A300B2/B4 maintenance analysis

The A300B2/B4 has high maintenance costs when operated on short cycles and at low rates of utilisation. The element with the highest cost is engine reserves. Costs need to be managed.

With only 40% of the original aircraft built still in operation, the A300B2/B4 now fills a niche role. One-third of the 98 aircraft still in operation are used in the passenger role. Many of these aircraft are operated by Turkish charter carriers, and only a few are flown by major passenger airlines. Two-thirds of the aircraft still flying are used by a core of freight carriers, who are exploiting the A300B4F's low capital cost on high-density, short-distance routes.

A300B2/B4 in operation

The A300B2/B4 fleet falls into two sub-fleets, the most important of which is the freighter fleet. Most A300B4Fs are utilised for express package operations. The majority of freighters, more than 50 units, are operated by the DHL subsidiary European Air Transport, Astar Air cargo, Air Contractors, Aerounion, Channel Express, Express.net, TNT and Tradewinds for this purpose. Most of these carriers use the aircraft on sectors that average 75-90 minutes' flying time so the aircraft only accumulate 950-1,200 flight hours (FH) and 750-900 flight cycles (FC) per year.

This low rate of utilisation has the effect of raising maintenance costs per FH. Virtually all elements of maintenance are affected by short average FC times and low utilisation, but reserve rates for engines are particularly high. Heavy components with FC-related removals, line checks and rotables all have high costs per FH as a result of short cycle times and low rates of utilisation. The aircraft requires careful management, especially with respect to engines, in such operations.

The few freight carriers that have longer average FC times and higher rates of utilisation will benefit from reduced maintenance costs per FH.

The 32 passenger aircraft in operation are predominantly owned by Turkish charter carriers, including Fly Air, MNG Airlines, Onur Air and Saga Airlines.

Most passenger aircraft accumulate in the region of 2,000-2,500FH per year. Most aircraft operate average FC times of 75-120 minutes, and so accumulate 1,000-1,600FC per year. Some aircraft operating with charter carriers, however, fly longer FC times of 2-3FH.

These higher rates of utilisation result in lower maintenance costs per FH than the freighter aircraft.

Maintenance programme

There are two maintenance programmes for the A300B2/B4. The first of these is the standard maintenance programme that was originally used for aircraft prior to conversion to freighter. This is similar to maintenance programmes used for all other Airbus aircraft types.

The second maintenance programme for the A300B2/B4 is a system for aircraft operating with low annual utilisations. This was developed by Airbus for aircraft operating as freighters and achieving utilisations of 2,000FH or less each year.

"The standard maintenance programme, or maintenance planning document (MPD) programme, for the A300B2/B4 is based on 1C tasks with an interval of 18 months and multiple 2C, 4C and 8C tasks with respective multiple intervals that result in a system of block checks," says Eric Price, executive vice president and chief operating officer at Aeroframe Services. "This results in a cycle of C1, C2, C3, C4/IL, C5, C6, C7 and C8/D checks. Similar systems are used by all other Airbus aircraft. The basic 18-month interval results in a 72-month interval for the C4/IL check, and a 144-month interval for the C8/D check. In addition to the C checks, there are also some corrosion prevention and control programme (CPCP) items and supplemental structural inspection document (SSID) items, which are incorporated into the C checks. The C4 and C8 checks are the biggest checks."

While the basic 18-month interval gave the full base check cycle up to the C8/D check an interval of 144 months, most operators were completing this in about 8-9 years. This implies that the oldest aircraft on this maintenance programme will have completed three base check maintenance cycles, and will be in their fourth cycle. The youngest aircraft, built in 1983 and 1984, on this maintenance programme will have completed two base check maintenance cycles and be in their third. All aircraft are thus mature.

The standard maintenance programme also has an A check every 450FH.

"The low utilisation maintenance programme has re-arranged most A and C check tasks from the standard programme into 3-month phases. That is, 1A check items have to be re-arranged into a group of tasks with a 3-month interval that forms a 3-month check," explains Ray Mosses, marketing manager at BASCO.

This 3-month check is referred to as a line A check. There are other tasks with multiples of this 3-month interval: the base A check at 6 months; the line A check again at 9 months; and the base A check repeated at 12 months.

"A 24-month group of tasks and check has replaced the C check," continues Mosses. "The FH-related tasks of the C check were changed to multiples of 24 months. The basic 24-month group of tasks and check would thus be performed every eighth A check. There are then multiples of 24-month tasks with 48-, 72- and 96-month checks. The 96-month check is the fourth and heaviest check, and is generically referred to as the 'D' check. These four checks have replaced the eight C checks in the MPD maintenance programme.

