737-300/-400/-500 maintenance analysis

The 737-300/-400/-500 have competitive maintenance costs for aircraft in their size class. Careful management of maintenance costs will ensure the aircraft remain economic.

The 737-300/-400/-500 was developed with a maintenance steering group 2 (MSG2) maintenance programme. Some airlines have bridged the aircraft on to an MSG3 maintenance programme. The 737's maintenance requirements include line maintenance, base airframe checks, heavy component repair and overhaul, line replaceable unit (LRU) rotable components, engine maintenance and spare engine support.

This analysis considers the 737-300/-400/-500's maintenance requirements and overall maintenance cost budget for aircraft operated at an average flight cycle (FC) time of 1.25 flight hours (FH) and a typical utilisation of 2,500FH and 2,000FC per year.

Maintenance programme

The 737-300/-400/-500's line maintenance programme is standard with all other aircraft types. It has a pre-flight check performed before the first flight of each day, a transit check prior to all subsequent flights during the day and a daily check performed every 24 hours. Most 737s are operated on short-haul operations during the day and so daily checks are performed overnight in most cases.

The 737-300/-400/-500 has a basic A check interval of 250FH, and four A check multiples of 1A, 2A, 4A and 8A items. These can be grouped into block checks or equalised.

When grouped into block checks the A8 check is the heaviest and completes the cycle at an interval of 2,000FH. The A1, A3, A5 and A7 checks have just the 1A tasks, while the A2 and A6 checks have the 1A and 2A tasks. The A4 check has the 1A, 2A and 4A tasks, while the A8 has all four multiples.

Air New Zealand Engineering Services (ANZES) has a system under which it performs its A checks as equalised checks, which are further split to allow checks to be fitted into overnight maintenance slots.

The 737-300/-400/-500's maintenance planning document also has a similar block check system for C check tasks. The basic C check interval is 4,000FH, and so two A check cycles are completed every C check interval.

The C check items are packaged into the 1C, 2C, 4C, 6C and 8C items, as well as the structural inspection (SI) tasks. "There are two ways these tasks can be grouped into a system of checks," explains Li Qiang, manager of engineering subdivision at Ameco Beijing. "There can be a system of eight checks in the C check cycle, with the 6C and SI tasks being performed in the C6 check, and the 8C items in the C8 check. This makes two heavy checks. The 1C, 2C and 4C tasks are performed at their appropriate intervals, so that the C1, C3, C5 and C7 checks have the 1C tasks, the C2 check has the 1C and 2C items, and the C4 has the 1C, 2C and 4C tasks. This way the 6C and SI items get out of phase with all the other tasks, since the 6C and SI items will be performed again at the twelfth C check, or the fourth C check in the next C check cycle.

"The other system that can be followed is that 7C and 8C tasks are brought forward to the C6 check and the cycle is completed at this check," continues Qiang. "This sixth check would have all the heavy tasks and is termed the 'D' check."

ANZES operates the system of completing the C check cycle with the heaviest check at the C6 check. "Our C check has a basic interval of 4,500FH, 4,000FC and 15 months, whichever is reached first," explains Viv de Beus, customer support manager for ANZES. "Considering that most aircraft achieve about 2,500FH per year, about 3,000FH are accumulated in the 15-month interval. This means the full C check cycle is completed about once every 85-90 months (about seven years) and every 18,000-19,000FH, rather than the maximum interval of 27,000FH that is allowed by the basic C check's FH interval. We operate a block check system, so the checks vary in size, with the C4 and C6/D checks being the largest. The C1, C3 and C5 checks just have the 1C items and so are the smallest."

Some operators have modified their maintenance programmes, and even bridged to an MSG3 system. KLM operates 14 737-300s and 13 -400s. "We changed our fleet to an MSG3 in 2004," says Ton de Geest, project engineer maintenance programs at KLM Engineering & Maintenance. "We did

The 737-300/-400/-500's line maintenance programme results in labour and material costs in the region of $290-355 per FH, not including supply of LRUs.

