The engine MRO market has experienced a slump in recent years due to early retirement of older engines and maintenance honeymoon of new ones. Although engine shop visit activity is forecast to grow 58% over the next 10 years, MRO providers believe overcapacity could still be a problem.

Will engine fleet growth deliver an MRO boom, or just provide relief?

Engine maintenance repair and overhaul (MRO) accounts for a major portion of maintenance providers' revenue. The volume of annual engine shop visits has been depressed in recent years due to the early retirement of older generation aircraft following 11th September, and the engine removal 'honeymoon' of younger aircraft that were delivered in the late 1990s. This has led to a softening of rates for shop visits, favouring airlines. The number of shop visits is expected to increase again over the next few years, providing some relief to engine MRO suppliers.

Engine MRO volumes

Several factors determine the annual volume of engine shop visits. The most important of these are the number of engines in service, average time between shop visit and the annual utilisation.

The number of engines in the fleet increases steadily with fleet growth, but a high proportion of younger generation aircraft have only two engines rather than the three or four used by many older generation types. The number of engines in service will therefore not increase in proportion with the number of aircraft.

The average time between shop visits for older engines is shorter that that for compared to younger ones. Shop visit removal intervals vary between 1,000 and 10,000 engine flight hours (EFH) for the CF6-50, 6,000-9,000 EFH for various variants of the JT9D and 4,000-6,000EFH for the JT8D series.

This compares with first on-wing runs of 15,000-20,000EFH for the CFM56-7, 12,000-15,000EFH for the CFM56-5B and V.2500-A5. These reduce to 8,000-12,000EFH for mature intervals.

Mature intervals are in the range of 10,000-14,000EFH for widebody engines used on medium- and long-range average cycle times, and 5,000-7,000EFH for engines used on short-haul cycles.

Shop visit intervals of modern generation narrowbody engines are therefore generally twice those of old generation engines at maturity. The engine removal 'honeymoon', however, means that first on-wing intervals are three to four times those of mature intervals of older generation engines. This increase in shop visit intervals offsets the effect of growth in engine fleet numbers in terms of the annual number of shop visits.

These two factors then have to be considered against the annual utilisation of engines; modern aircraft are generally operated at higher rates of utilisation than older aircraft. This offsets some the effect of longer removal intervals.

In an analysis with Aerostrategy, MTU Maintenance estimated that overall aircraft utilisation will increase by about 6% over the next 10 years. "This is due to increased cost pressure on all airlines generally, and the effect that low-cost airlines in the fleet will have," explains Katia Diebold-Widmer, manager marketing at MTU Maintenance.

Modern aircraft used in short-haul operations generate 2,750-3,000 flight hours (FH) per year against the traditional 2,250-2,500FH of older aircraft. A modern twin-engined aircraft will therefore generate about 5,800EFH per year, or about 1,200EFH more than types such as the DC-9, MD-80 or 737 Classic. This higher rate of aircraft productivity partially offsets the longer on-wing intervals of modern engines.

A modern aircraft type with an average shop visit interval of 10,000EFH with therefore have an engine removal about once every 21 months. This compares to about once every 12-15 months for an old-generation twin-engined aircraft.

The next major effect on the annual shop visit volume is the delivery profile of modern generation aircraft and engines. The long interval to first removal of modern engines is as high as 17,000 engine flight cycles (EFC), equal to about 18,000-20,000EFH when aircraft are operated on average FC times of 1.25FH, but up to 35,000EFH where the aircraft are deployed on networks where average cycle times are about 2.0FH. This 'honeymoon' up to the first removal means it takes place when the aircraft is eight to 10 years old. The first 737NGs, for example, were delivered in 1997 and the first engine removals are only expected in significant quantities from 2005. The 737NG fleet is forecast to be about 1,650 aircraft by the end of 2004, with a corresponding 3,300 CFM56-7s in operation. Only 300 shop visits are expected in 2004, however, accounting for about 10% of the engines in operation. In contrast, a mature fleet like the JT8D-200 has about 2,150 units in operation and 780 shop visits (36% of the fleet) are forecast for 2004.

Another major consideration is unscheduled shop visits. Scheduled shop visits can be forecast using typical rates of aircraft utilisation and engine removal intervals, but unscheduled visits due to faster-than-expected engine deterioration or foreign object damage result in early removals.

