While the engine-repair and overhaul market remains relatively stable with fleet size, the engine fleet is becoming dominated by a small number of engine types. The repair markets for these engines are being consolidated by a few providers, threatening remaining engine shops.

Engine shop visit demand & capacity

There is no doubt that the combined capacity potential of the globe's engine shops exceeds the annual production of about 11,000 shop visits. While an engine shop requires slack capacity to allow for variations in demand, the consolidation in the engine overhaul market means that the full capacity potential of some shops will be under utilised.

Engine overhaul market

The engine repair and overhaul market has changed in the past decade to become dominated by the original equipment manufacturers (OEMS) and a few major airlines. The number of independent shops and airlines performing full engine maintenance has decreased.

The global fleet has also changed over the same period. The major fleet workhorses of 10 years ago have been replaced by similar sized types with fewer and more reliable engines. The installed fleet of engines has not, therefore, grown as fast as fleet size, while the growth in demand for engine shop capacity has been even slower. The effects of improved engine reliability, and so fewer annual shop visits for a given fleet size, have increased competition in the engine repair and overhaul business.

The impressive reliability of the RB211-535, Trent 700/800, CFM56-3/-5A/B, CFM56-5C, CF6-80C2 and PW4000 is demonstrated by the fact that large numbers of engines in each fleet have first on-wing runs exceeding 10,000 engine flight hours (EFHs). Second-wing runs have also been 7,000-10,000EFH for many powerplants. These removal intervals are impressive compared to those of their older counterparts: the JT8D-200, JT9D, RB211-22/524 and CF6-50 series.

The long first and second on-wing intervals of modern engines buy them extended maintenance honeymoons. Subsequent shorter on-wing intervals to third and fourth removals increase shop visit activity. There is therefore a gap of several years between aircraft delivery and the first removal, before there is an increase in the number of engine shop visits, and a rise in demand for repair and overhaul capacity. This has now begun to occur, and makes up for some of the softer demand after these engines were initially delivered.

The airline industry has been through one of the largest re-equipping phases in its history in recent years, spurred on by traffic growth and low interest rates. This latter point has played a significant role in accelerating the retirement of older types, such as the 727. Powered by the JT8D, with intervals typically in the region of 5,000-6,000EFH, the mass retirement of the 727 and other older types has seen demand for older engine repair capability fall at alarming rates in recent years.

While new engines continue to be delivered at high rates, the large number of new generation engines already in operation means that the demand for engine shop capacity will continue to grow at a steady pace. There will be the usual time lag between delivery and increased shop visit rates for individual engines.

Another noticeable change in the engine repair market is the reduction in the variety of engine types and domination by a minority of latest-generation powerplants. The most obvious example is the CFM56. More than 10,000 units have been delivered, and more than 2,000 are on firm order. Sales show no sign of stopping.

The CFM56 repair and overhaul business is dominated by just 10 providers, which cater for about 1,300 shop visits or 13% of global annual demand of about 11,000 shop visits. The most prominent of these providers are General Electric Engine Services (GEES), Snecma Services, Lufthansa Technik, Air France Industries and United. This is in contrast to the JT8D. About 12,000 engines were sold, and the repair aftermarket was shared between more than 40 independent and airline engine shops.

This reflects the increased domination of the engine repair and overhaul business by the OEMs. These have taken a large share of the market from airlines and independent shops. OEMs have been attracted by the high profits in the engine aftermarket. By controlling a large share of the repair market they can also have a greater influence on spare parts prices.

OEMs have increased their presence in several ways. GEES has bought many shops, and has at least one major facility in each continent. Pratt & Whitney (P&W), Rolls-Royce and Snecma have all formed joint ventures with major engine shops. In many cases, these three manufacturers now also have a presence in most continents.