While most operators have retained an MSG2 maintenance programme for the 737, KLM has recently bridged its fleet to an MSG3 programme. This effectively rearranges tasks and the total number in the programme has overall been reduced. The system is expected to make the work content of base checks more predictable, and result in less man-hours consumed.

this in conjunction with a Boeing working group. The main difference to an MSG2 programme is that an MSG3 system allows the operator to group each task into checks that suit its operation. This means tasks with escalated intervals can keep their escalations, while others can be re-grouped into new checks. We have pre-flight, transit and overnight checks in our line maintenance programme like all other operators, as well as out-of-phase tasks that are either added to overnight checks or performed separately. We have an A check interval of 550FH, and basic C check interval of 4,000FH, 4,000FC and 18 months."

"The new MSG3 programme has effectively re-arranged tasks, deleted some and added others. The MSG2 programme had separate structural items and corrosion prevention and control programme (CPCP) items, as well as others," explains de Geest. "These have been re-arranged and an enhanced zonal programme has been added to the MSG3 system. The number of tasks overall has been reduced. In the meantime we have transferred the fleet to a new schedule in the MSG2 system where we have a base check cycle of six C checks. We had a problem in that some structural tasks had different initial and repeat intervals, which got more frequent as the aircraft got older. This meant checks were gradually getting heavier and less predictable in terms of content. The new system has all structural items concentrated in the 3C and 6C checks, and the 1C, 2C, 4C and 5C checks are light. These four are all similar in content, while all the structural tasks have the same intervals. The system means that every third check is a heavy check, with an interval of 54 months (four and a half years). This system should result in less overall MH per heavy-check cycle than the previous block-check system which was more complicated. This is because repetition of access required during lighter checks is avoided, and is only required during heavy checks. The 3C group of tasks, however, actually has some CPCP items that have an interval of 48 months. We therefore adjusted the C3 interval to 48 months, and the C6 interval to 96 months (eight years)."

The 737-300/-400/-500 fleet was built between 1984 and 1999, and so aircraft are now between six and 21 years old. The base check interval of about seven years means that most aircraft will not have had more than two D checks and will be in either their first or second base check cycle.

Line maintenance

On the basis of an aircraft operating for 350 days per year and completing about 2,000FC, about 350 pre-flight and 350 daily checks will be performed each year. A further 1,650 transit checks will be completed annually, and if weekly checks are included in the maintenance schedule then about 50 will be performed each year.

The number of MH used and consumption of materials and consumables for all of these checks can be totalled and compared to annual utilisation to provide a cost per FH for ramp checks.

MH and material consumption for A checks can also be analysed on the same basis. The length of the A check cycle in terms of calendar time will depend on the A check interval and number in the cycle.

As an example, ANZES has a phased A check interval of 250FH. Because of a daily utilisation of about 7FC, the actual interval it achieves between A checks is likely to be about 125FC. On this basis the number of ramp and line checks performed in the complete A check cycle is similar to the number completed in a year.

Estimations of MH used during ramp checks vary widely between operators. This is due to variations in how line mechanics' hours are recorded, how extensively the aircraft are cleaned and how defects are addressed. The MH used to have the most influence on the total number of MH consumed in the complete A check cycle. "Pre-flight and transit checks consume a similar number of MH, which total about 2.0," says de Beus. "This is enough for 1.0MH for routine items and another 1.0MH to cover defaults arising during operation. Also included in these MH are general servicing requirements. The cost of materials and consumables covers items such as oil and water." An amount which can be used for budgeting purposes is about $15 per check.

"A daily check requires 2.0-3.0MH for engineering items, and again general servicing requirements. This is the evaluation of dealing with technical log items. Cleaning and cabin work will add MH, although this can be done by a third party," continues de Beus.

Michael Keller, manager of production of engineering and planning at Ameco Beijing estimates that a daily check can consume up to an average of 13.5MH. Again, the cost for materials and consumables will be relatively light. Operators can use $50 per check as a budget for material and consumable consumption for daily checks.

Keller says that material and consumable cost overall for pre-flight, transit and daily checks can total about $7 per FH.

Some operators include weekly checks in their line maintenance schedules to complete out-of-phase tasks. These tasks can also be added to the content of daily checks.