FORECAST AIRCRAFT FLEET DEVELOPMENT

Aircraft	2003	2008	2013
Caravelle, BAC 1-11, & F.28	138	90	46
Fokker 70 & 100 & BAE 146	572	558	487
DC-9 & 737-100/-200	1,101	541	154
MD-80/-90	1,133	1,199	1,100
727-100/-200	652	554	386
707 & DC-8	396	222	117
Total old generation narrowbodies	**3,992**	**3,164**	**2,290**
A300B2/4	109	77	60
L-1011, DC-10, MD-10, KC-10 & MD-11	456	383	331
747-100/-200/-300	373	331	274
Total old generation widebodies	**938**	**791**	**665**
CRJ EMB RJs	1,754	3,009	4,043
737-300/-400/-500	1,876	1,954	1,893
717, 737NG, 757 & A320 family	4,525	6,792	9,544
Total new generation narrowbodies	**8,155**	**11,755**	**15,480**
767, A300-600 & A310	1,290	1,417	1,366
A330	273	506	762
7E7 & 777	463	709	1,149
A340, 747 & A380	831	1,160	1,551
Total new generation widebodies	**2,857**	**3,792**	**4,828**
GRAND TOTAL	**15,942**	**19,502**	**23,263**

Source: Aerostrategy

"Unscheduled events do, of course, replace some scheduled shop visits to a degree," says David Stewart, principal of AeroStrategy "and so the effect of unscheduled removals is to get a net increase in the amount of shop visits in the order of five percent over scheduled shop visits."

Other factors influencing the number of engine shop visits are airworthiness directives (ADs). ADs result in inspections which cause early removals that interrupt planned on-wing intervals and cause additional shop visits to those planned.

The older generation engine fleet is mostly affected by the aftermarket. Many types suffer the effects of fleet implosion, when a large number of aircraft in a fleet are taken out of service and their engines are released into the aftermarket. These surplus engines push down engine market values. Shop visit activity declines sharply when the low value of engines makes it more economic for airlines to buy time-continued ones than put completely used engines through a shop visit. This substitution effect is now common in the JT3D, JT8D standard series, CF6-50 and JT9D series, as well as other other older generation types operated in large numbers. The effect of fleet decline and implosion, and of engine substitution, is reflected in the forecast number of annual shop visits for these types.

Fleet development

A summary of the forecast of development of the aircraft and engine fleets over the next five and 10 years are shown *(see tables, this page and page 30)*. This forecast has been made by consultants Aerostrategy.

The global fleet of Bombardier and Embraer regional jets with 35 seats up to the A380 is considered: this totalled 15,942 aircraft at the end of 2003. This is sub-divided into four groups covering old-generation narrowbodies and widebodies and new-generation narrowbodies and widebodies.

Old-generation aircraft accounted for about 4,930 aircraft, while modern ones accounted for the remaining 11,012 in 2003 *(see table, this page)*. Narrowbodies account for the majority of aircraft.

The next 10 years will see a net fleet growth of about 46% (7,300 aircraft) with an annual compounded growth rate of 4% to a total of 23,263 aircraft *(see table, this page)*. This will be the net result of the old generation fleet declining by 40%, or nearly 2,000 aircraft and young and old generation fleet growing by 9,300 units to a total of 20,308.

"We expect to see 1960s and 1970s generation aircraft decline at a rate of 8-10% per year, leaving a small residual fleet in 10 years," says Klaus Mueller, marketing research manager at Lufthansa Technik. "We then expect 1980s aircraft, such as the A320 family, to increase by an annual rate of 2.5%, while 1990s aircraft like the 737NG, A330/340 and 777 will grow at a rate of 7% and the latest generation types like the A380, ERJ-170 and 7E7 at about 20% per year. We expect the fleet to total 23,400 aircraft in 2013. Regional jets will account for about 4,800 of these, narrowbodies 13,000 units, and the remaining 5,500 aircraft will be widebodies."

Old generation narrowbodies

There were about 3,992 old generation narrowbodies in service at the end of 2003. The DC-9, 737-100/-200 and 727 accounted for about 1,753 of these. This group will decline by about 70% over the next 10 years to about 540.

Another smaller group, the 707 and DC-8, is also forecast to go into steep decline between 2003 and 2013, as has already been witnessed during 2004. This group includes 242 707s in military service, which supply civil engine shops with the JT3D and CFM56-2. Numbers are expected to reduce by 70%.

Another small group of old generation aircraft, which includes the BAC 1-11 and F.28, has already diminished over the past 10 years, and only a residual fleet is expected to remain in 2013 *(see table, this page)*.

