The active fleet of regional jet and mainline jet engines has experienced a net decline of about 4,500 units since 2009. The fleet of active older engine types has declined by about 11,000. The affect of this has been to reduce the number of annual engine shop visits by about 2,000 to approximately 7,500.

2014 global engine maintenance market

As the world exits the global recession and aviation markets return to pre-crisis levels, it is appropriate to examine the global engine maintenance market. This survey will examine some of the major engine shops around the world, and how the size of the engine maintenance market has been affected by advancing engine material-reliability technology. Ageing engines, new developments in high-tech repair processes and how they reduce turn times and maximise returns are considered. A key influence is the change in the global aircraft and engine fleet.

Engine maintenance involves work performed on a planned or on-condition basis to inspect, maintain and repair to return an engine to service or restore performance margins.

Engine maintenance under consideration in this survey is limited to off-wing work that requires some effort to disassemble, repair, restore and return an engine to service. That is, what would be considered as a full shop visit.

Engine maintenance is broadly divided into shop visit overhaul work and replacement of life-limited parts (LLP). Maintenance involves removing an engine from commercial service for a period of time. While airline operators have some autonomy over when engine shop visits and maintenance occur due to the on-condition system of maintenance, LLP replacement must adhere to rigid part lives. For modelling purposes, however, all shop visit events are estimated at an average engine flight hour (EFH) or engine flight cycle (EFC) interval.

The engine repair and overhaul market has changed in the past decade to become dominated by original equipment manufacturers (OEMs). In the early 2000s, for example, most engine shop visits were performed by General Electric (GE), Pratt & Whitney (P&W), and Rolls-Royce (RR). The overall percentage of shop visits or share of the engine shop visit market accounted for by the OEMs has increased.

A few major airlines still have their own shops for overhauling engines, such as Lufthansa, Air France Industries, Delta TechOps and United Services. These airlines have developed in-house repair and overhaul capability for all or most of the engine types in their fleets, and offer their maintenance, repair and overhaul (MRO) services to other operators.

There are also independent shops, but their numbers have decreased.

The global fleet has changed since the early 2000s. The major fleet workhorses of 10 years ago have been replaced by similar-sized aircraft types that operate with fewer and more reliable engines. In particular, long-haul types like the 747, A340 and MD-11 have been replaced by twin-engined A330 and 777 aircraft. This has reduced the number of installed engines for the same aircraft fleet size.

The actual number of installed jetliner and regional jet engines has declined by 4,500 units since 2009 *(see table, page 36)*. This will have resulted in an overall drop in the number of engine shop visits.

Newer engines' longer removal intervals, and their fewer numbers, has led to a fall in the number of global annual engine shop visits.

The extension of certified LLP lives during early years of operation means that some engine types are able to remain on-wing for twice or three times the LLPs' original limit at service entry. The exhaust gas temperature (EGT) margins are also high for many types, allowing long removal intervals. An example is the CFM56-5B, which when first introduced had some LLP limits of less than 10,000 cycles. The latest version of the CFM56-7B now has uniform LLP lives of 20,000EFC, 25,000EFC and 30,000EFC.

These extended potential removal intervals have had an impact on the frequency of expected engine shop visits, prompting significant changes in how engine shops do business. The emphasis has now changed from full overhauls and performance restorations to lessor-driven workscopes and module exchanges.

Some MRO providers and OEMs that cater to the older generation types have even taken to offering mature engine asset exchange programmes. This has been prompted by large spares pools of both LLPs and complete engines.

Engine fleet

The fleet of active jet engines powering regional jets and jetliners has declined by 4,500 engines to almost 40,300 units *(see table, page 36)*. The active engine fleet in 2009 was 48,200 engines *(see Global engine shop activity survey, Aircraft Commerce, June/July 2009, page 53)*. This number, however, included 2,136 CFM56-2 engines and 1,700 BR700 series engines. Most of these power military and corporate jet aircraft. Discounting these from the 2009 fleet, the number of active installed jet engines stood at 44,850 units in 2009 *(see table, page 36)*.

The net decline of 4,500 engines is explained by several changes in the fleet.

First, there has been a decline of about 2,400 active AE3007- and CF34-powered regional jets (RJs). These are the ERJ-135/-145 and CRJ-100/-200 series aircraft that have been parked en masse by regional operators. This has been offset to a degree by an increase in the number of larger engines powering the CRJ-700, -900 and -1000, and the Embraer E-Jets.

There has also been a large retirement of BAE 146s/Avro RJs, leading to a reduction of about 560 active ALF502/LF507 engines.