Over the course of a year, a 737-300/-400/-500 will consume 8,000-10,000MH for the 2,300-2,400 ramp checks completed. This will be equal to a consumption of 3.2-4.0MH per FH. With labour for line maintenance charged at an industry standard of $70 per MH, this is equal to a cost of $220-275 per FH. Consumption of materials and consumables adds $7-20 per FH, taking total cost to $230-295 per FH *(see table, page 22)*.

A checks vary in size and so does the use of MH and materials. "The block check system we operate has MH consumptions of about 85MH for A1, A3, A5 and A7 checks," says Keller. "The larger A2 and A6 checks use about 125MH, the A4 check consumes about 235MH and the largest A8 uses about 325MH."

Ameco's schedule of an A check cycle of eight checks has an interval of 2,000FH, although the actual interval achieved is likely to be close to 1,600FH considering the utilisation of the A check interval achieved by most operators. MH consumption for all eight checks totals about 1,150. This is equal to about 0.7MH per FH. A labour rate of $70 per MH takes labour cost per FH to $50. Keller estimates the average material and consumable cost for A checks at about $1,500, totalling $12,000 for the cycle and equal to another $8 per FH. This takes total cost per FH for cost of A checks to about $60 per FH *(see table, page 22)*.

de Beus explains that under ANZES's 1/2 A check system, each half uses an average of about 40MH and about $200-500 in materials and consumables.

Although line replaceable units (LRUs) are exchanged during line maintenance, the capital cost of these parts and additional charges for repairs and management are accounted for as a separate item.

Base maintenance checks

As described, there are several ways a base maintenance programme can be organised. ANZES follows the system of block checks, with the cycle being completed at the C6 check. "The total number of MH used in each check in the series depends on how the programme is structured, as well as the content," explains de Beus. "Besides routine inspections and non-routine tasks that arise as a consequence, several other items have to be added. These are airworthiness directives (ADs), service bulletins (SBs), modifications and engineering orders (EOs), component changes such as landing gear or thrust reversers, non-routine repairs to components, interior work, and the supplemental structural inspection document (SSID) and CPCP. The heavier checks towards the end of the cycle will have a higher level of interior work for refurbishment of panels, lavatories and galleys. They will also include stripping and painting."

ANZES manages Air New Zealand's fleet of 12 737-300, as well as Freedomair's four aircraft, and Jetconnect's domestic fleet of nine aircraft in New Zealand. "These are aircraft built between the late 1980s and 1999, many of which are still in or have completed their first C check cycle, but have not got to their second D check," says de Beus.

Based on a review of several maintenance providers, the industry average for C1, C3 and C5 checks is about 5,000MH for the whole content. Only about 1,200-1,500MH of this is used for the MPD element and interior work. The remainder is used for ADs, SBs, modifications, EOs and component changes and all non-routine maintenance. The check uses about $125,000 for materials, consumables and some component repair activity.

A C2 check is slightly heavier and uses about 6,500MH when all items are considered and in the region of $150,000 or materials, consumables and some component repair activity. The C4 check is one of the heavier checks experienced by operators, and consumes an average of 8,000MH when all items are considered, plus about $200,000 in materials, consumables and component repairs.

Depending on the operator, the C6/C7 or D check is the largest check, and can include some significant modification packages. A lot of SBs and ADs are often completed in these checks so that the aircraft is clear until the next C check. Average consumption for a first D check is about 13,000MH plus another 1,500MH for stripping and re-painting. The cost of materials, consumables and some component repairs can vary widely, since the degree to which interior parts and items in the interior are either refurbished or replaced also varies widely. The cost of component repairs is also highest in this check, since items such as flap tracks are repaired during these checks. A typical range is $300,000-800,000, with an average of $550,000. These checks are also often required for aircraft at the end of a lease agreement, when bridging maintenance and changes to avionics and components are required.