Shop visit demand

The global market for annual engine shop visits is 11,000-13,000. The fleet of installed engines is estimated to be about 38,000 units. About 22,000 of these are new-technology engines *(see table, page 26)*, which reflects the trend towards

SUMMARY OF ESTIMATED GLOBAL INSTALLED AND SPARE ENGINE FLEET

Engine type	Installed engines	Number of annual removals
New Technology		
PW4000	2,100	720
JT9D-7R4	275	130
GE90	200	70
CF6-80	2,900	1,050
Trent 700/800	360	140
RB211-524G	520	200
PW2000	790	360
RB211-535	1,100	225
JT8D-200	2,300	1,080
CFM56-3/-5	7,860	1,450
V.2500	1,300	330
BR715	90	10
Tay 600	800	150
Old Technology		
JT9D-7	1,600	620
CF6-6/-50	1,950	720
RB211-22/524	800	260
JT3D	1,900	150
JT8D	7,000	1,700
CFM56-2	440	70

twin-engined aircraft. These new-technology powerplants are the CFM56, CF6-80, GE90, JT8-D-200, JT9D-7R4, PW4000, PW2000, BR715, Trent 700/800, RB211-535/524G, RR Tay and V.2500.

The remaining old technology engines are earlier variants of the JT9D, CF6, RB211, CFM56-2 and 'Baby' JT8D. These total about 15,000 engines *(see table, this page)*, with the 'Baby' JT8D accounting for about 7,000 units. This number is now falling fast each year. Despite the 727's popularity as a freighter, large numbers of 727Fs have been parked in recent years. The same applies to JT9D-powered aircraft, since there is a surplus of older 747-100s and -200s.

The balance between new and old technology engines is constantly shifting, with the largest change occurring between the CFM56 and JT8D.

The current fleet of CFM56-3/-5/-7 series engines numbers about 8,800 units, with about 700 spare engines in support. This compares to an installed fleet 7,000 JT8Ds and 2,350 JT8D-200s. CFM56s orders and deliveries continue.

The number of installed large fan and small fan engines, sub-divided into new and old technology engines for the 2000 fleet is summarised *(see table, this page)*.

In addition to installed engines, the fleet of 38,000-39,000 units is supported by about 4,000 spare engines. Installed engines are estimated to generate in the region of 10,500-11,000 engine shop visits each year. In other words, for every engine in the fleet, there are about 0.29 shop visits a year.

While this is an average for the whole fleet, there will be a wide variation in average shop visit intervals between engine types, within each fleet of the same engine type and between fleets of the same type.

The number of engine removals also depends on annual utilisation. Younger aircraft generally have engines with longer on-wing intervals between removals, but also achieve higher utilisations. Older types, with poorer reliability, tend to have shorter removal intervals and lower rates of utilisation.

The JT3D, powering the DC-8 and 707 has the highest removal rate of 0.20 per 1,000 engine flight hours (EFHs), which is equal to an interval of 5,000EFH. Most older technology engines have removal rates in the region of 0.14-0.20 per 1,000EFH, or 5,000-7,000EFH. This includes the CF6-6/-50, RB211-22/524, JT9D-7, JT3D and JT8D.

These high removal rates generate about 4,000 shop visits per year for these 15,000 older engines. This equates to about 0.28 shop visits per engine annually. This number of shop visits will decline in proportion with the retirement of older aircraft.

In contrast with their older counterparts, most new technology engines have removal rates in the region of 0.06-0.10 per 1,000EFH, or 10,000-17,000EFH. These average intervals are likely to reduce for each engine type, as the oldest units in each fleet increase with age and have shorter removal intervals.

A few types, like the JT9D-7R4 and JT8D-200 have higher removal rates, equal to intervals of 5,000-6,000EFH.

The number of annual visits for these 22,300 engines is estimated to be about 6,000. This is also equal to 0.27 visits annually for each engine. Although new technology engines have longer on-wing intervals than older technology powerplants, the higher utilisations that modern aircraft achieve means that new and old technology engines visit the repair shop at approximately equal rates.

This indicates that the effect of improved engine reliability on reducing shop visits is balanced by the higher usage of these new-technology engines. This implies that although the global fleet is changing to new technology engines, the number of shop visits required each year will not decrease. The number of annual shop visits will remain about constant, and may even increase, because newer aircraft experience higher rates of utilisation than older types, and there is a gradual reduction in shop visit intervals for older individuals in new technology fleets.

The demand for engine maintenance capacity will also be influenced by fleet size, the number of installed engines, and the amount of each type in the fleet. The fleet will continue to grow, but the variety of major engine types will decrease.