The other main change is in the jetliner fleet. A large number of four- and three-engined 1980s- and early 1990s-generation aircraft have been parked or retired since 2009. This includes 747s,

2009 & 2014 ACTIVE JET ENGINE FLEET

Engine OEM	Engine Type	Installed Engines 2009	Installed Engines 2014	Change in fleet size
Regional aircraft jet engines				
	CF34-3		1,338	
	CF34-8C		1,276	
	CF34-8E/-10E		1,968	
	SUB-TOTAL CF34	5,400	4,582	-818
	AE3007	2,524	1,402	-1,122
	ALF 502/507	1,214	656	-558
	SaM146	4	74	70
Sub-total regional jet engines		**9,142**	**6,714**	**-2,428**
Mainline jet engines				
CFMI	CFM56-3	3,298	1,614	-1,684
	CFM56-5A/-B	4,314	6,256	1,942
	CFM56-5C	952	672	-280
	CFM56-7B	5,660	9,166	3,506
IAE	V2500	3,326	4,946	1,620
General Electric	CF6-6	195	0	-195
	CF6-50	739	32	-707
	CF6-80A/-80C2	3,251	1,404	-2,117
	CF6-80E1	348	466	118
	GE90 Classic & Growth	774	1,374	600
	GEnx	0	250	250
Pratt & Whitney	JT3D	476	0	-476
	JT8D	3,872	1,178	-2,694
	JT9D	574	82	-492
	PW2000	792	498	-294
	PW4000-94	1,841	770	-1,071
	PW4000-100	320	388	68
	PW4000-112	328	338	10
	PW6000	30	30	0
Engine Alliance	GP7200	20	260	240
Rolls Royce	RB211-22	24	0	-24
	RB211-524	726	314	-412
	RB211-535	1,100	648	-452
	Spey	176	2	-174
	Tay 600	523	374	-149
	BR700	310	308	-2
	Trent 500	456	372	-84
	Trent 700	526	1,096	570
	Trent 800	440	436	-4
	Trent 900	48	264	216
	Trent 1000	0	100	100
Sub-total mainline jet engines		**35,709**	**33,637**	**-2,072**
Overall total jet engines		**44,851**	**40,351**	**-4,500**

A340s, DC-10s, MD-11s, DC-8s and 727s. This has resulted in a net reduction of 2,100 engines powering the jetliner fleet *(see table, this page)*.

These older types and their engines have been replaced mainly by 737NGs, A320s, A330s, 777s, A380s and more recently by 787s.

Fleet reductions

A breakdown of the overall change in major models reveals how the engine MRO market has and is being affected.

CFM56-3

The CFM56-3 fleet has declined to just over 1,600 active engines. The remaining 737 Classics are retiring and being phased out at a fast rate.

The implosion of the -3 fleet means there are a large number in the aftermarket. This makes it more economic to acquire time-continued engines and modules than to continue with regular maintenance. Some airlines are still managing their fleets, however, to keep them on a long-term operable basis.

CFM56-5C

The A340-200/-300 fleet has declined by one-third since 2009, with the oldest aircraft now more than 20 years of age. The aircraft has also become costly to operate. Demand for used A340-200s/-300s is limited, and further large numbers are expected to retire over the coming years. This has resulted in 280 engines coming out of active service *(see table, this page)*.

There has also been a reduction in active A340-500s/-600s, with a consequent drop in the number of active Trent 500s by 84 units *(see table, this page)*.

CF6-6/-50/-80A/-80C2

The General Electric CF6 family has experienced the largest decline in the mainline jet engine fleet. More than 3,000 engines have come out of active service in the five years since 2009.

The CF6-6 fleet has now fully retired, following the retirement of all the last DC-10-10s/MD-10-10s by FedEx.

Almost all CF6-50s have now retired, following the retirement of all DC-10-30s, A300B2/4s, and 747 Classics over the past five years.

