to be sold shortly, Verbocht adds: "The workscope of such engines typically consists of a core overhaul including new LLPs. The fan disk and booster spool are re-lifed, and the LPT left intact. The engine is then limited by the LPT LLPs at 25,000EFC."

During the first shop visit, many parts are repaired and do not need replacing. According to General Electric (GE), HPC, HPT and LPT blades and vanes are typically replaced. Enrique Robledo, engine shop director with Iberia Maintenance, says: "The fan section is almost fully repairable, with a very low percentage of replacement parts. The HPC requires 32% of parts replacement on blades and 16% on vanes. NGVs require 12% parts replacement. HPT blades and LPT blades require 46% and 6% parts replacement respectively."

During the second and third shop visits, the percentage of replacement of HPT and HPC blades is likely to increase, but most other parts will remain repairable. Operators in harsher environments are likely to find that more parts have to be replaced.

Maintenance contracts

Maintenance providers offer two different types of maintenance contract. The first is a power-by-the-hour (PBH), or flat-rate-per-hour maintenance contract. A customer simply pays a flat rate per engine flight hour (EFH) for the maintenance of the engine. The advantages of this are that the cost can include cover for unforeseen or unplanned, maintenance events. Without this, an unforeseen maintenance event could cost an operator a significant sum. This may be unplanned in the budget and has the potential to add unexpected financial pressure on to the operator. A PBH contract is attractive because it keeps engine maintenance costs completely predictable for the operator.

The second type of contract is based on maintenance charged on a time and material basis, whereby a customer pays for the labour, materials and parts used in each engine shop visit. The customer takes a larger role in managing the engine with respect to the timing of removals for shop visits, defining shop visit workscopes, and deciding when to replace LLPs. The customer only pays for what is used, and when it is required. The

customer therefore assumes the risk, because of the possibility of a high rate of unplanned shop visits. Such contracts have the potential to cut a customer's long-term costs because the customer manages their engines.

Engine management plays an important role in both these types of contracts. This involves engine health monitoring (EHM), to decide when maintenance is required on an engine, based on factors including the LLPs and their replacement, general wear and tear on the engine, and parts that need repairing. Most maintenance shops provide engine management in some capacity alongside the relevant maintenance contracts.

Starting with the OEM for the CFM56-7B, GE provides a PBH maintenance contract called its OnPoint solution. GE says this transfers risk from the customer to GE, and offers the customer predictable maintenance costs, and comprehensive services coverage. GE also offers short- and long-term time and material maintenance contracts, which allow the customer to pay at the time of the shop visit. As a full spectrum MRO, GE offers the capability to manage an engine's maintenance from the outset, working with its customers to maximise the operational efficiency of the engine.

MTU Maintenance offers two different types of PBH contracts. Under its traditional contract, customers pay a monthly flat rate per EFH flown. This payment is due right away. It also offers payment per event, in a flat-rate contract. With this, the customer still pays the flat rate per EFH, but payment is only made at the time of the shop visit. This helps MTU Maintenance's customers conserve cashflow until the shop visit comes due. It also offers a time-and-material contract for its customers. In terms of engine management, MTU Maintenance offers its Total Engine Care programme, which includes fleet management and engine condition monitoring for its customers.

Lufthansa Technik has very similar capabilities. It offers two types of PBH contract, with monthly payments, or payments at the time of an engine's shop visit, as well as time-and-material maintenance contracts. Lufthansa Technik offers various levels of engine management. It operates an Engines Operations Center (EOC), which is available 24/7 and supports customer troubleshooting, AOG support, and on-wing maintenance. Lufthansa Technik customer support engineering supports all engineering activities for engines undergoing a shop visit. The propulsion system engineering team also supports customers by developing engine management plans to reduce the overall cost per EFH.

Most other engine shops worldwide offer comparable services to their customers as has been described for GE, MTU Maintenance and Lufthansa Technik. Pratt and Whitney (PW), AFI KLM E&M, SR Technics, Iberia Maintenance and IAI Bedek all offer PBH contracts, time-and-material contracts, and engine management support.