Individual types

The number of shop visits for each type shown in the table is subjective. Although the number is based on average removal intervals, these can vary widely each year according to delivery schedule and operation.

The largest market is for the CF6 and CFM56 families. The CF6 variants between them generate in the region of 1,800 shop visits annually, but this can rise to 2,000 in a high-demand year. The CF6 is one the most popular widebody powerplants, but sales have now matured. The exceptions are a low annual volume of 747-400, 767-300 and A300-600 sales. The CF6 has largely been overshadowed by the introduction of the large widebody twins, and larger

Engines such as the Trent 700/800 have limited markets for repair and overhaul. Their numbers are small and the OEMs control most or all of the market for these powerplants. Other engine facilities will have to look to mainstream engines for business.

engines to power the 767-400 and A380. The CF6 repair market will therefore not grow significantly from its present level.

The CFM56-3/-5 series repair market is similar in size to the CF6 overhaul business. The table *(see page 26)* shows a market in the region of 1,500 shop visits each year. The fleet is continuing to grow and some estimate that the CFM56 market has already reached 1,800-1,900 shop visits annually. This will continue to grow in the foreseeable future as the current order book of about another 2,500 units is delivered. The CFM56 repair market is expected to grow to about 2,500 shop visits by 2005 and reach 3,000 visits in 2010. This will then make it the dominant engine in the repair market, and explains why a large number of engine shops have expressed an interest in acquiring CFM56 capability.

After the CF6 family, the second largest market is the 'Baby' JT8D family. The 'Baby' variants generate about 1,700 visits, but this number is falling rapidly and they are being overtaken by the CFM56. It is estimated that at least 200 JT8D engines were taken out of operation in 2000, and that a similar number will be retired during 2001. This will result in the 'Baby' JT8D market soon falling to about 1,500 shop visits per year.

The JT8D-200 generates in the region of 1,100 annual shop visits, equal to about one for each aircraft it powers in the fleet. The MD-80 is still popular, but has limited secondary-market prospects. The fleet is dominated by just 10 airlines, with American and Delta operating about 400 units. When these airlines start to retire their aircraft there is a danger of en-masse retirements, and a consequent fall in the JT8D-200 repair market. For now, JT8D-200 repair activity has prevented the complete collapse of the JT8D market.

The PW4000 and JT9D both generate in the region of 800 shop visits each year. While the PW4000 remains strong, and is increasing in small numbers, the JT9D is in decline. The PW4000 market continues to grow with orders for the 777 and A330. The smaller PW4000-94 is also increasing in numbers, but at a low rate with 747, 767 and A300-600 orders.

The main JT9D user is the 747-100/-200/-300, which are falling in popularity for both passenger and freighter use.

The current fleet of 1,900 JT9Ds has begun to experience a similar decline to the Baby JT8D family. The biggest threat comes from the conversion of younger 747-400s into freighters, diminishing the market for used 747-200s.

The sixth major market is the RB211 family, which requires about 700 shop visits per year. This is split between the older -22B and -524 variants, which account for about one-third of shop visits, and the younger -535 and -524G models. The -22B and -524 models are rapidly declining in popularity, as the L-1011 has become a minority aircraft and there are few 747-200s in operation. These have been shunned by the freight conversion market, and there are few or no secondary market prospects for these aircraft. The majority of the 800 engines generating these 260 shop visits will leave the market over the next decade.

The RB211-535 and -524G markets have now matured, with few 747-400s now being sold and the 757 market past its peak. The RB211 market will therefore become a minority.

The other major engine types are the GE90 and Trent 700/800 series. These will shortly be joined by the Trent 500 and, in about five years, the Trent 900. In all cases, the number of engines in operation and due for delivery means that the annual repair market for each of these will remain small. The Trent 700/800 is the largest, with about 140 shop visits required each year. This will grow beyond 200, but will still remain a minority. The repair business of these engines will be left to the OEMs and the joint ventures that they have formed with major airline shops.

The other major types generating significant numbers of shop visits are the PW2000 (360) and V.2500 (330). The PW2000 has reached maturity, but the V.2500 is still selling and will grow to be a larger market.

Shop visit peaks

Removal intervals between shop visits will be reduced from the theoretical possible levels by unscheduled removals, airworthiness directives (ADs) and the need to replace life limited parts (LLPs).