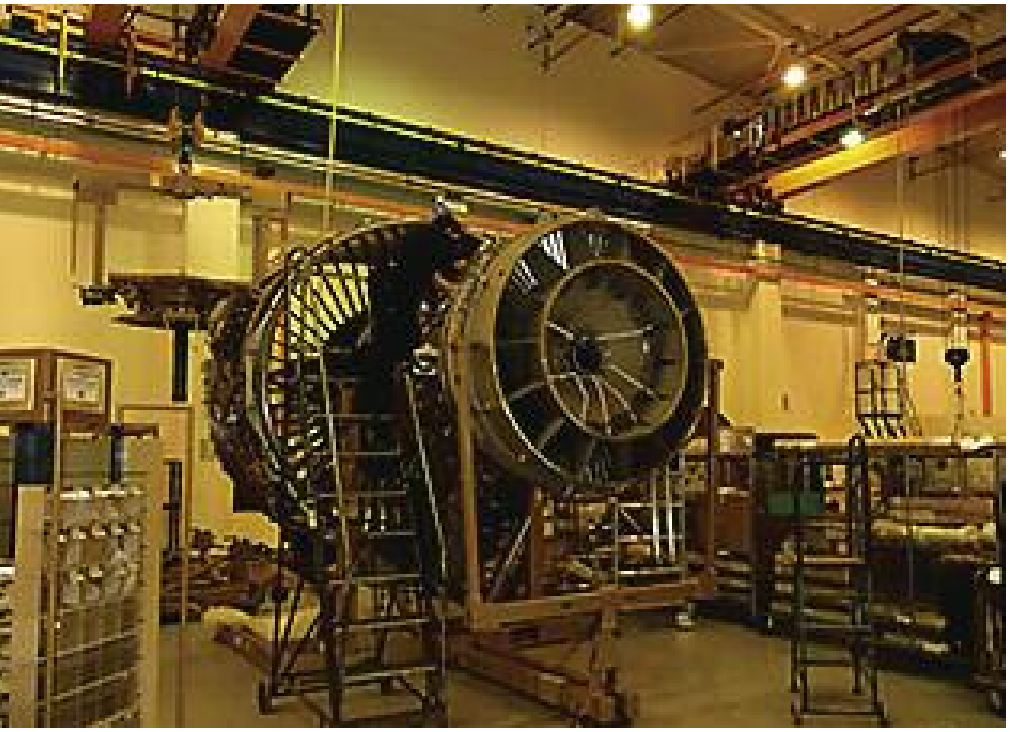
More than 2,100 CF6-80A/-80C2s have been retired from active service since 2009, representing 65% of the active fleet. This is explained by the large number of 747-400s, A300-600s, A310s, early-build 767s and some MD-11s that have been parked or retired. Most A300-600s and A310s built, for example, are no longer in operation, while many 747-400 freighters have been parked because of the downturn in global air freight. A large number of passenger-configured 747-400s have been retired and replaced with 777-300ERs and other types.

JT8D series

Not surprisingly, there has been a large decline in the number of active JT8Ds, as well as the last operational JT3Ds. This follows the retirement of many of the last operational 727Fs by FedEx and smaller carriers, as well as the few remaining DC-9s and 737-200s, and a large number of MD-80s. There are still about 480 MD-80s left in operation. Some are likely to remain in service with major operators, such as Delta Air Lines, for several more years.

JT9D

The remaining JT9D operational fleet has declined to almost zero over the past five years. Only a small number of early-build 767-200s remain in freighter configuration, leaving the JT9D as a niche market.



A growing portion of engines are maintained under OEM-related contracts. A smaller portion of younger and new generation engine types are maintained by airline and independent shops.

RB211 & PW2000

The number of remaining RB211-22/-524s has declined steeply, following the retirement of L-1011s and 747 Classics. This has always been a niche market.

The RB211-535 and PW2000 fleets powering 757-200s have declined by 750 engines. There remain, however, almost 1,150 active engines for the 757-200/-300.

PW4000-94

Like the CF6-80C2, the PW4000-94 powered all main types of 1980s generation widebodies. Almost 1,100 PW4000-94 engines have come out of active service since 2009, due to the retirement of large numbers of 747-400s, plus other types, such as the A300-600 and A310-300.

Reductions summary

Of those engine types that have seen large reductions in active numbers, the most important ones for airline and third-party or independent engine shops are the JT8D, CFM56-3, PW2000, JT9D, CF6-50, CF6-80C2 and PW4000-94. These six types have collectively fallen by 9,059 active engines since 2009, equal to 25% of the active mainline jet engine fleet in 2009 *(see table, page 36)*.

Less numerous engines, including the CFM56-5C, CF6-6, JT3D, RB211, RR Spey, RR Tay and RR Trent 500, account for a reduction in the active engine fleet of another 1,800 engines.

There has, therefore, been a reduction of almost 11,000 older engine types in the active fleet since 2009, equal to 31% of the 2009 mainline engine fleet.

Fleet additions

Unsurprisingly, engine types that account for most additions to the fleet include the CFM56-5B, CFM56-7B, CF6-80E1, GE90 Classic and Growth, GEnx, PW4000-100, GP7200, Trent 700, Trent 900 and Trent 1000. These have added 9,240 active engines since 2009 *(see table, page 36)*, just exceeding the reduction of older mainline jet fleet engine types since 2009. These delivered new engines all power the A320, 737NG, A330, 777, 787 and A380.

CFM56-5B/-7B & V2500

The active fleets of CFM56-5B/-7B and V2500 engines that power the A320 and 737NG families have increased by a total of 7,068 engines. Replacement of older generation aircraft with the A320 and 737NG is clearly demonstrated by the increase in these engine types.

CF6-80E1 & GE90

The A330 and 777 account for most of the widebody deliveries since 2009, and have replaced most of the older types. The number of active CF6-80E1, Trent 700 and PW4000-100 engines, powering the A330, has consequently increased by 756 units. The Trent 700 accounts for the majority, with the active fleet having increased by 570 units since 2009.

The active GE90, Trent 800 and PW4000-112 fleet, powering the 777 family, has grown by 860 engines since 2009. The GE90 accounts for virtually all of these, with the GE90 Growth being the sole engine powering the 777-200LR and 777-300ER.