FORECAST ENGINE FLEET FLEET DEVELOPMENT

Engine type	2003	2008	2013
CFM56-2	464	340	212
JT3D	1,108	546	256
JT4D	12	0	0
JT8D	3,959	2,579	1,328
JT8D-200	2,169	2,261	2,051
PW narrowbody engines	**7,248**	**5,388**	**3,635**
Tay	572	550	529
Spey	82	30	12
RB183	186	144	80
RR narrowbody engines	**840**	**724**	**621**
ALF502	656	608	324
LF507	680	680	680
Lycoming narrowbody engines	**1,336**	**1,336**	**1,336**
Total narrowbody engines	**9,888**	**7,740**	**5,472**
CF6-6	171	135	78
CF6-50	1,086	882	748
GE widebody engines	**1,257**	**1,017**	**826**
JT9D-7A	348	276	168
JT9D-7Q	313	191	173
JT9D-7R4	454	408	346
PW widebody engines	**1,115**	**875**	**687**
RB211-22B	48	15	3
RB211-524B	315	275	210
RR widebody engines	**363**	**290**	**213**
Total widebody engines	**2,735**	**2,182**	**1,726**
Total old generation engines	**12,623**	**9,922**	**7,198**
CF34 series	2,028	3,844	5,374
CFM56-3	3,752	3,908	3,786
CFM56-5A	980	1,116	1,218
CFM56-5B	1,348	2,214	3,620
CFM56-5C	828	1,032	1,152
CFM56-7B	2,830	4,666	7,372
CFMI engines	**9,738**	**12,936**	**17,148**
PW2000	810	842	808
PW6000	2	40	154
PW narrowbody engines	**812**	**882**	**962**
AE3007	1,480	2,174	2,712
BR715	240	358	470
RB211-535	1,140	1,208	1,172
RR narrowbody engines	**2,860**	**3,740**	**4,354**
V.2500-A1	272	286	286
V.2500-A5/-D5	1,632	2,498	3,350
IAE engines	**1,904**	**2,784**	**3,636**
Total narrowbody engines	**16,202**	**22,978**	**30,302**
CF6-80A	256	262	206
CF6-80C2	2,833	3,165	3,419
CF6-80E	110	214	336
GE90	276	516	868
GP7000	0	144	392
GE widebody engines	**3,475**	**4,301**	**5,221**
PW4000-94	1,638	1,958	2,108
PW4000-100	206	338	550
PW4000-112	280	394	566
PW widebody engines	**2,124**	**2,690**	**3,134**
RB211-524G/H	530	538	538
Trent 500	152	508	968
Trent 700	230	346	514
Trent 800	370	488	630
Trent 900	0	148	384
RR widebody engines	**1,282**	**2,028**	**3,034**
Total widebody engines	**6,881**	**9,019**	**11,389**
Undecided engines	14	884	1,568
Total new generation engines	**24,237**	**34,089**	**44,431**
TOTAL ALL ENGINES	**36,860**	**44,011**	**51,269**

Source: Aerostrategy

Few MD-80s/-90s are expected to be retired *(see table, page 28)*, despite there being no passenger-to-freighter conversion market for the type. The MD-80/-90 is durable, and fully depreciated aircraft provide attractive economics.

This pattern of retirement will lead to a sharp reduction in the volume of JT8D Standard engines in operation, with numbers declining by the same proportions of the DC-9, 737-200 and 727 fleets. The number of JT8D-200 series powerplants will change little over this period, and will be the only old generation engine remaining in any significant numbers in 2013.

Old generation widebodies

The fleet of old generation widebodies is smaller that that of old generation narrowbodies. About 940 widebodies were in operation at the end of 2003. This fleet is dominated by tri-jets, and the DC-10, KC-10 and MD-11 form the majority of aircraft.

The L-1011 has already gone into terminal decline and the fleet is expected to be almost fully retired in 10 years. The RB211-22B fleet will also decline.

The same applies, however, to the DC-10 which has not experienced the high number of conversions to freighter configuration predicted in the 1990s. Only 54 DC-10s/MD-10s are forecast to be in operation in 2013: a small fraction of the original 400 or so aircraft built. Numbers of the military KC-10 tanker will, however, remain undiminished. The overall effect of this is to put a large number of CF6-50 series engines on the aftermarket.

The MD-11 fleet will remain unchanged, and indeed a few aircraft that were parked in 2003 are forecast to be in operation in 2013. All MD-11s are expected to be converted to freighter configuration by this time, since the type offers a strong combination of payload characteristics and operating costs. This will leave a fleet of 195 aircraft, and keep all CF6-80C2s and PW4000-94s powering these aircraft operational.

The 747-100/-200/-300 fleet, which originally numbered 897 aircraft, had already declined to 373 units at the end of 2003 *(see table, page 28)*. This decline has already led to a surplus of JT9D, CF6-50 and RB211-524 engines on the aftermarket. The surplus of CF6-50 engines from 747-200s adds to those coming from the DC-10-30 fleet, compounding the implosion of the CF6-50 fleet. The JT9D fleet has already imploded, and only the -7R4 series is expected to be operational in any substantial numbers in 10 years. The 747 Classic fleet is forecast to further decline to less than 300 units by 2013, with the majority operating as freighters.