Engine removals should be planned so that the average engine flight-cycle (FC) is taken into account, and LLP replacement does not interrupt the subsequent on-wing run. However, many engines are not managed this way, and LLPs are often left in engines with remaining lives shorter than would otherwise be possible with the build standard at a shop visit. These 'stub' life LLPs interrupt the next on-wing run, thereby reducing the average on-wing life between shop visits and increasing shop visit rates.

LLPs throughout an engine also have different lives, and so the removal and replacement of each one at the most suitable shop visit has to be planned so as to maximise on-wing times.

LLPs in the same module do not always have similar lives; if they did it would be easiest to remove and replace them together at the same shop visit. LLPs in fan and high-pressure compressor sections have longer lives than those in the turbine and hot sections of the engine. LLPs in the cooler parts of the engine can therefore be replaced at a later visit, after the parts in the hot sections.

This is convenient, since in many cases the cooler parts of the engine often do not need to be worked on at every shop visit. The cooler modules would have to be worked on if LLPs had to be replaced. The long life of LLPs in these cooler modules therefore helps maintain high average removal intervals. If, however, some LLPs in a module have a much shorter life than all others this will force an early or more frequent removal and shop visit.

The issue is further complicated by the fact that some engine types have several variants with different thrust ratings. Lower thrust-rated models tend to be capable of longer on-wing intervals and to have LLPs with longer lives. Airlines swap these engines between aircraft types, changing their thrust ratings and remaining lives allowed for LLPs within the engine. Careful engine management is necessary to prevent early removals. In some cases the same engine type is capable of powering several aircraft. One example is the CF6-50, which can be used on the A300, DC-10-30 and 747-200. These aircraft types operate a wide range of average cycle times. Swapping engines between aircraft types therefore requires careful LLP management, since a reduction in average FC time will force earlier LLP replacement.

A well planned engine removal, shop visit and LLP replacement pattern can prevent increases in shop visit rates.

Repair providers

Providers of engine repair and overhaul capacity fall into one of three categories: the OEMs, independent facilities and airline shops.

Care must be taken when assessing the suitability of these shops. Many airlines, for example, have what are known as 'hospital' shops, which carry out minor repairs and fan blade changes, but cannot perform module disassemblies and shop visits.

Assessing shops with capacity and capability is also complicated by the fact that these shops perform shop visits on regional aircraft engines. The table *(see page 26)* and market for about 11,000 annual shop visits refers only to large jet aircraft powerplants.

There are four major OEMs in the large aircraft jet engine repair and overhaul market: GEES, Pratt & Whitney Engines Services, Rolls-Royce Aero Engine Services (RRAES), and Snecma Services.

GEES is the largest in terms of number of facilities, with a total of 10 shops. These include four in the US (Miami, Dallas, Ontario and Strother Field) and two in the UK (Cardiff and Prestwick). Others are the facility in Kuala Lumpur which involves a joint venture with Malaysian Airlines, two shops in Brazil, and a shop at Xiamen in China.

GEES not only has the capability for all CFM56, CF6 and GE90 models, but also the JT3D, JT8D, PW4000, V.2500 and RB211 at some of its facilities. It has expanded to become the world's largest provider by either buying these shops from airlines and independent maintenance providers, or forming joint ventures. GEES acquired capability to repair and overhaul other OEMs' engines when it acquired British Airways' shop at Cardiff and Aviall's at Dallas, and formed the joint venture with Malaysian Airlines at Kuala Lumpur.

Following GEES' massive and rapid expansion in the early 1990s, P&W, RR and Snecma followed a similar strategy to protect their market share. In many cases these three OEMs formed joint ventures, rather than making all out acquisitions.

P&W has two main facilities in the US; one at Cheshire, CT and the other at Columbus, GA. It has also formed joint ventures with Singapore Airlines Engineering Company and Braathens. P&W is also due to form a joint venture with KLM Engineering and Maintenance.

P&W has capabilities for all P&W engines, but also the CFM56 after forming the joint venture with Braathens. P&W will also acquire CF6 capability after it forms a joint venture with KLM.