GP7200 & Trent 900

With A380 deliveries advancing at full pace from 2009, the active GP7200 and Trent 900 fleets increased by 240 and 216 units over the period, representing a total of 456 engines.

Trent 1000 & GEnx

With the first 787 and 747-8 deliveries starting in 2011, there have been 250 GEnx and 100 Trent 1000 deliveries. More deliveries will continue. The 787, in particular, has several hundred outstanding orders due for delivery over the next decade. The Trent 1000 and GEnx fleets are, therefore, each due to increase by hundreds of units.

Regional jet engines

While the number of active AE3007 and CF34-3 engines has experienced a large decline since 2009, there have been a large number of CRJ-700s/-900s/-1000s and E-Jets delivered over the same period. These account for the growth of the CF34-8C, -8E and -10E engine fleets by about 1,000 units.

Fleet additions summary

The addition of 9,240 new mainline engine types is equal to 26% of the active mainline engine fleet in 2009. The mainline active engine fleet has overall experienced a net fall of about 2,100 active engines due to the decline of older aircraft types since 2009.

The majority of the new engines delivered since 2009, about 7,100 units, powers narrowbody types, and these represent the best opportunity for airline and independent MRO shops to maintain a presence in the market.

The additions to the widebody engine fleet constitute types that the OEMs have a control over, representing the majority or totality of the MRO market.

New engine types

New engine types yet to enter service include the PW1000G and the CFMI LEAP-1A/-1B.

The PW1000G is the exclusive engine on the Mitsubishi MRJ, the Bombardier CSeries, the Irkut MC-21 family, and the Embraer E-Jets E2 family. The PW1000G

2014 ANNUAL GLOBAL JET ENGINE SHOP VISITS

Engine OEM	Engine Type	Approximate annual number of shop visits
Regional aircraft jet engines		
	CF34-3	300
	CF34-8C	140
	CF34-8E/-10E	180
	SUB-TOTAL CF34	180
	AE3007	250-320
	ALF 502/507	200-270
	SaM146	10-15
Sub-total regional jet engines		**1,260-1,405**
Older generation mainline jet engines		
CFMI	CFM56-3	215-300
	CFM56-5A	175-205
	CFM56-5C	180-190
General Electric	CF6-50	20
	CF6-80A/-80C2	515-550
Pratt & Whitney	JT8D	250-330
	JT9D	10-20
	PW2000	100-130
	PW4000-94	140-180
Rolls Royce	RB211-524	70-90
	RB211-535	120-160
	Spey/Tay/BR700	140-180
Sub-total older generation mainline jet engines		**up to 2,360**
New & young generation mainline jet engines		
CFMI	CFM56-5B	400-510
	CFM56-7B	730-890
IAE	V2500	800
General Electric	CF6-80E1	90-100
	GE90 Classic & Growth	300-400
	GEnx	10-20
Pratt & Whitney	PW4000-100	70-90
	PW4000-112	60-80
	PW6000	5-10
Engine Alliance	GP7200	100-130
Rolls Royce	Trent 500	110
	Trent 700	270
	Trent 800	100
	Trent 900	130
	Trent 1000	N/A
New & young generation mainline jet engines		**up to 3,700**
Overall total jet engines		**up to 7,500**

is also one of two choices on the A320neo. In total, there are at least 2,900 outstanding firm orders for the PW1000G. These engines will start to be delivered to airlines from 2015.

The LEAP-1A is an engine option on the A320neo, while the -1B is the exclusive engine on the 737 MAX family. Both types have gained a large number of firm orders, and CFMI has firm orders for close to 8,000 LEAP-1A/-1B engines.

Another new main engine type yet to enter service is the RR Trent XWB to power the A350.

Engine MRO market

The engine global shop visit market constituted about 9,500 shop visits in 2009 *(see Global engine shop activity survey, Aircraft Commerce, June/July 2009, page 53)*. This included several hundred shop visits for 2,400 CFM56-2 and BR700 engines powering military and corporate jet aircraft. The market for mainline jet and regional jet engines would have therefore been 9,000-9,100 annual shop visits.

The market in 2013/14 is estimated to decline to about 7,600 shop visits. The three main reasons for this will be the smaller fleet, the increased reliability and longer on-wing lives of modern generation engines, and the maintenance 'honeymoon' period that new engines experience following the first few years of operation.

The market for regional jet engine types is up to about 1,400 shop visits per year. This includes about 300 for the older CF34-3 and up to about 270 for the ALF502/LF507.

The market for the older mainline engine types that already have been phased out in large numbers and are continuing to decline, accounts for up to about 2,400 *(see table, page 40)*. This number will clearly contine to decline.

The main current and new generation engine types that account for this portion of the engine MRO market are: the CFM56-5B and -7B (up to 1,400); the V2500 (700-800); the CF6-80E1 (up to 100); the GE90 family (350-400); the PW4000-100/-112 (130); the GP7200 (130); and the RR Trent family (up to 600) *(see table, page xx)*.