FORECAST ENGINE SHOP VISIT ACTIVITY DEVELOPMENT

Engine type	2003	2008	2013
CFM56-2	56	16	8
JT3D	92	56	8
JT4D	4	0	0
JT8D	699	324	144
JT8D-200	754	825	721
PW narrowbody engines	**1,549**	**1,205**	**873**
Tay	223	176	188
Spey	6	4	6
RB183	36	28	4
RR narrowbody engines	**265**	**208**	**198**
ALF502	260	268	116
LF507	220	220	208
Lycoming narrowbody engines	**480**	**488**	**324**
Total narrowbody engines	**2,350**	**1,917**	**1,403**
CF6-6	42	21	21
CF6-50	288	210	167
GE widebody engines	**330**	**231**	**188**
JT9D-7A	104	60	44
JT9D-7Q	171	107	91
JT9D-7R4	188	180	132
PW widebody engines	**463**	**347**	**267**
RB211-22B	12	0	0
RB211-524B	80	65	41
RR widebody engines	**92**	**65**	**41**
Total widebody engines	**885**	**643**	**496**
Total old generation engines	**3,235**	**2,560**	**1,899**
CF34 series	140	460	998
CFM56-3	1,028	1,324	1,158
CFM56-5A	208	320	348
CFM56-5B	110	396	690
CFM56-5C	324	436	500
CFM56-7B	156	682	1,110
CFMI engines	**1,826**	**3,158**	**3,806**
PW2000	240	284	244
PW6000	0	0	18
PW narrowbody engines	**240**	**284**	**262**
AE3007	384	722	1,048
BR715	0	68	114
RB211-535	262	344	312
RR narrowbody engines	**646**	**1,134**	**1,474**
V.2500-A1	100	86	112
V.2500-A5/D5	288	684	976
IAE engines	**388**	**770**	**1,088**
Total narrowbody engines	**3,240**	**5,806**	**7,628**
CF6-80A	38	62	34
CF6-80C2	1,117	1,178	1,492
CF6-80E	20	74	154
GE90	42	136	212
GP7000	0	0	88
GE widebody engines	**1,217**	**1,450**	**1,980**
PW4000-94	439	653	655
PW4000-100	28	62	96
PW4000-112	64	58	134
PW widebody engines	**531**	**773**	**885**
RB211-524G/H	140	220	220
Trent 500	0	4	48
Trent 700	24	52	122
Trent 800	40	124	180
Trent 900	0	0	92
RR widebody engines	**204**	**400**	**662**
Total widebody engines	**1,952**	**2,623**	**3,527**
Undecided engines	0	104	244
Total new generation engines	**5,192**	**8,533**	**11,399**
TOTAL ALL ENGINES	**8,427**	**11,093**	**13,298**

Source: Aerostrategy

The decline in old generation aircraft has led to a corresponding decline in the number of old generation engines. The only type forecast to be little changed is the JT8D-200 series. This has serious implications for shops serving older types which have not yet acquired the capability for younger types.

Young & modern narrowbodies

Three groups of aircraft constitute the narrowbodies. The first of these is the 737-300/-400/-500, which are no longer in production. The current fleet is 1,876 aircraft and will rise to 1,954 *(see table, page 28)*, since a group that are in storage is expected to be reactivated. Although the oldest 737-300s will be 28 years old in 2013, the family will continue to provide viable economics for airlines, and a large number will be converted to freighters.

The second group comprises the 717, 737NG, A320 family, which are still in production, and the 757, which has just recently ceased production. This group forms the largest portion of the whole fleet, and the 737NG and A320 family are the two most important types.

The 737NG fleet numbered 1,415 aircraft at the end of 2003, and is forecast to reach 3,686 by the end of 2013, growing by an average annual delivery rate of 227 aircraft. This fleet will thus experience a proportionate increase in the number of CFM56-7s from 2,830 to 7,372 engines *(see table, page 30)*.

The A320 family had 2,015 aircraft in operation in 2013, and is forecast to climb to 4,492 units after 10 years: an annual delivery rate of 248 aircraft. This fleet will see growth in the number of CFM56-5Bs and V.2500-A5s. The V.2500-A5 fleet is expected to more than double to 3,350 engines *(see table, page 30)*. Numbers of CFM56-5As will grow by about one third to 1,218 units, but the CFM56-5B will experience the highest forecast growth with an almost three-fold increase in numbers, to about 3,620 engines. This is based on the share of orders placed so far, but this could change to favour the V.2500.

Although it is a niche aircraft, the 717 is forecast to double its fleet to about 235 aircraft, leading to a proportionate increase in BR715 engines.

Production of the 757 has recently ceased, although a few aircraft are currently in desert storage. The re-introduction of these aircraft into operation will take the fleet up to 1,025 aircraft by 2008, after which it will contract again to about 990 with a few expected retirements. The 757 has good prospects as a freighter and several hundred could be converted over the next 10 years. The fleet numbers will thus see little change in the volume of PW2000s

and RB211-535s in operation.

The third main group of young and modern narrowbodies are the regional jets. This is forecast to have the highest rate of expansion of all categories of aircraft, from about 1,750 to 4,040 aircraft (an increase in the fleet by a factor of 2.3). This group includes the Bombardier CRJ family, Embraer ERJ135/-140/-145 and Embraer ERJ-170/-175 and ERJ-190/-195 aircraft.

The CRJ-700/-900 and large Embraer jets (the ERJ-170 to -195) will experience the highest rates of growth. Fleets of both sub-groups are currently small, but the two combined could reach about 1,300 units by 2013. The Bombardier CRJ and larger Embraer regional jets are powered by variants of the CF34. The growth of these regional jets will result in a rise in the number of CF34s from about 2,000 to 5,400 engines *(see table, page 30)*. The continued forecast growth of the smaller Embraer regional jets will see the number of AE3007s rise by about 1,200.

The forecast does not include the possible addition of a new Bombardier regional jet, although this would take some projected orders from the larger Embraer aircraft and CRJ-900.