Sourcing maintenance

With the fleet of CFM56-7B engines widespread globally, there are a variety of engine shops and parts-repair specialists of differing capabilities worldwide. The capabilities of engine overhaul and parts repair shops are summarised *(see tables, pages 42 & 43)*.

The first table *(see page 42)* divides the engine into six module areas. The first is the fan module, which comprises: the fan blades and guiding vanes; the fan casing and frame; the fan module LLPs; the seals and rub strips; the bearings and bearing supports; and other components such as gearing and accessory drives.

Next are the low-pressure compressor (LPC), HPC, LPT and HPT modules, which contain the same types of components as the fan module: blades, vanes, LLPs and seals.

The next module is the combustor, containing the HPC rear frame, fuel nozzles, the combustor liner and chambers, and the casing. The final section shows capabilities with respect to quick engine change (QEC), accessories and line-replaceable units (LRUs).

In the first table, three types of capability are listed: disassembly (D), cleaning and inspection (C), and full repair (F). The table also shows where these engine shops sub-contract (S) different parts of modules.

The second table *(see page 42)* has been drawn from the ACAS database, and shows the third-party support capabilities for both engine shops and

CFM56-7B - FAN MODULE CAPABILITY

Maintenance Provider	Blades & guide vanes	Casing & frame	Module LLPs	Seals & rub strips	Bearings & bearing supports	Other components e.g. gearing acc. drives
AFI and KLM E&M	D/C/F	D/C/F/S	D/C/F	D/C/F	D/C/F	D/C/F
Delta TechOps	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
GE	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
IAI Bedek	D/C/S	D/C/F	D/C/S	D/C/F	D/C/F/S	D/C/F
Iberia Maintenance	D/C/F/S	D/C/F	D/C/F/S	D/C/F	D/C/F/S	D/C/F
Lufthansa Technik	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
MTU Maintenance Hannover	D/C/F/S	D/C/F	D/C/F	D/C/F	D/C/F/S	D/C/F/S
MTU Maintenance Zhuhai	D/C/F/S	D/C/F	D/C/S	D/C/F	D/C/F/S	D/C/F/S
PW	D/C/S	D/C/F	D/C/S	D/C/F	D/C/S	D/C/S
SR Technics	D/C/F/S	D/C/F	D/C/F	D/C/F	D/C/F/S	D/C/F/S
TAP M&E	D/C/F/S	D/C/F	D/C/F/S	D/C/F/S	D/C/F/S	D/C/F

CFM56-7B - LOW PRESSURE COMPRESSOR MODULE CAPABILITY

Maintenance Provider	Blades & guide vanes	CasingHPC & frame	Module LLPs	Seals & rub strips	Bearings & bearing supports	Other components e.g. gearing acc. drives
AFI and KLM E&M	D/C/S	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
Delta TechOps	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
GE	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	
IAI Bedek	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F/S	D/C/F
Iberia Maintenance	D/C/F	D/C/F	D/C/F	D/C/F		
Lufthansa Technik	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
MTU Maintenance Hannover	D/C/F	D/C/F	D/C/F/S	D/C/F	D/C/F/S	D/C/F/S
MTU Maintenance Zhuhai	D/C/F	D/C/F	D/C/S	D/C/F	D/C/F/S	D/C/F/S
PW	D/C/F	D/C/F	D/C/S	D/C/F	D/C/S	D/C/S
SR Technics	D/C/F/S	D/C/F	D/C/F	D/C/F	D/C/F/S	D/C/F/S
TAP M&E	D/C/F/S	D/C/F	D/C/F	D/C/F/S	D/C/F/S	D/C/F