A substantial portion of this market will be accounted for by engines that are largely or completely under the control of the OEMs. This includes all of the RR Trent family and a large portion of the PW4000-100/-112, CF6-80E1, GE90 and GP7200 markets.

The market is forecast to rise to about 10,000 engine shop visits by 2023. This will include, however, a higher portion of shop visits for younger and new generation engine types. Many of these engines will be included in programmes offered by the OEMs to airlines. It will also include shop visits for types that enter service from 2014 to 2023. A large number are likely to be involved in OEM support programmes. Pratt & Whitney, for example, is offering a comprehensive services plan for the PW1000G.

Most engine OEMs are located in North America and West Europe. Given OEM dominance in the engine MRO market, it is no surprise that these regions are the largest suppliers of engine maintenance services.

Aircraft Commerce has collated results as part of a survey of over 100

The majority of new widebody engine deliveries have been for types like the CF6-80E1 and the GE90.

engine shops: OEM, airline, joint venture, and independent shops. Based on this, it is estimated that the OEMs control 55% of the engine MRO market, with airline shops that have their own in-house capabilities accounting for another 30%. Independents with no link to the OEMs or airlines make up 10% of the market. The remaining 5% is made up of various joint ventures that are formed by joining in-country resources with a particular OEM. One example, is RR and American Airlines with Texas Aero Engine Service LLC (TAESL) in Texas, USA.

America

The world's largest MRO market may not grow much over the next decade, but the lack of expansion will not hold back a change in response to shifting customer demand and market fluctuations. The stagnation is due in part to North America's major re-fleeting.

Aviation consulting firm Team SAI estimates that North American carriers will take delivery of 3,700 new commercial aircraft over the next 10 years. About 80% of these deliveries will be replacement aircraft. This will take the North American fleet up to 8,000 aircraft from the current 7,300 units. Younger aircraft and engines require less maintenance, so a slight increase in total fleet size will not yield much new MRO work.

While the market's size will not grow, an influx of new narrowbodies will change its make up. Team SAI calculates that three aircraft families, the 737, A320 and 757, each account for a double-digit share of North American MRO spending, and account for 40% of the total fleet. No other aircraft type operated in North America has more than an 8% share of the total fleet.

Besides OEM-related shops there are several major airline and third party engine shops in North America. Examples are Delta TechOps, United Services, CTS Engines, and Lockheed Martin.

Delta TechOps is located at Atlanta, and has one of the most comprehensive engine services capabilities in the US. Besides engine maintenance it can assists with engine leases and exchange services, and aircraft-on-ground (AOG) support.

Maintenance capabilities include full performance restoration and overhaul shop visit capabilities, lighter engine maintenance, high-tech repairs and non-destructive testing, and engine health monitoring and maintenance management. These capabilities are provided by the CF34-3/-8C/-8E, CFM56-3/-5B/-7B, CF6-80A/-80C2, JT8D-219, PW2000 and PW4000 engines, It also has capability for auxiliary power units (APUs).

Delta TechOps has capacity for up to 1,000 engine shop visits per year, and averages more than 650 visits per annum.

Besides a range of high-tech repairs that include plasma spray, plating and machining, spray coatings; Delta TechOps also develops and approves major repairs through designated engineering representatives (DERs) and organisation designation authorisation (DOA) resources.

CTS is based in Fort Lauderdale, Florida. It has repair and overhaul capability for the CF6-50, -80A and -90C2. It performs 50-60 shop visits per year for north American, south American and European customers. It also has some specialist high-tech repair capability.

Lockheed Martin Commercial Engine Solutions (LMCES), previously known as Kelly Aviation Center, has two facilities. The first is in San Antonio, Texas, USA. It specialises in the CF6-50, 80A and -80C2, and all four variants of the CFM56 family.

The second facility is in Montreal Canada, and was originally Air Canada's engine shop. This specialises in the CF34 family, and all the three variants of the CFM56 family that power the 737 and A320 families.