Overall, the young and new generation narrowbody fleet will nearly double from 8,155 aircraft to 15,480 units *(see table, page 28)*. The two major engine types to benefit from this are the CFM56-56B and V.2500-A5.

Young & modern widebodies

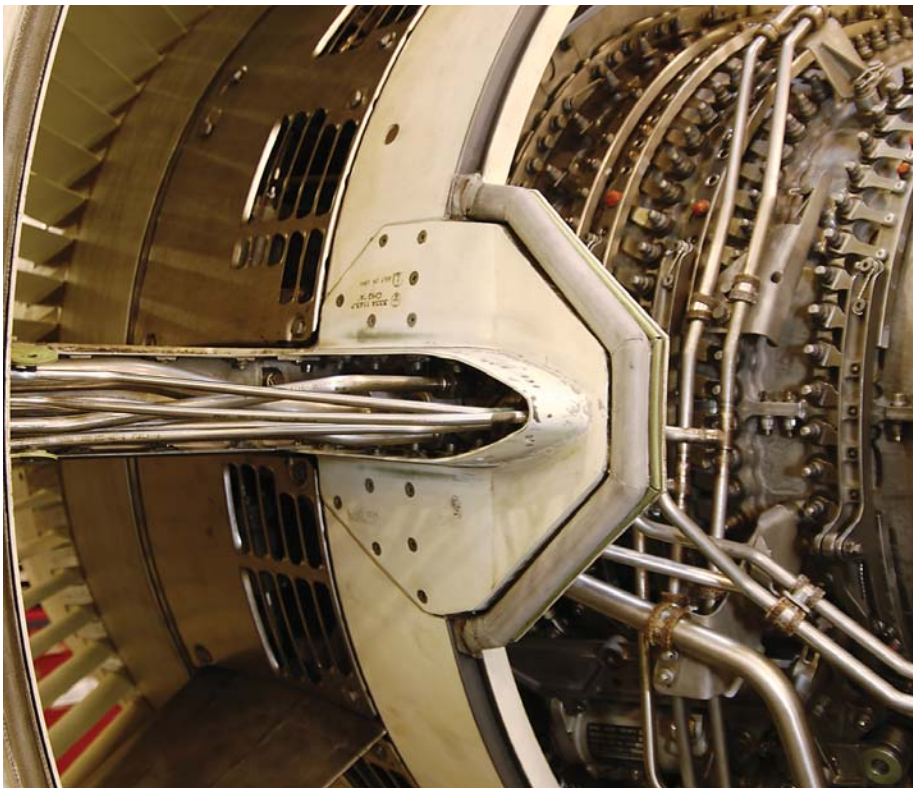
The fleet of young and modern widebodies is split into various groups of twin-engined types and three types of four-engined aircraft. The first of these groups is the 1980's 767 family and A300-600/A310 aircraft. While these aircraft are still being formally offered by Airbus and Boeing, sales have slowed and only a few more orders are expected with the arrival of the 7E7 on the market. The 767 fleet at the end of 2003 comprised 830 units, and is expected to be at a similar level in 2013. While the A300-600 is still being manufactured for freight operators and the fleet is expected to increase by about 90 units to 2013, the A310 fleet is forecast to steadily decline, since no orders for the type have been won in recent years.

Most of these aircraft are powered by the PW4000-94 and CF6-80C2, which also power the MD-11 and 747-400. The unchanged numbers of MD-11s and 747-400s means the fleets of PW4000-94s and CF6-80C2s will continue to expand.

The second group of widebodies is formed by the A330. The current fleet of 273 aircraft is forecast to grow to 762 aircraft by 2013, but this forecast does not include a possible challenge to the 7E7 from Airbus in the form of the A350. If the aircraft is launched, then growth of the A330 fleet will be smaller than forecast. The A330 is powered by the Rolls-Royce (RR) Trent 700, GE CF6-80E series and PW4000-100. Numbers of Trent 700s are forecast to more than double to 514 units *(see table, page 30)*, the PW4000-100 fleet is expected to nearly treble to 550 engines, and the CF6-80Es to treble from 110 to 336. These shares are based on current orders.

The third group of widebodies is the 777 and 7E7. The 777 first entered service in 1997 and there were already 463 aircraft in operation at the end of 2003. There are a large number of 777 orders outstanding and the aircraft is expected to continue to sell well. The fleet is forecast to grow by 523 to 986 aircraft by the end of 2013 *(see table, page 28)*. The 777 is powered by the RR Trent 800, GE90 and PW4000-112. The GE90 is forecast to get the largest share of future orders since it is the only engine powering the highest weight variants of the 777. The GE90 fleet contains 276 units and is forecast to reach 868 by 2013: an increase of 592. The Trent 800 is expected to grow by 260 engines to 630 units, and the PW4000-112 fleet to approximately double to 566 engines. These shares are based on orders to date.