CFM56-7B - HIGH PRESSURE COMPRESSOR MODULE CAPABILITY

Maintenance Provider	Blades & guide vanes	CasingHPC & frame	Module LLPs	Seals & rub strips	Bearings & bearing supports	Other components e.g. gearing acc. drives
AFI and KLM E&M	D/C/S	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
Delta TechOps	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
GE	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
IAI Bedek		D/C/F	D/C/F	D/C/F		D/C/F
Iberia Maintenance	D/C/F	D/C/F	D/C/F	D/C/F		
Lufthansa Technik	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
MTU Maintenance Hannover	D/C/F	D/C/F	D/C/F	D/C/F/S		D/C/F/S
MTU Maintenance Zhuhai	D/C/S	D/C/F	D/C/F/S	D/C/F/S		D/C/F/S
PW	D/C/F/S	D/C/F	D/C/S	D/C/F	D/C/S	D/C/S
SR Technics	D/C/S	D/C/F	D/C/F	D/C/F	D/C/F/S	D/C/F/S
TAP M&E	D/C/S	D/C/F	D/C/F	D/C/F		D/C/F

CFM56-7B - COMBUSTOR CAPABILITY

Maintenance Provider	Rear frame	Fuel nozzles	Combustor liner& chambers	Casing
AFI and KLM E&M	D/C/F	D/C/S	D/C/F	D/C/F
Delta TechOps	D/C/S	D/C/S	D/C/F	D/C/F/S
GE	D/C/F	D/C/F	D/C/F	D/C/F
IAI Bedek	D/C/F	D/C/F	D/C/F	D/C/F
Iberia Maintenance	D/C/F	D/C/F	D/C/F	D/C/F/S
Lufthansa Technik	D/C/F	D/C/F	D/C	D/C/F
MTU Maintenance Hannover	D/C/F	D/C/S	D/C/F	D/C/F
MTU Maintenance Zhuhai	D/C/S	D/C/S	D/C/F	D/C/S
PW	D/C/F	D/C/F/S	D/C/F	D/C/F
SR Technics	D/C/F	D/C/S	D/C/F	D/C/F/S
TAP M&E	D/C/F	D/C/S	D/C/F	D/C/F

D = Disassembly
C = Cleaning & inspection
F = Full repair
S = Sub-contracted

parts repair facilities. This is done with respect to engine overhaul, hot section inspection (HSI), accessory drive gearbox, electrical system, fuel system, LRUs, the lubrication system and thrust reversers.

Shop module capability

Three main types of engine shops offer capabilities on the CFM56-7B. First are the OEMs, such as GE and Snecma. As the CFM56 is a joint venture (JV) between these manufacturers, these are both considered OEM shops for the -7B.

GE Engine Services (GEES) accounts for almost a third of all contracts (32.8%) for the CFM56-7B split between four locations. The busiest of these shops is at Strother, USA, (14.5% of all contracts). This is closely followed by the GE shop in Wales (13.5%). The other GE locations are at GE headquarters in Cincinnati, and GE at Celma, Brazil.

Snecma Services, as the other OEM for the CFM56-7B, accounts for 8.5% of maintenance contracts, split between three locations. This gives a total market share for GE and Snecma of over 45%.

Although PW is not an OEM for the CFM56-7B, it operates several engine shops, which are also significant players in the maintenance and support market for the CFM56-7B, accounting for more than 5% of global shop visits, split between three locations: PW Norway, Shanghai and a JV with Turkish Technic.

The second type of engine shop in the maintenance and support market for the CFM56-7B is connected to airlines, including: AFI KLM E&M; Lufthansa Technik; Delta TechOps; Iberia Maintenance; TAP Maintenance and Engineering (TAP M&E); American Airlines MRO (AA MRO); and ANA Engine Services, among others. Together, airline-affiliated shops account for about 25% of the engine support contracts.

Delta TechOps accounts for almost 9% of CFM56-7B engine shop visits and is the biggest provider of the airline-affiliated shops. Lufthansa Technik and Lufthansa JVs such as Lufthansa Airmotive Ireland and LTQ Maintenance account for 7%.

A third are independent engine shops, which account for 20% of engine shop visits. The biggest independent providers of maintenance and support for the CFM56-7B are MTU Maintenance and affiliates (7%), SR Technics (4%) and ST Aerospace (3%). There are also a number of smaller independent maintenance providers for the CFM56-7B.

As the CFM56-7B is an incredibly popular engine, which will be in production for the foreseeable future, almost all engine shops surveyed anticipate an increase in -7Bs coming through their facilities. The maintenance and support market for the CFM56-7B is likely to further increase, and competition will remain fierce between providers.