Asia Pacific

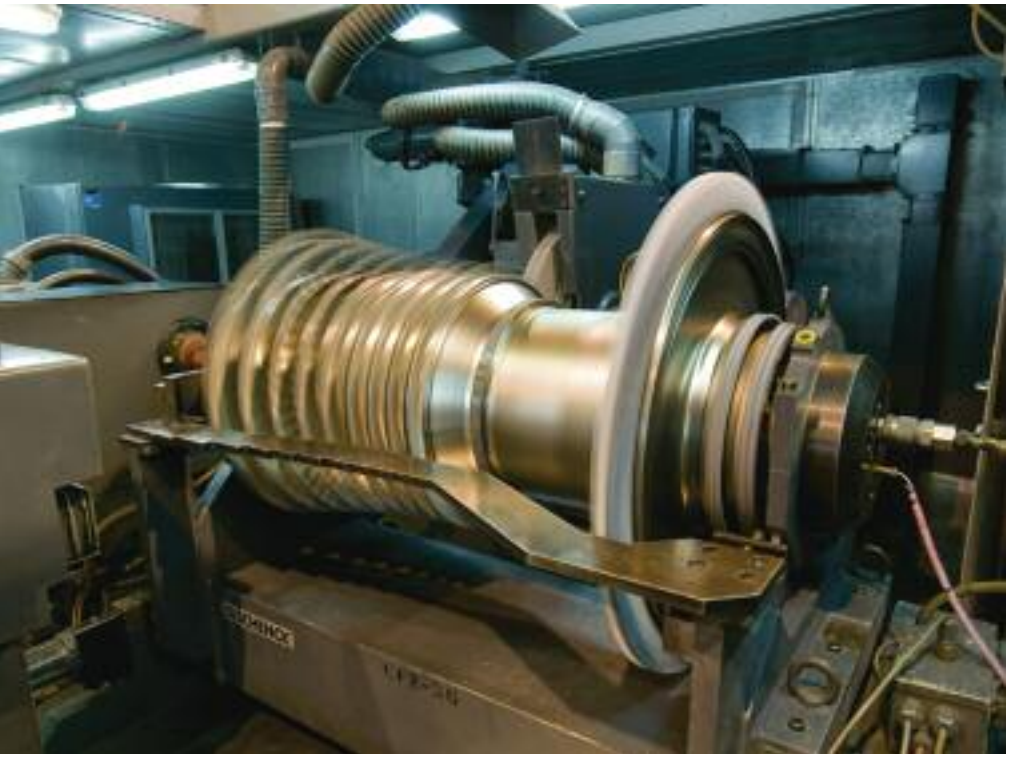
Major providers of aero engine MRO services in the Asia Pacific have seen expansion over the past few years. Important players in this market include: Evergreen Technologies in Taipei, which focuses on General Electric (GE) CF6-80C2 and International Aero Engines (IAE) V2500 powerplants; Eagle Services Asia (ESA); Singapore Aero Engine Services (SAESL); GE Engine Services Malaysia (GEESM); Hong Kong Aero Engine Services (HAESL); Beijing-based Aircraft Maintenance and Engineering (Ameco Beijing); MTU Maintenance Zhuhai, one of the largest repair shops in China; and Sichuan Services Aero Engine Maintenance (SSAMC).

SAESL

SAESL is one of the biggest engine MRO providers in the region. It is a joint venture involving: Singapore Airlines' SIA Engineering (SIAEC) unit, which holds a 50% stake; Rolls- Royce, which holds 30%; and HAESL, with a 20% holding. The venture is RR's Asia Pacific centre for excellence for the repair and overhaul of Trent-family turbofan engines.

SAESL started operations in 2001, and has since expanded its capabilities to support the full range of Trent family engines. The venture is now an integral component of RR's aftermarket services capability.

SAESL's's in-line gantry system for engine strip and assembly is the first in the region, and its fully automated engine parts cleaning line is the first in the world. RR has appointed SAESL as the first Trent 900 centre of excellence, supporting SIA's fleet of 19 A380s.



High-tech repairs, such as high-speed grinding and balde tip welding are expensove to develop. Engine shops that are joint ventures with OEMs have clauses with respect to the volume and location of high-tech parts repairs.

GEESM

GE Engine Services Malaysia (GEESM) was set up in 1997 at the Sultan Abdul Aziz Shah Airport in Subang, 25km outside Kuala Lumpur. It is a joint venture between GE Aviation (70%) and Malaysia Airlines (30%). The company offers MRO services for PW4000 and CFM56-3/5B engines. GEESM also has an engine test cell that can handle powerplants with up to 72,000lb thrust.

HAESL

Hong Kong Aero Engine Services Ltd (HAESL) is a joint venture that includes RR, Hong Kong Aircraft Engineering (HAECO) and SIAEC. HAESL focuses on the RR RB211 and Trent engines.

Engine Services Asia (ESA), meanwhile, is a joint venture between SIA Engineering (51%) and PW (49%). ESA offers MRO services for PW4000-series engines.

China's Ameco Beijing offers full MRO capability for RB211-535 E4 and -E4B engines. It also has an engine test cell, handling engines with up to 100,000lbs of thrust.

Air China-CFM venture

Sichuan Services Aero Engine Maintenance China (SSAMC) is a joint venture between Air China, which holds a 60% stake, and CFM, with 40%. The company was established in December 2010 after three years of complex negotiations between Air China and CFMI, before the Chinese government gave the green light for the venture.

SSAMC's facility at Chengdu-Shuangliu airport provides overhaul services for CFM56-5B and -3/7B engines. These engines power Air China's narrowbody fleet of about 200 A320 and 737NG jetliners. Air China's four A340-300 quadjets are powered by CFM56-5C engines, which are also overhauled by the joint venture.