Total MH consumption for base checks over the first C check cycle is about 45,000. Charged at an industry average labour rate of $50 per MH, total labour cost is $2.3 million. Total cost of materials, consumables and component repairs is about $1.3 million. This total cost for labour and materials amortised over the interval of 18,600-20,000FH works out at an average of 2.4MH per FH, and total cost for base maintenance

The base checks in an MSG2 programme consume in the region of 50,000 man-hours for the second base check cycle. This, and material costs, result in an overall cost in the region of $210 per FH.

checks is $180-195 per FH *(see table, page 22)*.

Ameco Beijing's C check programme is similar to that of ANZES. "A total of about 15,000MH are consumed for the first D check, which includes labour for MPD tasks, engineering orders and modifications and component repairs," says Torsten Kurznack, manager subdivision of aircraft overhaul at Ameco Beijing. "Material consumption for the check is about $300,000 which is for materials and consumables, but does not include the cost of component repairs. The MH consumed for the second D check will rise over the first, mainly because of an increase in the non-routine ratio. About 8,000MH will be required for routine and CPCP tasks, about another 5,000MH for non-routine tasks, about 4,000 for EOs and modifications, 2,300MH for component repairs and another 1,600MH for stripping and re-painting. This would be a total of about 21,000MH. Total material cost for these heavier checks has averaged about $550,000."

Total MH for the second base check cycle is about 52,000, depending on the non-routine ratio. This increase, plus a rise of total material costs to about $1.6 million over the cycle will take total charge for the base maintenance cycle to about $3.9 million. This will be equal to about $210 per FH.

Heavy components

Heavy components fall into four categories: landing gear, thrust reverser, wheels and brakes, and auxiliary power unit (APU). These four component types have independent maintenance schedules. Apart from the landing gear, all are maintained on an on-condition basis.

Most operators now opt for exchange programmes for landing gears, which will have to be used for small airlines acquiring used aircraft. Maintenance intervals are 8-10 years and up to 32,000FC, and exchange programmes are a single cost to cover exchange fee and overhaul cost. "Exchange costs vary widely depending upon availability, but they normally include a fixed cost of overhaul, " explains Steve Hodgkiss, managing director of FlyerTech. "An overhaul fee of $150,000 is reasonable depending on condition of the landing gear. Exchange fee will be about $40,000."

A total cost of $190,000 incurred every eight years will be equal to a cost of $10 per FH *(see table, page 22)*.

Costs for wheels and brakes are related to FC intervals. Wheels require tyre remoulds and replacement, as well as wheel rim inspections. Tyre removal and re-tread intervals will be affected by landing weight, which will vary by aircraft variant. Average intervals of 250FC for main wheels and 200FC for nose wheels can be expected, and tyres are remoulded an average of three times before being replaced at the fourth removal. This would make the total life cycle of main and nose tyres 1,000FC and 1,200FC

Re-tread of main wheel tyres has an average cost of $400, while nose tyres will be about $350. New main and nose tyres cost about $1,400 and $800. Total cost for remould and replacement for a complete shipset of four main wheel tyres would be about $10,400, and about $3,700 for a shipset of two nose wheel tyres. Amortised over the replacement interval, this results in a rate of $13 per FC *(see table, page 22)*.

Wheel inspections are made at tyre removal and have an average cost of $650 for main wheels and $600 for nose wheels. This results in a cost of $12 per FC *(see table, page 22)*.

Brake repairs are made on average every three wheel removals, and so about every 900FC. The average cost for a brake repair is about $11,000, and the cost per FC for all four main wheel brake units is $49 *(see table, page 22)*.

Thrust reversers for mature aircraft have an average removal interval of about 8,000FC. A cost of $190,000 for an average shop visit can be used for a thrust reverser shipset. The total cost for both reverser shipsets amortised over the removal interval is about $48 per FC *(see table, page 22)*.

The 737-300/-400/-500 uses the GTCP 85-129 auxiliary power unit (APU). Many operators will use the APU while taxiing to the gate before connecting to a ground power unit, and then use the APU again during engine start. The APU thus gets used twice in each FC for an average of 45 minutes, and will therefore accumulate about 1,500 hours per year. The average time between shop visits is about 3,500 APU hours, equal to more than two years of aircraft operation. An average shop visit cost of $150,000 is equal to $32 per FC *(see table, page 22)*.