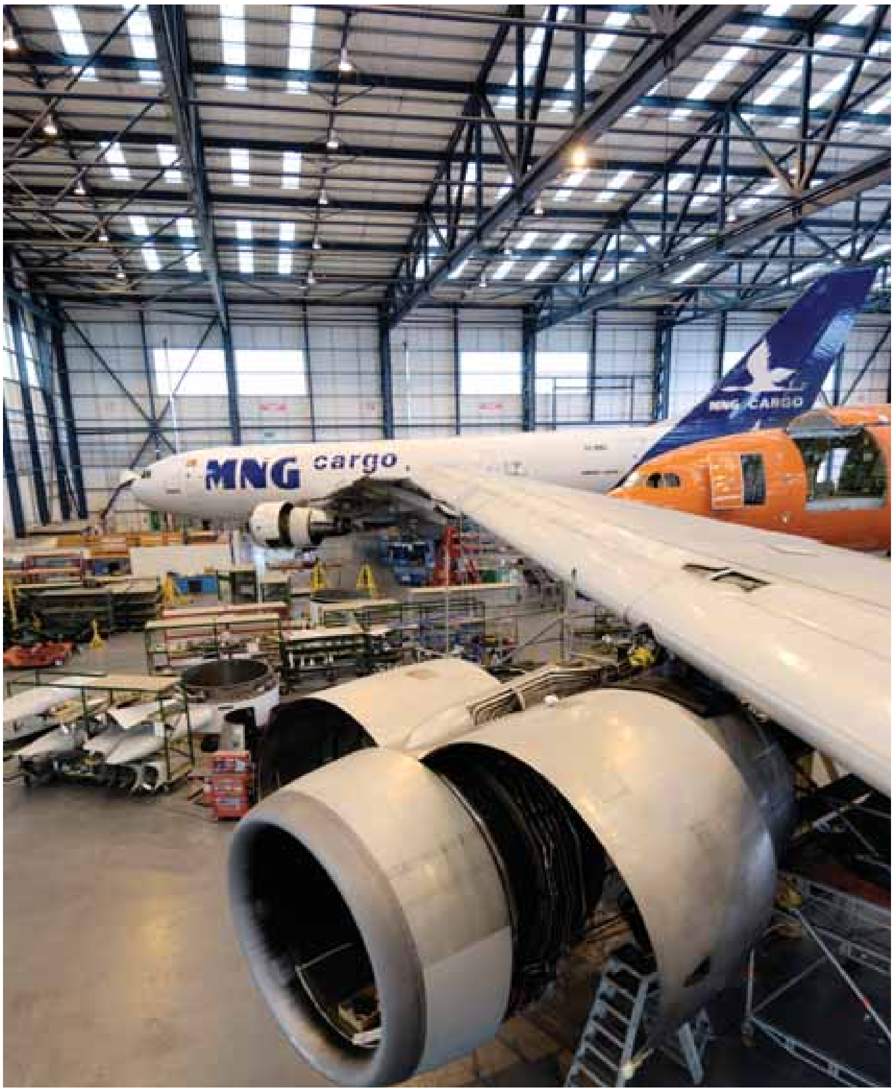
"There are also the CPCP tasks with an interval of 60 months to consider," continues Mosses. "These can be treated as a separate group of tasks, and so require a check different to the 48-month and 72-month C checks. This will increase overall downtime for maintenance and so these 60-month checks are therefore brought forward to the 48-month check by most operators. There is also a group of corrosion tasks with an interval of 108 months. To avoid separate maintenance inputs and out-of-phase maintenance checks, these are also brought forward to the 96-month check."

There is a third group of tasks to consider. "These are the SSID items which have FC-related intervals," says Ugur Kalkan, engineering manager at MNG Airlines. "These look for structural cracks, and include an inspection every five years of the aircraft belly, and other structural areas on the wings and tail, and engine pylons at different intervals."

Finally, there are a few out-of-phase maintenance tasks that Airbus was unable to change to multiples of 3-month calendar intervals. These items therefore have to be dealt with separately.

The majority of A300B4s that were converted to freighter were modified

Airbus devised a low utilisation programme for aircraft that were expected to operate less than 2,000FH per year. Many aircraft were bridged to this programme when they were converted to freighter. The programme exchanged C checks for 24-month checks. The base check cycle is completed at the 96-month check.



between 1995 and 1998. "Most aircraft had their base maintenance check cycles zeroed at conversion and the aircraft were bridged to the low utilisation maintenance programme," explains Mosses. "This means that the first aircraft that were modified will have been through their first 96-month check, while most will have yet to undergo it."