The 7E7 is expected to be successful, but will not be in operation until 2008. The fleet will have reached 163 units by the end of 2013, with an average delivery rate of 25 per year. The 7E7 will be powered by the GEnx and RR Trent 1000. No engine selections had been made by any 7E7 customers when the forecast was made, so their engines are included in the group of undecided



The CFM56 & CF34 families will experience the highest rate of fleet development and will account for the first and third largest group of shop visit numbers. The CF6-80 series will account for the second largest group of shop visit numbers.

engines in the forecast. These reach 1,568 units by 2013 *(see table, page 30)*, and include the 320 engines for the 7E7 fleet in operation at that time, as well as other engine selections outstanding at the end of 2013.

The fourth group of widebodies includes the large four-engined aircraft: the 747-400, A340 family and A380. Numbers of 747-400s are expected to increase over the next 10 years. This is based on some orders for freighter models as well as a resurgent demand for passenger aircraft.

The current fleet is expected to increase by 213 aircraft to 798. The 747-400 is powered by the CF6-80C2, PW4000-94 and RR RB211-524G/H. Derivative 747 models will be larger and will use later generation engines.

Combined with the effects of the static MD-11 and A310 fleets, and enlarged A300-600 and 767 fleets, the numbers of CF6-80C2s and PW4000-94s will continue to rise. The CF6-80C2 fleet is expected to grow by about 600 units to 3,419 engines and the PW4000-94 fleet by 400 units to 2,018 engines *(see table, page 30)*. The number of RB211-524G/H engines is meanwhile not forecast to grow.

The A340 fleet comprised 245 aircraft at the end of 2003 and is expected to reach 530 by the end of 2013 *(see table, page 28)*. The A340 is split between the -200/-300 variants powered by the CFM56-5C and -500/-600 models powered by the Trent 500. Most new A340 orders are for the -500 and -600 models. The fleet of CFM56-5Cs is correspondingly expected to grow from 828 engines to 1,152, while the Trent 500 fleet will experience a higher rate of expansion, with an increase from 152 to 968 engines.

The growth of the CFM56-5C fleet means that with the other variants in the CFM56 family, it will become the most popular engine type in the fleet in 2013, with 17,150 units in operation *(see table, page 30)*.

The A380 will enter service in 2006 and deliveries will continue at an average annual rate of about 28 aircraft to reach a fleet of 223 by 2013. The A380 is powered by the Trent 900 and GP7000. This analysis assumes a virtual 50:50 split between the two engine types, each with a fleet of about 400 engines *(see table, page 30)*.

Fleet summary

The engine types with the highest rate of fleet growth are: the CF34-3/-8, powering the CRJ-200, CRJ-700/-900 and ERJ-170/-175; the CFM56-5B and V.2500-A5; powering the A320 family; the AE3007, powering the smaller Embraer regional jets; and the CF6-80E, GE90, PW4000-100, PW4000-112, Trent 500, Trent 700 and Trent 800. New types, such as the GEnx and Trent 1000, will in time become high volume engines. Types like the Trent 900 and GP7000 will be operated in relatively small numbers until about 2020.

"The fleet development over the next 10 years will be showing a steady decline of PW engines," says Mueller at Lufthansa Technik. "We think GE's share of the fleet will increase by about 4% each year, CFMI's share by about 5% per year, IAE's share will increase the fastest by 6% per year, while rather surprisingly RR's share will increase by only about 3% per year."

Engine MRO activity

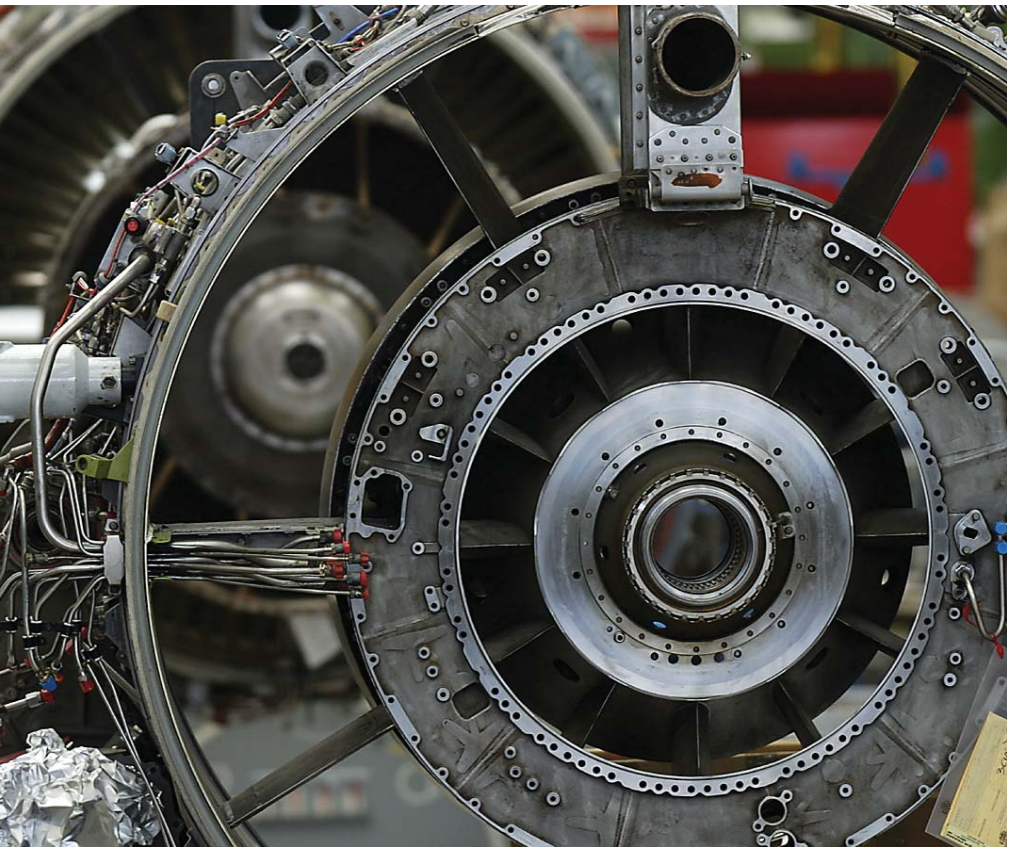
This engine fleet development gives some indication of which engines will be the major types for engine shops to concentrate. Aerostrategy has extended its engine fleet development forecast to a shop visit activity forecast for each year by engine type. This takes into consideration delivery profiles and typical rates of utilisation and removal intervals.