Line replaceable components

The 737-300/-400/-500 is now widespread in the global fleet, and there is a plentiful supply of rotable LRUs on the used market. Prospective operators of 737-300/-400/-500s have several choices for sourcing LRUs. Many maintenance providers offer LRUs, as do specialist component providers.

The standard practice would be for an operator to be supplied with a home-base stock and given access to a component pool for the remainder of the items once it had established the confidence level it required in its operation, what the failure rates of the components are likely to be, as well as the structure of its operation.

Ralf Aljes, manager subdivision component services at Ameco Beijing says a small operator can be supplied with an LRU contract at a rate of $110-120/FH to cover the cost of repair and management of the parts, and a further $40-50/FH for access or lease costs of the material. "Total cost is $180-220 per FH for the airline if it joins the access pool *(see table, page 22)*. This cost includes the repair and management of parts and access to all LRUs. This compares to a probable cost of $300/FH if an airline were to lease its own stock and manage the repair by itself," says Aljes.

Every rotable supply contract is different, and Hodgkiss says it is possible to get a contract for about $110 per FH. "This would be the rate for the supply and repair of all LRUs, without including wheels and brakes, interior parts and large insurance items. It does not include the cost of shipping all items sent for repair. The $110 per FH rate includes the supply of a minimal home-base stock worth about $500,000 for one or two aircraft," says Hodgkiss. "Another $50 per FH could be added to cover all miscellaneous and unknown items, such as cabin items, oil and unscheduled problems and accidents."

Engine maintenance

There are three variants of the CFM56-3: the -3B1, -3B2 and -3C1. The -3B1 is rated at 18,500lbs and 20,000lbs, and powers the 737-300 and -500. The -3B2 can be rated at 22,000lbs and powers all three family members. The -3C1 is the most numerous and can be rated at 23,500lbs and all lower thrust ratings for all three 737 variants.

The lower-rated engines have installed exhaust gas temperature (EGT) margins in the region of 135-140 degrees centigrade, while those rated at 20,000lbs have margins of about 110 degrees, those rated at 22,000lbs rated at 70 degrees and the highest powered models have margins of about 50 degrees.

These margins and the rate of EGT margin erosion generally allow long removal intervals between shop visits. Most CFM56-3s built have been through their first shop visit and are on their second or subsequent on-wing runs. The lowest maintenance cost per engine flight hour (EFH) contributes to lower overall aircraft maintenance costs. Low rates per EFH are achieved by optimising removal intervals, shop visit workscopes and LLP replacement timing. LLPs can generally be divided into three groups: in the high pressure (HP) section, the low pressure turbine (LPT); and fan and booster section. Most HP system LLPs have lives of about 20,000EFC, although a few are restricted at 15,000-17,000EFC. The list price for LLPs in this section is about $650,000. LPT LLPs have lives of 25,000EFC, and have a list price of about $410,000. Fan/booster LLPs have lives of 30,000EFC and list price of $263,000.

The high EGT margins of the lowest rated engines allow on-wing intervals to average about 18,500 engine flight cycles (EFC). This compares to an annual rate of utilisation of about 2,000EFC, and so is equal to about nine years of operation. HP and LPT LLPs should be replaced at this stage, since the restored EGT margin after the shop visit will allow a second removal interval of 11,000-12,000EFC. Besides HP LLP replacement, the engine should require a performance restoration on the core engine and a workscope on the LPT. This will have an approximate cost of $1.1 million, not including LLPs.

The second run of about 11,000EFC will be followed by another core engine performance restoration and workscope on the fan and booster section, as well as replacement of fan and booster LLPs. This will incur a cost in the region of $950,000, not including LLP replacement. The third removal interval will be 500-1,000EFC less than the second and will be followed by a shop visit workscope similar to the first at which HP and LPT LLPs would be replaced. This would have a cost of about $1 million, not including LLPs. By this stage the engine will have accumulated about 40,000EFC on-wing, equal to about 20 years of operation. Maintenance reserves, including LLP amortisation, up to the first removal will be in the region of $90 per EFH. This will increase to $110-115 per EFH for the