Line maintenance

The line and ramp maintenance programme for the A300B2/B4 consists of pre-flight and transit checks prior to each flight. A daily check has to be performed if the aircraft is grounded for more than four hours. The time between two consecutive daily checks cannot exceed 48 hours. A weekly check is also required, and the largest check in the series is a 150FC check. These are then followed by the 3-month checks.

The majority of aircraft are operated on a low utilisation programme, accumulating only about 800-900FC per year. An example is Irish carrier Air Contractors which flies three aircraft for the French post office and FedEx. Aircraft are only flown five days per week at an average of about three flights per night, depending on schedules. The average block time of 90 minutes means aircraft accumulate four to five block hours (BH) per night, and 20-25 (BH) per week). Pre-flight and transit checks are small enough to be performed by the flight engineer.

Transit checks only require about 1 MH for completion. Kalkan says the daily check usually requires about five MH from four mechanics, consuming a total of about 20MH. The consumption of consumables and materials is negligible for these two checks.

The weekly check, performed every 20-25BH, uses six MH from four mechanics, coming to a total of 24MH and a negligible quantity of consumables and materials.

The 150FC check occurs about once every 10 weeks of operation, coming close to the 3-month check interval. Brendan Smyth, technical services engineer at Aircontractors, says the checks are occasionally performed together if they coincide, but the 150FC check is otherwise performed as a ramp check. The 3-month check is a larger check. The 150FC check consumes an average of 25MH and only a few hundred dollars of consumables.

On this basis, an aircraft will require about 550 transit checks, 250 daily checks, 50 weekly checks and five or six 150FC checks each year. This will consume a total of about 800MH in line and ramp labour.

A total of about 7,000MH would therefore be required to complete these line and ramp checks. At a labour rate of $70 per MH, total cost would be about $490,000. This would have to be amortised over the corresponding 1,000FH for an aircraft operated on a low utilisation operation. The cost per FH would therefore be about $500 per FH, and an additional allowance of $50 per FH would be required for materials and consumables. This would take total cost to $550 per FH *(see table, page 22)*.

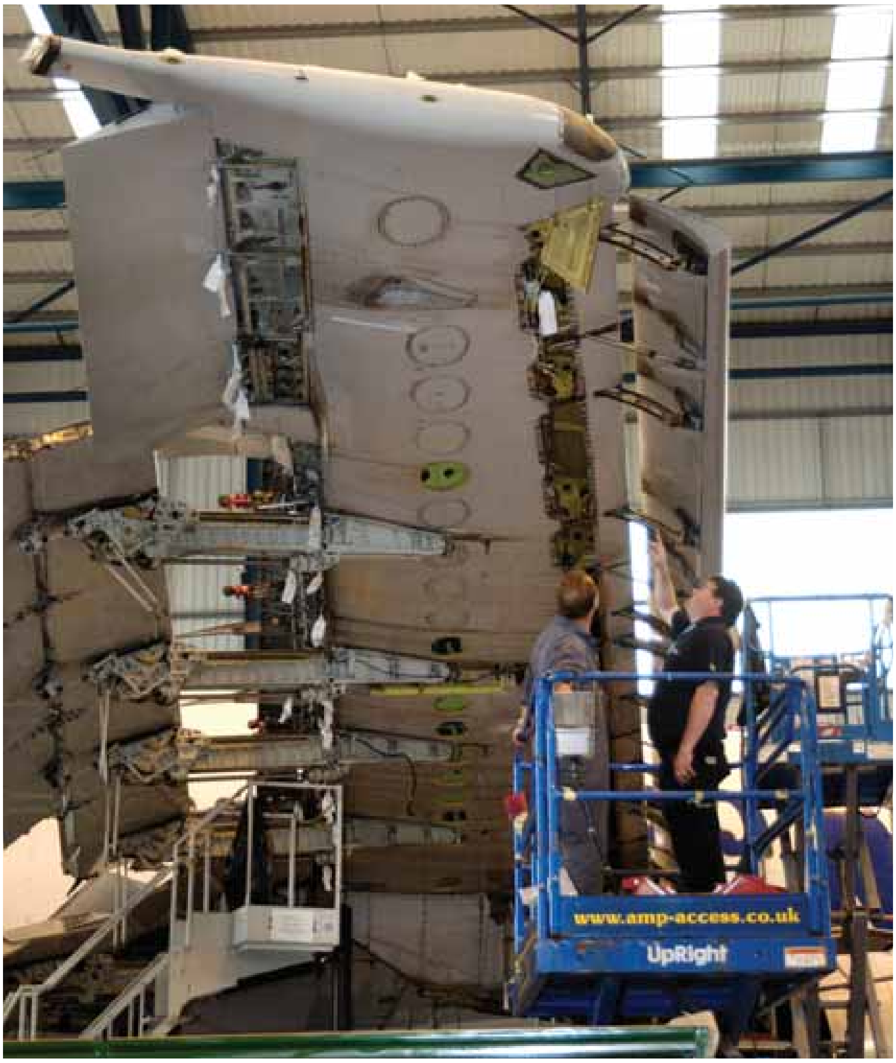
This cost per FH would be reduced for aircraft achieving higher rates of annual utilisation. Longer average cycle times mean fewer transit checks would be required each year, and the final cost for all checks would be amortised over a larger number of FH.