MTU Maintenance currently overhauls about 50 -7B engines per year. "We expect that to double to about 100 CFM56-7 shop visits per year within the next five years," says Bullenkamp.

Robledo echoes this sentiment. "We expect this engine to get to the same level of shop visits as the -5B in our shop; about 60 visits per year." This is a huge increase from the 10 -7B shop visits that Iberia Maintenance expects in 2012.

Africa

Because Africa only makes up a small percentage of the global CFM56-7B fleet, at just 4.5%, there are few maintenance and overhaul facilities there. The major provider in Africa is an OEM engine shop, Snecma Morocco Engine Services.

Asia Pacific

The Asia Pacific has the second largest fleet of CFM56-7B engines worldwide, totalling 2,322 active engines and 24 parked ones. The several maintenance and support facilities there account for almost 31% of the global fleet.

MTU Maintenance Zhuhai and ST Aerospace are the major providers in this region. Both are independent, accounting for 5% and 4% of global contracts.

The main OEM providers in the region are PW at its Shanghai Engine Centre, which is a JV between PW and China Eastern Airlines, as well as Sichuan services, another JV between CFM and Air China. LTQ Engineering is an airline-affiliated major provider of maintenance. ANA Engine Services, Air India, China Airlines, and Korean Air are also airline-affiliated providers in the region.

Europe

Europe accounts for a quarter of the total CFM56-7B fleet, with more than 1,800 active engines, but holds more than 33% of maintenance and support contracts. The main providers in Europe are, unsurprisingly, GE and Snecma as the OEMs for the CFM56-7B. The main GE engine shop is in Wales, and accounts for a large number of global maintenance contracts for the CFM56-7B, maintaining about 13% of the world's CFM56-7Bs.

Snecma's MRO division services account for 7.5% of CFM56-7B engines globally, divided between Snecma's facilities in France and Belgium.

PW has a large presence in Europe at its Norway engine centre, and its JV with Turkish Technic at its Turkish engine centre. These account for 4.5% of global shop visits.

Lufthansa Technik is the largest airline-affiliated provider in Europe, accounting for 5% of global contracts, split between its facilities in Hamburg and Lufthansa Airmotive Ireland, Dublin. AFI KLM E&M, Iberia, TAP M&E and MTU Maintenance Hannover, also support the CFM56-7B in Europe.

Middle East

The Middle East is the smallest region for CFM56-7B activity, with just 2.23% of the global fleet based here, comprised of 160 active and 10 parked engines.

Bedek Aviation, a division of IAI and based in Israel, is the main maintenance and support provider for the CFM56-7B in the region, and accounts for 1% of global shop visits. "We expect the number of shop visits to grow significantly in the coming years," says Jack Gaber, vice president and general manager (GM) of marketing and business division at IAI Bedek Aviation.

CFM56-7B - HIGH PRESSURE TURBINE MODULE CAPABILITY

Maintenance Provider	Blades & guide vanes	CasingHPC & frame	Module LLPs	Seals & rub strips	Bearings & bearing supports	Other components e.g. gearing acc. drives
AFI and KLM E&M	D/C/S	D/C/F	D/C	D/C/F	D/C/F	
Delta TechOps	D/C/S	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
GE	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
IAI Bedek	D/C/S	D/C/F	D/C/F	D/C/F		D/C/F
Iberia Maintenance	D/C/F/S	D/C/F/S	D/C/F	D/C/F		
Lufthansa Technik	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
MTU Maintenance Hannover	D/C/F/S	D/C/F	D/C/F	D/C/F	D/C/F/S	
MTU Maintenance Zhuhai	D/C/S	D/C/S	D/C/S	D/C/F/S	D/C/F/S	D/C/F/S
PW	D/C/F	D/C/F	D/C/S	D/C/F	D/C/S	D/C/F/S
SR Technics	D/C/S	D/C/F	D/C/F	D/C/F	D/C/S	D/C/F/S
TAP M&E	D/C/S	D/C/F/S	D/C/F/S	D/C/F/S		D/C/F