DIRECT MAINTENANCE COSTS FOR 737-300/-400/-500

Maintenance Item	Cycle cost $	Cycle interval	Cost per FC-$	Cost per FH-$
Ramp checks	$600,000-700,000	1 year		230-295
A check	$60,000-90,000	1,300-1,600FH		60
C & D checks	$3,600,000	18,500-20,000FH		180-195
Heavy components:				
Landing gear	$190,000	16,000FC	13	10
Tyre remould & replacement	$12,000	800FC/1,400FC	13	10
Wheel inspections	$3,800	200FC/250FC	12	10
Brake inspections	$44,000	900	49	39
Thrust reverser overhauls	$340,000	8,000	48	38
APU	$150,000	4,700	32	26
Total heavy components			167	133
LRU component support				180-220
Total airframe & component maintenance				**$785-910/FH**
Engine maintenance:				
High rated (mature)				$180/EFH X 2
Mid rated (mature)				$135-150/EFH X 2
Low rated (mature)				$130-145/EFH X 2
Total direct maintenance costs:				
Aircraft with high rated engines				**$1,145-1,270/FH**
Aircraft with medium rated engines				**$1,055-1,210/FH**
Aircraft with low rated engines				**$1,045-1,200/FH**

Annual utilisation:
2,500FH
2,000FC
FH:FC ratio of 1.25FH:1.0FC

second removal intervals *(see table, this page)* and increases again to about $130 per EFH for the period up to the third removal. Subsequent intervals are expected to be in the region of 9,000-11,000EFC, given the high EGT margin, and $130-145 per EFH should be allowed for maintenance reserves.

Mid-rated engines have planned first-run removal intervals of about 11,000EFC, and can be expected to have a subsequent on-wing time of 9,000EFC. It is therefore not necessary to replace any LLPs at the first shop visit. The first shop visit workscope is usually a core performance restoration, since the LPT and fan/booster sections can remain on-wing until the second removal. The cost of this first workscope will be in the region of $900,000.

The second removal interval of 9,000EFC takes total time to about 20,000EFC, equal to about 10 years of operation, at which point HP and LPT LLPs should be replaced. The shop visit workscope at this stage is a core refurbishment and LPT workscope. The cost for this shop visit, not including LLPs, is about $1 million. The third and subsequent on-wing intervals will be in the region of 8,500EFC.

Maintenance reserves, including LLP amortisation, are in the region of $105 per EFH up to the first removal, $125 per EFH up to the second removal, and $135 per EFH up to the third removal and a similar rate thereafter *(see table, this page)*.

The highest-rated engines naturally have the shortest on-wing removal intervals, which are about 8,500EFC for the first interval. At this point the engine has a core engine performance restoration workscope, but no LLPs are replaced since the engine is capable of a second removal interval of about 6,500EFC. The first shop visit workscope is a core performance restoration, which will cost about $900,000 not including LLPs.

The second removal interval will be about 6,500EFC and the engine will have a heavy core workscope, since accumulated time on-wing will not necessitate work on the fan/booster or LPT sections. Total accumulated time at this stage will be about 15,000EFC, and so HP LLPs should be replaced, although fan/booster and LPT LLPs can remain for the third on-wing run. The second shop visit will cost about $950,000, not including LLPs.

Mature intervals to subsequent shop visits will be 6,000-6,500EFC. Total time to the third shop visit will be about 21,500EFC and the engine will require a full workscope on the core engine and LPT section, as well as LPT LLP replacement. The cost of this workscope will be in the region of $1.1 million, not including LLPs. Maintenance reserves to the first shop visit will be about $135 per EFH, climbing to about $180 per EFH at maturity *(see table, this page)*.

Maintenance cost summary

The total direct maintenance costs for the 737-300/-400/-500 vary between $1,050 and $1,270 per FH *(see table, this page)*. The actual cost per FH is influenced by all elements of maintenance cost, but ramp and line checks, repair of heavy components, LRU rotable component support and engine maintenance vary widely. Despite their magnitude and attention they attract, the costs of base airframe checks are relatively predictable.

The eventual cost per FH for ramp checks will be affected by efficiency of labour, but also how labour for line maintenance is recorded and allocated, as well as an airline's maintenance practices.