Following the global economic downturn that stifled demand for air travel, growth in the MRO market is returning. Continued economic uncertainty, resurgent fuel prices and external factors led to a number of aircraft being grounded, and a decline in the engine MRO market.

Analysts are now predicting a fresh surge in air traffic over the next two decades, led by the Asia Pacific. Growth in the engine MRO market is set to return.

China's share

China is projected to claim a major share of global engine MRO revenue. Several joint ventures are clamouring to set up shop to tap into the growing MRO demand for the CFM56 MRO sector.

CFM56 and V2500 engines, which power the A320, are widely used in Asia. MRO providers describe the powerplants as 'cash cows'. This has been helped by the growth of low-cost carriers, which tend to operate 737NG or A320 families.

An estimated 3,000 CFM56 engines are operating in the region, with China-based carriers accounting for more than half of that total.

The latest foreign MRO service provider to enter the Chinese market is Singapore's ST Aerospace, which has formed a partnership with Xiamen Aviation Industry (XAIC). Known as ST Aerospace Technologies (Xiamen) Company (STATCO), the joint venture will provide engine MRO and total-support services, initially for CFM56-7B and -5B series turbofans.

The venture's $78 million, 38,620 square metre facility, located near Xiamen Gaoqi International Airport, opened in 2011. It offers capacity to support as many as 300 engines per year.

STATCO received Part 145 certification from the Civil Aviation Administration of China (CAAC) on the day it opened its doors. It also has certification from the US Federal Aviation Administration (FAA) and Korea's Ministry of Land, Transport and Maritime Affairs for the maintenance of CFM56-7B engines used by airlines in those two countries.

STATCO offers a state-of-the-art, fully computerised data-acquisition engine-test facility, capable of testing engines up to 90,000lbs of thrust. The facility complements ST Aerospace's engine MRO site in Singapore that can handle up to 350 engines annually.

STATCO is one of the few Chinese MRO joint ventures that lacks the involvement of a major local airline partner.

GFM AeroAsia

In Indonesia, Garuda's Jakarta-based maintenance unit GFM AeroAsia has plans to expand its engine capability to include the CFM56-7B.

CFM International, which has a 15-year contract to provide MRO services for the engines that power Garuda's 737-800 fleet, is also helping to provide AeroAsia with the expertise required to add this capability.

Most CFM56-7B engines now in service worldwide are coming due for shop visits. Some engines will need some of their LLPs to be replaced.

One challenge facing engine MRO providers in the Asia Pacific is the shortage of skills for specialist repair processes. Poaching of local skilled and trained personnel is widespread, with many lured away to lucrative jobs in the Middle East.

It is often the case that as soon as specialised technicians gain some experience, they are courted with

attractive job offers from a large engine MRO service provider.

The main drawback for local MRO providers is that there is nothing much that they can counter-offer.

Although labour costs are rising in the Asia Pacific, they remain lower than in Europe and the US. Hong Kong and Singapore have the highest labour costs, while rates in China and Malaysia are also on the rise as skilled engineers demand more pay.

Europe

Europe's MRO market is generated by aircraft operators. According to the latest Team SAI global report, the European engine market will grow at 2.9% annually, climbing from $16.9 billion in 2014 to $21.8 billion in 2023. The growth is a few points below the global expectation of 3.1% per year average through the decade, from $56.2 billion to $76.0 billion.

Airbus and Boeing continue to dominate the European fleet mix. They are expected to account for 82% of all deliveries to Western Europe through to 2023. The majority of these deliveries represent replacement of older airframes, with 737 Classics, early 737NGs, and early A320s joining four-engine aircraft, such as the A340 and 747, all due to be retired and phased out. Many will be replaced by A320neos and 737 MAXs.

While the Western European market is maturing, the Eastern European market is growing. The region will nearly double its MRO spend over the next 10 years, from $2.8 billion in 2013 to $5.0 billion in 2023. Despite the European MRO market's slow organic growth, the region continues to handle more MRO activity than any other. This is largely due to the presence of well-established legacy facilities and heavy engine overhaul presence.

Europe handles about $10 billion in engine work annually, while its fleet produces only $5.7 billion in yearly work. The remainder is split between Asia and North America at $1.5 billion and $2.0 billion respectively.

The largest airline and independent shops in Europe and those operated by Air France Industries (AFI) KLM Engineering & Maintenance (E&M), Lufthansa Technik, Iberia Maintenance, TAP Maintenance & Engineering, and MTU Maintenance.

AFI KLM E&M has three shops, two at Paris airports and at Amsterdam Schiphol. It has shop visit and overhaul capability for all four CFM56 variants, the CF6-50/-80C2/-80E1, the PW4000, GE90 Classic and Growth, GEnx, and GP7200.

Its subsidiary CRMA specialises in several high-tech repairs. The two Paris shops have a combined annual throughput of about 300 engines per year, and the Schiphol facility performs about 250 performance restoration and lighter shop visits.