Although Snecma is a partner in the CFM56 programme, Snecma Services competes with GEES in the repair and overhaul business. Snecma Services has four facilities, including its own facility near Paris, which has capability for all CFM56 models. Its three other shops all involve joint ventures: with Royal Air Maroc in Casablanca; with Sabena in Brussels; and with the Sichuan Aero-Engine company in China.

RRAES has two shops in the UK, one in Canada and one in Brazil. It has also formed four joint ventures, with HAESL (with HAECO), SAESL (with Singapore Airlines), TEMRO (with SR Technics) and TAESL (with American Airlines). These joint-venture shops are separate from the other shops owned by RRAES' joint-venture partners, where the engines of other manufacturers are overhauled. HAESL and TAESL are in operation. SAESL is due to open in 2002 and TEMRO in 2001.

The number of independent engine repair shops has declined in recent years, because the OEMs have acquired some of the larger independents. GEES, for example, has acquired Aviall and Greenwich Air Services. Independent relied on JT8D repair business, which has dwindled with the engine's decline. The obvious strategy for these shops was to move into the most popular engine, the CFM56. This market has been protected, however, by GEES and other big CFM56 repair and overhaul providers. In addition, moving into the CFM56 is expensive, since new and specialised tooling is required.

The major independent engine repair and overhaul providers are MTU, Aerothrust, Avteam, Pacific Gas Turbine Center (PGTC), Wood Group, Fiat Avio, Modern Jet Support, Volvo Aero Engine Services (VAES), Bedek Aviation, GAMCO, IHI and ST Aerospace. The capabilities of these shops are summarised *(see table, this page)*.

MTU is the only global independent engine-maintenance provider. Its largest shop in Hanover, Germany has CFM56-7, CF6, V.2500 and PW2000 capability. Its second shop in Richmond, Canada has CFM56-3, CF6-50 and JT8D capability. MTU is also due to open shops in Brazil, with V.2500 capability, and in Zuhai, China, with CFM56 and V.2500 capability.

The third group of engine repair providers are the large airline shops. In North America these are United, American, Delta, US Airways, Northwest and Air Canada. Continental no longer has an engine shop and FedEx subcontracts its engine repairs.

The major European airline shops are led by Lufthansa Technik, which has shops in Hamburg, Frankfurt and Dublin. Lufthansa Technik also has a

MAJOR ORIGINAL EQUIPMENT MANUFACTURER AND INDEPENDENT ENGINE SHOP FACILITIES

Provider	Location (s)	Large engine capabilities
Original equipment manufacturers		
GEES	Strother, AS; Ontario, CA; Dallas, TX; Miami, FL;Rio de Janeiro; Petropolis;. Cardiff; Prestwick; Kuala Lumpur & Xiamen.	CFM56, CF6, GE90, JT3D, JT8D, JT9D, PW4000, V.2500 & RB211.
Snecma Services	Paris, Brussels, Casablanca & Sichuan.	CFM56, CF6, JT8D, JT9D, PW2000 & PW4000.
Pratt & Whitney	Columbus, GA; Cheshire, CT; Singapore & Stavanger.	JT8D, JT9D, PW2000, PW4000, & CFM56.
RRAES	Derby, Glasgow, Lachine Canada & Sao Paolo Brazil	Tay, V.2500, RB211 & Trent family.
HAESL	Hong Kong	RB211-524, Trent & V.2500
TAESL	Dallas, TX	RB211-535, Trent & Tay
North American Independent		
Aerothrust	Miami, FL	JT8D
Aviation Engine Services	Miami, FL	JT8D
Avteam	Miami, FL	JT8D
MTU Canada	Richmond, BC	CF6-50, JT8D
Newjet	Miami, FL	JT8D
PGTC	La Jolla, CA	JT8D
Wood Group	East Windsor, CT	JT8D
European Independent		
Fiat Avio	Turin, Italy	JT8D
Modern Jet Support	Ramsgate, UK	JT3D
MTU	Hannover, Germany	CFM56-3/-7, CF6-50/-80, V.2500 & PW2000
VAES	Bromma, Sweden	JT8D, JT9D & PW4000
Middle East Independent		
Bedek Aviation	Tel Aviv, Israel	JT3D, JT8D, JT9D & RB211
GAMCO	Abu Dhabi, UAE	CFM56-5A/-5C, CF6-80C2 & RB211
Asia Pacific Independent		
Ameco	Beijing, China	CFM56-3, JT9D, PW4000 & RB211-535
ST Aero Engines	Singapore	JT8D

Small independent repair facilities have relied for many years on the JT8D and JT9D for work. These engines are now in decline, while the market for the most popular powerplants is being dominated by a select number of providers.

joint venture with China Airlines at Ameco Beijing and has taken over the Philippine Airlines facility in Manila.