CFM56-7B - LOW PRESSURE TURBINE MODULE CAPABILITY

Maintenance Provider	Blades & guide vanes	CasingHPC & frame	Module LLPs	Seals & rub strips	Bearings & bearing supports	Other components e.g. gearing acc. drives
AFI and KLM E&M	D/C/S	D/C/F	D/C/F	D/C/F	D/C/F	
Delta TechOps	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
GE	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
IAI Bedek	D/C/S	D/C/F	D/C/F	D/C/F	D/C/F/S	D/C/F
Iberia Maintenance	D/C/F/S	D/C/F	D/C/F	D/C/F	D/C/F/S	
Lufthansa Technik	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F
MTU Maintenance Hannover	D/C/F/S	D/C/F	D/C/F	D/C/F/S	D/C/F/S	D/C/F/S
MTU Maintenance Zhuhai	D/C/S	D/C/S	D/C/S	D/C/F/S	D/C/F/S	D/C/F/S
PW	D/C/F	D/C/F	D/C/S	D/C/F	D/C/S	D/C/S
SR Technics	D/C/F	D/C/F	D/C/F	D/C/F	D/C/F/S	D/C/F/S
TAP M&E	D/C/S	D/C/F	D/C/F	D/C/S	D/C/F/S	D/C/F

CFM56-7B - QEC, ACCESSORIES & LRU CAPABILITY

Maintenance provider	QEC, accessory & LRU capabilities
AFI and KLM E&M	D/C/F
Delta TechOps	D/C/F
GE	
IAI Bedek	D/C/F
Iberia Maintenance	D/C/F
Lufthansa Technik	D/C/F
MTU Maintenance Hannover	D/C/F/S
MTU Maintenance Zhuhai	D/C/F/S
PW	D/C/S
SR Technics	D/C/F/S
TAP M&E	D/C/F/S

D = Disassembly
C = Cleaning & inspection
F = Full repair
S = Sub-contracted

North America

North America has the largest fleet of CFM56-7B engines worldwide, with marginally more than in the Asia Pacific. The number and size of the maintenance providers in the region reflect this.

GE, as the engine's OEM, has a large maintenance facility at Strother Field, Kansas, accounting for 15% of global contracts. It is the market leader in the region.

Delta TechOps, with its facility in Atlanta, Georgia, also has a large market share of maintenance of the CFM56-7B, accounting for almost 9% of global SVs. It is also the largest airline-affiliated provider in the region. AA MRO and MTU Maintenance Canada also provide maintenance and support in the region. Smaller independent providers in North America include Aerothrust, in Florida.

South America

Like the Middle East and Africa, South America has a relatively small fleet of CFM56-7Bs in operation, totalling 6.77% of the global fleet. GE's facility at Celma, Brazil, is therefore the only major engine shop with facilities to maintain and support the CFM56-7B in South America. It accounts for a significant number of shop visits, totalling 4% of global contracts.

Repairs

Although many of the large engine shops have the capability to deal with most engine components, some small sections of the engine require specialist work. Examples of these are certain LLPs, LRUs, seals, bearings and nacelles.

There are two different categories of

Some of the most important repair capabilities are high-technology repairs for airfoils. Specialists in this are Chromalloy, Lufthansa Technik, Air France Industries and KLM Engineering & Maintenance, SR Technics and TAP Maintenance & Engineering.

repairs. First are repairs approved or licensed by the OEM. These are referred to, and listed in the engines' repair and shop-visit manual. Non-OEM engine shops that carry out OEM repairs are obliged to pay the OEM a royalty for each component repaired in this fashion.

The second category of repairs is non-licensed by the OEMs, and is referred to as designated engineering representative (DER) repairs. Such repairs are not listed in the engines' repair and shop-visit manual and must be actively marketed by the repair agencies themselves. The OEM receives no royalties for these repairs. DER repairs must be of similar quality to OEM repairs, and are approved by the European Aviation Safety Agency (EASA) and the Federal Aviation Administration (FAA), among many other aviation safety agencies worldwide.