About one-third of the current engine MRO activity is accounted for by old generation engines *(see table, page 32)*. This is dominated by the two main JT8D series, the JT9D and to a lesser extent the CF6-50. These three families generate about 2,200 shop visits per year. This volume is not only smaller than it has been in the past, but is also small as a fraction of the fleet in service due to fleet implosion.

The young and modern generation engine fleet generated about 5,200 shop visits in 2003 *(see table, page 32)*. This volume is dominated by the CFM56 family which accounts for about 1,800 of these. The large GE engines form the next largest group, making about 1,200 shop visits. The CF6-80C2 accounts for most of these. The other 2,200 shop visits are spread between the CF34, PW2000/6000, RR narrowbody engines, V.2500, PW4000 series and large RR engines.

Original equipment manufacturers (OEMs) have entered the engine MRO market over the past 10 years and taken about a 45% share of the global activity. Rolls-Royce has always had a high degree of control of the aftermarket for its engines, and airline, and independent shops have found it hard to gain any significant volume of MRO of RR engines. RR has strengthened its position in the aftermarket, which effectively closes off the MRO market for all RR engine types to airline and independent shops. Airline and independent shops will also have difficulty in taking a share of the GE90, GP7000 and PW6000, or will be able to operate them in small numbers along with some of the old generation types left in small quantities.

The types that will be operated in any significant volume, and that airline and independent shops can hope to gain a



The large number of A320 family & 737NG deliveries in the 1990s means a bow wave of CFM56-5B, CFM56-7 & V.2500 shop visits is due. This will partially alleviate the weak engine MRO market, but many new shops have entered the market with capacity for these engines and the problem of oversupply could persist for the next 10 years.

share of, are the JT8D family, the CF34, CFM56, AE3007, V.2500, CF6-80A/C2, CF6-80E and PW4000 family. The MRO activity of 2003 generated about 5,300 shop visits for these engines. There was also MRO activity of a few minority types, such as the ALF502 and PW2000.

The forecast of MRO shop visit activity sees the rate of increase in the number of shop visits being higher than the growth in the fleet for the CF34-3B, CF34-8, CFM56-5A/5B, CFM56-7B, AE3007, V.2500, CF6-80E, GE90 PW4000-100 and PW4000-112. This is because many of the engines in the current fleet are relatively new and the market will experience a 'bow wave' of shop visits in the next few years. These engines will be removed for the first time and then have reducing intervals between subsequent visits as they mature.

This is demonstrated by comparing the % growth in the fleet each year with the % increase in the number of annual shop visits. The total number of engines is forecast to increase at a steady rate of 3-4% each year. Overall, the fleet will increase by 40% from 2003 to 2013.

This compares to more widely fluctuating annual rates of increase in the number of annual shop visits. First, the number of shop visits will increase by 58% *(see table, page 32)* between 2003 and 2013. The absolute number will rise from about 8,400 to 13,300. Second, the annual rate of increase in shop visits will vary between 0% and 14%. The number of shop visits is expected to rise by 7.5% in 2004, 13.6% in 2005, 7.9% in 2009 and 5.8% in 2011. Low rates of increase will be experienced in 2006, 2007, 2010 and 2013.

The types that will generate the largest volume of activity in the market, and that are also open to airline and independent shops, will generate about 10,800 shop visits in 2013. This includes the types already listed, but may be added to by the GE90 and a small number of shop visits coming from engines in the undecided group. The GE90 currently generates a small number of shop visits, but will have about 200 in 2013. This may therefore present a small market opportunity to some airline and independent engine shops. The total market for these major engine types available to these facilities is therefore expected to approximately double, although the OEMs will be able to control a large portion of this increase.