Other major European airline providers are Air France, KLM Engineering & Maintenance, Iberia, Finnair, SR Technics and Alitalia.

Few airlines in the Middle East and Africa have the capability to perform full engine shop visits. South African Airways has ceased its own engine shop visit capability in recent years and now subcontracts its work to other providers.

Major airline engine shops in the Asia Pacific are Singapore Airlines Engineering Company (SIAEC), Japan Airlines, All Nippon Airways and Qantas.

Engine-repair capacity

There are, in addition to the shops mentioned, other facilities, but these account for only a small portion of annual demand for engine repair capacity.

Most of the engine repair and overhaul business is becoming increasingly dominated by major providers. This is illustrated by the small number of facilities that dominate the CFM56 market. The annual CFM56 repair business comprises 1,500-1,800 shop visits. GEES has the largest share, completing more than 500 shop visits each year. Snecma Services, the second largest in the CFM56 market, completes about 300 a year. GEES and Snecma Services therefore account for about half the CFM56 repair and overhaul business. Lufthansa Technik, Air France Industries and United Airlines each perform 100-200 CFM56 shop visits annually, while SR Technics, Iberia, Air Canada, Delta and Qantas perform in the region of 35-50 each. Combined, these shops account for about 1,300-1,400 CFM56 shop visits a year. Another 10 shops each complete about 15 shop visits every year. Together these main suppliers perform 1,500-1,600 shop visits annually.

While GEES completes a large number of JT8Ds each year, the market is also divided between eight major airline and eight large independent shops. This spreads the annual throughput of work evenly, thereby avoiding the dominance of a minority of facilities that is seen in the CFM56 market.

Some of MTU's 200 annual shop visits at its Canadian shop are JT8Ds, while Aerothrust and Avteam each complete in the region of 125 shop visits and PGTC handles a slightly higher number. The Wood Group performs in the region of 90 JT8D shop visits and other smaller independent shops in the US account for about another 200 visits.

GEES has the largest share of the total market. Its facilities have a combined annual throughput of about 3,000 shop visits, which is equal to about 25% of the total annual demand.

By comparison, Snecma Services' four facilities, including the joint venture with Sabena at Brussels, have an annual throughput in the region of 425 engines, or less than 5% of the global market.

RRAES total annual production is about 850 engines. About 500 of these are performed at its two UK, Canadian and Brazilian facilities. HAESL has an annual throughput of about 150, while TAESL completes about 210. RRAES's maximum capacity is about double its current production.

Independent shops now account for a reduced share of the total market. MTU, which has focused on new technology engines, performs about 325 shop visits at its main Hanover facility, on CFM56, CF6, PW2000 and V.2500 engines. The facility has a maximum capacity in the region of 375 shop visits.

MTU's other shop at Richmond, Canada performed about 200 shop visits in 2000, and has an annual capacity for about 225. MTU's capacity will be boosted when it opens its Brazilian and Chinese facilities in 2003. These will focus only on the V.2500 and CFM56, with MTU aiming for subcontracted A320 business.

Independents in North America are the major JT8D shops. All of these have seen their workloads decrease in recent years following large scale 727 retirements. Aerothrust, Avteam, Newjet, Aviation Engines Services, PGTC and The Wood Group account for more than 600 shop visits each year. The majority are JT8Ds, but The Wood Group also has JT3D capability.

VAES is one of Europe's largest remaining facilities. The ex-SAS engine shop at Bromma, Sweden has JT8D, JT9D and PW4000 capability. It performs in the region of 200 shop visits each year, and has been almost full for the past three to four years. One major contract includes JT8D-200 business for Continental. VAES is also part of Volvo Aero, which provides spare parts and short- and long-term engine leasing.