As the OEMs for the engine, GE and Snecma both have large parts repair capabilities for the CFM56-7B, either at their own engine shops, or with affiliates. GE has extensive capability to repair many of the core components of the -7B. This includes all blades and vanes, casing and frames, seals and rub strips, all LPT, HPT, LPC, and HPC LLPs, bearings and bearing supports, as well as other accessories. This is undertaken in several shops worldwide, including their facilities at Strother, Wales and Brazil. The only components GE does not repair are the QEC kits and related accessories.

Snecma, the other OEM for the CFM56-7B, undertakes similar repairs as part of its MRO division in France and Belgium. PW, as the other OEM in the maintenance and support market for the CFM56-7B, also has an extensive parts repair network.

Apart from the OEMs, various airline- affiliated engine shops have extensive parts repair capabilities. Lufthansa Technik has the largest capability, offering a broad spectrum of repairs. "In general, we can offer up to 94% in-house capability of engine parts and accessories," says Bernd Habbel, director of corporate communications at Lufthansa Technik. "We revise our offers continuously and expand our capability on customers' demands." Lufthansa Technik provides specialist repairs on all blades and vanes, actuators, combustor repairs, seals, bearings, among many other parts. Component repairs are carried out at Lufthansa Technik's repair facilities worldwide.

Engine modules

The main components of the fan module, and LPC, HPC, LPT and HPT modules are the relevant blades and guide vanes, and can be some of the most expensive parts to repair in the engine. Most engine shops surveyed listed some, if not all, blades and vanes in their list of parts repairs. PW, for example, listed repair capability for all airfoils in the engine, except for the fan blades.

In the fan module, full repair of the fan blades and guide vanes is listed by GE, Lufthansa Technik, AFI KLM E&M, Delta TechOps, MTU Maintenance, Iberia Maintenance, SR Technics, and TAP M&E. PW, MTU Maintenance, Iberia Maintenance, SR Technics, and TAP M&E outsource some of this work.

All shops surveyed list full repair capabilities for the LPC blades and guide vanes, apart from AFI KLM E&M, which sub-contracts this work. SR Technics and TAP M&E also outsource these repairs alongside their full repair capabilities.

More engine shops outsource repairs for HPC blades and guide vanes: AFI KLM E&M, MTU Maintenance Zhuhai, SR Technics, and TAP M&E. PW offers full repair capabilities as well as outsourcing. GE, Lufthansa Technik, Delta TechOps, Iberia Maintenance and MTU Maintenance Hannover all offer full repair capabilities of these components in-house. IAI Bedek offers no repairs to HPC blades and guide vanes.

In terms of the LPT module blades and guide vanes, GE, PW, Lufthansa Technik and SR Technics offer full repair capabilities. Iberia Maintenance and MTU Maintenance Hannover offer both in-house and outsourcing capabilities. AFI KLM E&M, MTU Maintenance Zhuhai, IAI Bedek and TAP M&E all outsource this work.

Only GE, PW, and Lufthansa Technik offer full repair capabilities for the HPT module blades and guide vanes. MTU Maintenance Hannover and Iberia Maintenance also offer full repair capabilities, but outsource as well. All other engine shops surveyed outsource.

Chromalloy offers both OEM-approved and DER repairs. Repairs to airfoils are provided for most major engine types, and Chromalloy has 33 facilities in 14 countries. Repairs are provided for HPT blades, vanes and shrouds, compressor blades, sealstators, cases and frames.

One of Chromalloy's specialities is HPT blade repair, which it performs at its New York

There are also a number of specialist providers for this kind of maintenance work. Airfoil Services (ASSB), a JV between MTU Aero Engines and Lufthansa Technik, based in Malaysia, is a specialist repair provider for compressor and LPT airfoils. It provides repairs to the compressor rotor blades, stages 1-9, and LPT blades stages 1-4. The vast majority of repairs by ASSB are OEM-approved, and are supported by some MTUPlus DER repairs.

Combustor and HPT module repairs are another specialist area.

Honeycomb & knife-edge seals

Honeycomb and knife-edge seals are made up of two components: a honeycomb rub on the inner wall of the casing; and a series of rotating knife-edge discs with seal teeth. This set of components prevents longitudinal airflow through the engine.