The most important type in the market will be the CFM56 family, which will generate about 3,800 shop visits each year. Of this group, the -3 and -7 series will each contribute about 1,100 of the total. This volume equates to about 10% of the predicted market that will be available to airline and independent shops. The -5B series will be the third largest group, generating about 700 shop visits: 7% of the predicted market in 2013.

SR Technics makes its own studies into the engine MRO market for the types it has capabilities for, and this includes these three CFM56 models. "We chose the CFM56-7B because of its popularity," explains Hans Weder, manager of business support engine service center at SR Technics. "Our forecast goes out to 2009 and we expect the number of CFM56-5Bs to increase by 20%, and its MRO volume to double over the same period. There is a time lag of four to five years for the first removal, and so the effect of the delivery profile will result in a sharp increase in shop visits over the next five years.

"We have also studied the -7B market," continues Weder "and while the population will grow by about 24% to 2009 the number of shop visits will more than double. The oldest engines are now coming close to their first shop visit, while the fleet continues to grow. The CFM56-5C fleet will now grow moderately as most A340-200/-300s have been delivered. There are still some new engines to be delivered or have their first removals, but the increase in MRO activity will be moderate."

The second largest number of shop visits will come from the CF6-80 series, generating about 1,700 shop visits.

The V.2500 will be the third largest, with about 1,100 shop visits. This will be followed closely by the AE3007, and then the CF34 with almost 1,000 shop visits *(see table, page 32)*. The PW4000 family will also generate about 1,000 shop visits each year, with the -94 series accounting for about two thirds of these. While the A330 fleet will have grown to a fleet of more than 700 aircraft by this time, the PW4000-100 will be generating less than 150 shop visits each year.

The remaining JT8D standard fleet and JT8D-200 series engines will be producing about 900 shop visits a year by 2013. Additional shop visits, totalling 200-400 may also be available from the GE90 and CF6-50 fleets.

Engine MRO market

While this growth will be welcome in the market, the initial period of 2004 to 2006 is important to engine shops, because the market has been depressed since 2001 and volumes need to increase again for market rates to improve.

"The problem in recent years has been the large number of old generation engines that have retired at the same time when that the gap to first removal for the CFM56-5B/-7B and V.2500 engines has caused a slump in the engine MRO market," explains Wolfgang Weynell,

director sales and commercial services, Lufthansa Technik Engine Service. "While we now expect to see an increase and then expansion of the engine MRO market as new engines start being removed for the first time and have mature removal intervals, the actual $ volume will increase at an even higher rate. This is because modern engines have higher average shop visit costs than older generation engines. The CFM56-3, for example, has shop visit costs in the region of $1.3-1.5 million, compared to $0.5-0.8 million for a JT8D. There has been a strong increase in the cost of engine material, with prices having risen by 22% in just the past four years. The annual volume of shop visits should be about 13,000 in 2013; about 25% of the number in service. Without considering inflation, the effect of more shop visits and the higher cost of modern engines, means that the engine MRO market should grow from $13 billion a year now to $24 billion a year in 2013."

Market share

The OEMs rapidly increased their share of the market in the 1990s. By 2003 this had increased to 45-50%, mainly by the acquisition of independent shops. As a consequence independent shops' share dropped to just 5-10% in 2003. The remaining 40-45% of the market is held by airline shops. "There is still some consolidation in the market," says Weynell "With some independents closing, some airline shops are also deciding to sub-contract their engine MRO while others are going into the third party business."

Aerostrategy's estimate for 2003 is that OEMs had 43% of the market, airlines' performing shop visits on their own engines accounted for 30% of the market, airlines operation on third party work was 14% of the market, and independent shops performed the remaining 13% of the market, while 10% is unknown. MTU estimates the current OEM share to stand as high as 48%. "We think the OEM's share could increase over the next 10 years to about 60%. This is because there is an increasing trend towards long-term service agreements between airlines and OEMs as part of purchase and order agreements for new engines," says Diebold-Widmer.

"The overall issue is how the growth in the market will affect demand versus capacity, and consequently the rates," says Weynell. "Although volumes are forecast to increase over the next few years, we still expect the market to have overcapacity until about 2008. This is despite the bow wave of engines coming into the shop for the first time over the third period and lifting volumes because there is still a lot of price pressure and overcapacity in the market. Many airlines have also built up a lot of capacity for the new engine types they have introduced in recent years, but this has not actually been required because most engines have not yet been removed."

Diebold-Widmer explains that the problem has been compounded by the fact that the first wave of CFM56-7 removals has been delayed by one or two years, and that the expected first batch of shop visits has not materialised, and this has delayed the compensation of the slump following 11th September. "We have performed our own supply versus demand analysis for the engine types we have capability for, and it shows that overcapacity ranges between 30% and 200%, depending on engine type," says Diebold-Widmer. "The types most affected by overcapacity are the CFM56 and older generation engines whose numbers are decreasing fast. Although the CFM56-7 is the most popular engine type, there is a serious problem with overcapacity because a lot of new players keep entering an already saturated market. There is also overcapacity for the CFM56-3. Even though the situation will improve in 5-6 years, there will still be a degree of oversupply for both engines." AC