GAMCO is the Middle East's best-known third-party maintenance facility, with airframe check capability in addition to engine overhaul. GAMCO has an annual production of about 45 CF6, CFM56 and RB211 shop visits.

Ameco Beijing completes in the region of 120 engine shop visits. It is one of the few independent facilities with RB211-535 capability, as well as CFM56, JT9D and PW4000.

ST Aerospace in Singapore is one of the few Asia Pacific facilities to retain JT8D capability, and performs in the region of 120 shop visits annually.

The airline shops are the second largest provider of engine shop visit capacity. The mega carriers in the US account for the largest portion.

Rolls-Royce has effective control over the majority of its engines. It has achieved this by forming joint ventures with some of its largest operators in every major continent. Only a handful of shops independent of Rolls-Royce have repair capability for its engines.

American's Tulsa facility, whose capability includes the JT8D and CF6, performs in the region of 500 shop visits each year. It has a maximum capacity of about 700. This facility does not include TAESL, American's joint venture with Rolls-Royce.

American's Tulsa facility therefore only has work for its P&W and GE engines, and does not account for the whole of its fleet. Engines put through the Tulsa facility include a small quantity of third-party work.

Air Canada's shop in Montreal has capability for the JT9D, PW4000 and CFM56-2/5A. Its annual production is in the region of 220 shop visits, but this could rise to a maximum of 360.

In total, American, Air Canada and other US mega carrier shops account for 2,200-2,400 shop visits each year. This equates to about 22% of the global market. The majority of US mega carriers perform their maintenance in-house, and this is unlikely to change. Their share of the engine repair and overhaul market will therefore match their fleet size in the future.

Europe's major airlines comprise the second largest group of airline engine shops. Lufthansa's Hamburg and Frankfurt facilities generate 460 shop visits each year. While the Frankfurt shop does not have the capability to perform sophisticated repairs, it can complete full shop visits. Lufthansa Airmotive in Dublin, Ireland performed 60 shop visits in 2000.

SR Technics and Air France Industries are both Europe's second largest airline facilities, each performing about 300 shop visits in 2000. SR Technics' capabilities include the PW4000, CF6-80C2, CFM56-5A/B and the JT8D-200. Air France Industries has CFM56-2/-3/-5, CF6-50/-80 and JT8D capability.

KLM Engineering & Maintenance is the fourth largest airline shop in Europe. It concentrates solely on the complete CF6 family, but will acquire PW4000 capability when it forms its joint venture with P&W. KLM Engineering & Maintenance will also be building a new facility, since its current shop was built in the 1950s. KLM Engineering & Maintenance performs engine work for its own MD-11 and 747 fleet, but also has a wide range of third-party customers, several of which are flag carriers from the Asia Pacific region. Throughput in 2000 was 250 shop visits, but maximum capacity is 400 engines.

Iberia is another major shop, and completed almost 200 shop visits in 2000. It has a wide range of capabilities, which include the JT8D, JT8D-200, JT9D and CFM56-5A/B/-5C. It is also, like Ameco, one of the few shops independent of Rolls-Royce to have RB211-535 capability.

Sabena is another large shop, and completed about 175 shop visits in 2000. This includes 50 CFM56s, which are accounted for in Snecma Services' total. Finnair has JT8D-200 and CF6-80C2 capability for its MD-80 and MD-11 fleets, but will add the CFM56-5 to cater for its A320s. Current production is 800-100 shop visits.

The annual throughput of the facilities listed above accounts for about 9,900 shop visits. Although the annual production of some facilities includes a small portion of regional aircraft engines, these facilities account for about 80% of the global market for engine repair and overhaul of jetliner powerplants.

Other major providers include P&W, Alitalia, Bedek, SIAEC, Japan Airlines, All Nippon Airlines, Thai, and Qantas.

Summary

While the OEMs have the dominant share of the aftermarket, there are still enough other facilities with the right capabilities to provide competition.

Despite better on-wing reliability, the engine repair market remains substantial and will grow approximately in line with fleet growth. The problems for non OEM shops will be retaining capabilities that match the engines generating the highest level of demand. Consolidation in the CFM56 market is the best illustration of this. Formation of joint ventures by some big shops with manufacturers has allowed both to acquire new capabilities and increases chances of survival. AC