This goes partly in-hand with the cost of LRU rotable support, which is also highly variable. The ultimate cost per FH for this element can vary by more than $100 per FH. Engine maintenance costs will be most affected by thrust rating, and consequently by aircraft variant and gross weight.

The 737-300/-400/-500 are still popular, and many are operated by original users, although more aircraft are now being acquired by secondary users and are becoming mature. The last manufactured aircraft is now six years old, and most engines are mature, having been through their first and second shop visits. Tight control of all these elements can keep maintenance costs stable.

Spare engine support

Operators also have to consider the costs of spare engine provisioning. Removal intervals for mature engines are in the 7,500-12,000EFH range, depending on thrust rating and style of operation. This is equal to three to five years of operation in most airlines' cases, but will be 30-55 months once unscheduled removals are taken into account. Typical shop turn times of three to four months mean that one spare engine will support 10-15 installed engines, or a fleet of five to seven aircraft.

This is a small fleet, and airlines with at least this number of aircraft would find it economic to own a spare engine that had full utilisation in covering for removed units going through shop visits. Demand for the 737-300/-400/-500 has increased over the past year to 18 months, following a surplus. A number of aircraft were repossessed from United Airlines and USAirways. Some were broken for parts and engines, which temporarily brought down values of aircraft and the CFM56-3s. "The last peak in CFM56-3 values was in 1998, and they then reached a trough in 2000-2002," says Tom MacAleavey, senior vice president of sales and marketing at Willis Lease Finance Corporation. "CFM56-3 values have gone up by 20-25% and there is now a shortage of them. The engine is also no longer built and this has exacerbated the problem. Values mainly depend on the maintenance status. It can cost nearly $3 million to put an engine through a heavy shop visit and replace a complete set of LLPs. Core values of completely run-out engines are $600,000-700,000. Values of -3C1s fresh from an overhaul that have LLPs with at least 10,000EFC remaining have a value of $3.5-4.0 million. Values of -3B2s are slightly less at about $3.2 million."

Andrew Pearce, director at Macquarie Aviation Capital puts values for -3C1s and -3B2s in a good maintenance condition at a similar level. "A -3B2 fresh from a shop visit and with fairly good LLP status has a market value of $3.2-3.45 million. A -3C1 in the same condition has a value of about $4.0 million."

These values have to be considered in relation to long-term lease rates that airlines would alternatively have to pay if they did not own spare engines. Maintenance reserves would also have to be paid with lease rentals. "More airlines are now taking engines on long-term leases," says MacAleavey. "Long-term lease rentals have now risen to $40,000-44,000 per month for -3C1s, and are slightly lower for -3B2s."

Pearce confirms that lease rates have firmed up to this level over the past 12 months. "Maintenance reserves also have to be paid, and these are about $120 per EFH and $70-80 per EFC," says Pearce. This equates to a total reserve of $184 per EFH for an engine operated at an average EFC time of 1.25EFH.

MacAleavey puts reserves at $115 per EFH and $71 per EFC for -3C1s, $84 per EFH and $62 per EFC for -3B2s, and $98 per EFH and $62 per EFC for -3B1s.

Most airlines also have to consider short-term leases for coverage in the event of unscheduled failures and engine removals, and emergency requirements. "Short-term lease rentals are in the range of $1,800-2,000 per day, plus maintenance reserves, although they do drop by about $400 per day in off-peak seasons when airlines are not so busy, " comments Pearce.

Technical support

Besides direct maintenance costs, airlines have to consider having the infrastructure in place for the technical management of their aircraft. "This will be expensive for small and start-up operators to consider," says Hodgkiss at Flyertech. "We specialise in providing this technical management and can source maintenance providers, set a maintenance control department, and manage the whole range of technical management aspects for airlines. This includes managing the aircraft's maintenance programme, determining maintenance task workscopes, deciding which ADs and SBs to perform, monitoring reliability data, keeping maintenance records, and a whole range of other tasks. The cost for providing all of these services for a small fleet will be in the region of $2,500-3,500 per aircraft month, and will reduce with fleet growth." AC