The main OEM shops, such as GE, Snecma, and PW provide repairs to these seals, as do all of the other large engine shops surveyed including Lufthansa Technik, MTU Maintenance, and SR Technics. PAS Technologies and IAI Bedek Aviation also provide maintenance for these components. CRMA listed OEM-approved repairs for honeycomb brazed parts and rotating seals.

LLPs

LLPs can be broadly divided into three categories: discs, shafts and rotating air seals. In the fan module, GEES, Delta TechOps, AFI KLM E&M, MTU Maintenance Hannover, and SR Technics all offer full repair capabilities for the LLPs. Iberia Maintenance and TAP M&E offer both in-house capabilities and outsourcing, while MTU Maintenance Zhuhai, IAI Bedek and PW only outsource the repair of LLPs in the fan module.

Full repair capabilities of the LPC and HPC module LLPs are offered by GE, Lufthansa Technik, Delta TechOps, IAI Bedek, AFI KLM E&M, SR Technics, Iberia Maintenance and TAP M&E.

PW sub-contracts this work, while MTU Maintenance offers both in-house and outsourcing repair capabilities of these LLPs. For the LLPs in the LPT and HPT modules, these capabilities are almost exactly the same for the engine shops surveyed.

Other specialist providers, such as Component Repair Technologies, also offer specialist repairs on a variety of LLPs found within the engine.

Cases & frames

The cases and frames of the engine are some of the simplest parts to repair, since there are no moving parts. Almost all engine shops surveyed list full repair capability for cases and frames on the CFM56-7B. This includes AFI KLM E&M, Delta TechOps, MTU Maintenance, Lufthansa Technik, IAI Bedek, Iberia Maintenance, TAP M&E, and the OEMs, GE, Snecma and PW.

Some case and frame repair work is outsourced by these engine shops. For example, MTU Maintenance Zhuhai outsources the maintenance of the LPT and HPT casing and frame. Most do all cases and frames in-house, however.

Bearings & seals

Most of the major engine shops provide repairs for bearings and seals, but some choose to sub-contract this specialist work.

Timken is one such speciality repair provider for bearings and seals for the CFM56-7B, and has long-term repair contracts with several airlines. It offers DER repairs. Service inspections are typically completed in seven days, with repair and reconditioning completed in 15 days or less. Air Concepts Repair Technologies and Component Repair Technologies also have specialist bearing-repair capabilities.

Accessories & LRUs

Components mounted on the outside of the engine include the main engine control (MEC), fuel pump, pneumatic starter motor, variable stator vane actuators, sensors and lubricant units. These are classed as accessories and LRUs of the engine.

Delta TechOps, MTU Maintenance, SR Technics, Lufthansa Technik, AFI KLM E&M, IAI Bedek, Iberia Maintenance and TAP M&E listed full repair capability for accessories and LRUs.

Specific QEC and LRU components listed as repair capabilities by MTU Maintenance Hannover include leads and harnesses, actuators and fuel components, bleed valves and tubing, cooling manifolds, exhaust components, and engine mounts. IAI Bedek lists repair capabilities of the main fuel pump, HMU, air valves, fuel nozzles, and oil pumps as well as a range of other QEC and LRU components.

Nacelles & thrust reversers

Nacelles and thrust reversers require a specialist capability. As with many parts listed before, the GE and Snecma OEM engine shops provide MRO capability with these parts. Although thrust reverser repair facilities are plentiful, Lufthansa Technik, Nordam and Triumph Airborne Structures are major providers.

Goodrich Aerostructures, headquartered in Charlotte, North Carolina is the OEM for the inlet and fan cowls on nacelles of the CFM56-7B. It therefore offers full MRO capabilities for these components, and conducts OEM repairs. Goodrich also offers full MRO capabilities on thrust reversers and exhaust nozzles for the CFM56-7B, and nacelle maintenance management solutions encompassing all elements of nacelle maintenance. Services are provided at Goodrich Aerostructures' Alabama service centre, their European service centre and Asia service centre. Air Tran Airways is a major customer of Goodrich for nacelle and thrust reverser repairs, among many others. AC

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