Although it is headquartered in Germany, MTU Maintenance has four engine shops. Two are located in Hannover and Berlin, Germany; while the other two are in Zuhai, China; and Vancouver, Canada.

MTU Maintenance has shop visit capability for the CF34 family, the CF6-50 and -80C2, the GE90 Growth, the CFM56-3/-5B/-7B, the GP7200, the V2500, the PW2000, and the PW6000.

It has developed a large number of high-tech repairs over the years, and likes to have the capability to perform all types of component repairs wherever possible. These include OEM-licensed repairs, and its own in-house DOA-approved repairs that it has developed.

Collectively, its four shops perform more than 700 shop visits per year.

Most engine shops have the basic capabilities of disassembly, inspection, reassembly and test. Larger airline-related shops, however, still have a high level of sophisticated part and component repairs for a wide range of engine types.

Middle East & Africa

The air transport market will see a steady increase in the importance of the Middle East and Africa. Extensive investments into aviation infrastructure and logistics, and expanding and renewed fleets in the region, will definitely impel the MRO sector to concentrate on the Middle East, and especially the North African and Asian regions.

Airlines based in the region placed large aircraft orders in 2013. Despite this, the quality and diversity of aircraft technical support services remain largely inferior to those offered in the West. The region still faces a shortage of high quality MRO support for engine services.

Over the past 10 years the situation in the Middle East's aviation market has changed dramatically. According to one recent forecast, the number of air passengers in the region is expected to double to reach 386 million by 2020.

The Team SAI data suggests that over the upcoming decade the Middle East fleet will increase from 808 to 1,482 aircraft. In the meantime, by 2020 the current $3 billion MRO market is predicted to top $54 billion.

Alternatives to overhaul

MTU Maintenance has recently introduced new aftermarket services for mature aircraft engines under the name MTUPlus Mature Engine Solutions. Services are being launched in response to current market needs and largely focus on non-power by the hour (PBH) contracts for airlines and lessors.

MTUPlus Mature Engine Solutions are fully customised and can offer considerable savings over a regular shop visit. The modular set-up of MTUPlus Mature Engine Solutions offers customers a variety of options that can be summarised under two main products: 'Instant Power' focuses on leasing or exchanging the engine; while 'Smart Repair' combines customised workscopes with extensive use of part life material.

These solutions cater to the specific needs of operators of mature engines, which in many cases have been in service for 20 to 30 years. Upon receipt, powerplant engineers evaluate the condition of an engine and carry out back-to-birth traceability on its components, and consider the remaining service life of major components and LLPs before proposing the most cost-effective solution to the customer.

If the condition of an engine and its components is such that repair is no longer economic, then MTUPlus Mature Engine Solutions offers alternatives that provide instant power, such as a leasing arrangement or an engine exchange.

If a customer has new aircraft that will be delivered over the next few years, an exchange engine can be a cost-efficient interim solution for an existing fleet. Under these conditions, a customer sells MTU Maintenance its current engine as a trade-in for an exchange engine that fulfils all operating requirements for the intended period of use. Should an operator require short-term replacement for an engine that has minimum running time left, MTU Maintenance offers engine lease arrangements that save a customer the cost of investing in engine maintenance. These alternatives have to be carefully weighed against return conditions and operating costs.

Should an operator plan to keep an engine in service for a longer period of time, engine repair remains the most appropriate solution. MTU has coined the term 'Smart Repair'. This option restores an engine to a serviceable condition that exactly matches customer needs, often aimed at meeting lessor end-of-lease handback conditions.

In this context, used material may be the most effective way to maximise residual value of the asset at the end of its life cycle. Used serviceable material is accessed from customer-owned engines or provided by MTU Maintenance. It has services that range from 'bag and tag' teardown to extensive parts management, including storage and re-marketing of used serviceable material removed from a customer's engine.

This is a promising and welcome development in the ageing engines market. In the 757 RB211 market, for example, MRO options in the past have been AMECO in Beijing, Iberia in Madrid, TAESL in the USA, and RR.

Given the age of an asset, it is unlikely that a European engine would be sent to RR, since RR may find it hard to compete. This is largely due to AMECO Beijing's aggressive pricing (Iberia follows close behind) and is able to beat 'wing-to-wing' turn times due to location.

For RB11s located in the US, it is likely that TAESL or similar shops in the US would be chosen over those in the Asia Pacific, due to the ability to reduce turn times.

Summary

The price of fuel and additional environment-related issues, brought on in part by the European Union Emissions Trading Scheme (EU ETS), which is expected to come into force for all airlines flying within the EU, are expected to drive a continued push for better engine designs and new drop-in fuels. These developments are complementary to improved aircraft and air traffic control system designs.

Although the effects of these changes on the engine MRO market remain uncertain, continuing improvements in engine performance and care will be required. These factors alone will significantly impact the aircraft engine MRO market. AC