Mosses says MH consumption for 3-month checks is 700-1,100MH, depending on which check in the cycle is being performed and the inclusion of out-of-phase tasks. Average labour use is 1,000MH, and a typical labour rate of $50 per MH will result in a cost of $50,000. The cost of materials and consumables used is about $10,000, taking the total for the check to $60,000. Four checks are completed each year, and when amortised over the annual utilisation, the resulting cost per FH is about $240 *(see table, page 22)*.

Base maintenance

Most operators that have bridged their aircraft to the low utilisation maintenance programme have elected to bring the 60-month and 108-month CPCP tasks forward to the 48-month and 96-month checks respectively.

As described, all aircraft are now mature. The aircraft that were converted to freighter were all A300B4-103s and -203s built between 1975 and 1985, across the full period of A300B2/B4 production. This means aircraft will have completed one or two full base check cycles at the time of conversion and another low utilisation maintenance cycle since, and have thus reached maturity. This will affect the number of MH used



While some rotable components are in plentiful supply due to the large number of A300B2/B4s that have been dismantled for parts, other major components are becoming harder to find on the used market. This is forcing airlines to source new components from Airbus, and will increase costs.

in the four base checks.

"With a fully integrated maintenance programme that incorporates the SSID and CPCP tasks into the base checks, downtimes for other maintenance are avoided over the two-year interval between the checks," says Kalkan. "The integration of base check items and 3-month check items means the number of task cards for checks performed every 24 months varies between 300 and 700."

The first and third checks in the cycle are relatively small in terms of number of tasks and MH consumed. The second check is larger, and the fourth or 96-month check is the heaviest in the cycle.

"The 24-month check on a freighter consumes a total of 7,000-8,000MH," estimates Mosses. "This includes routine inspections and defects arising as a result, as well as MH used for interior work, modifications and SBs, and heavy component changes. About $30,000 is budgeted for materials and consumables consumption, whose use will be relatively low for an aircraft of its size because many items of interior work are not required on a freighter. This check will have a downtime of about 30 days.

"The third or 72-month check is similar in content and size, and also uses about 8,000MH and $30,000 for materials and consumables," says Mosses. "The 48-month check will use about 14,000MH in total and about $70,000 in materials and consumables. The 96-month check is expected to require an average of 20,000MH for most aircraft, and about $100,000 for materials and consumables. This check has a downtime of 45-50 days."

Can Sasmaz, technical manager at MNG Technic explains that 8,000MH of the 20,000MH used in the total for the 96-month check are for defects arising from routine inspections. "The second check will use 12,000-14,000MH," says Sasmaz, "and about 3,000-4,000MH are required for the clearing of defects. More than 40,000MH will be used for the four checks in the cycle."

The MH estimates provided by Mosses indicate that the total MH consumption for the cycle will be in the region of 50,000. At a labour rate of $50 per MH, this will be equal to an expenditure of $2.5 million. Total cost of materials and consumables for these four checks will be $230,000-250,000. The total cost for the four base checks will thus be about $2.8 million.

This cost has to be considered against the number of FH accumulated during the eight-year maintenance interval. The cycle is more likely to be completed in a seven-year period, considering typical utilisation rates of maintenance intervals. At most, this will be equal to about 14,000FH. In this case, the reserve for base checks will need to be in the region of $200 per FH. Many freighter aircraft are, however, operated at rates of utilisation equal to about 1,200-1,500FH per year. Aircraft would thus accumulate 7,000-8,400FH over the seven-year interval. In this case, the reserve for base maintenance would be higher at $330-400 per FH *(see table, page 22)*.

Heavy components

There are four groups of heavy components: wheels and brakes; landing gear; thrust reverser; and auxiliary power unit (APU).

The general high supply of used components on the aftermarket means operators can source some time-continued components at rates that are cheaper than putting them through shop visit overhauls. This analysis assumes all components are put through shop visits at typical removal intervals.

The A300B2/B4 has eight wheels and two nose wheels. Operators also have the choice of using steel and carbon brakes.

The average interval between wheel removals for tyre remoulds and wheel inspections is 200FC. Tyres can be remoulded as many as six times, and so last seven removals and 1,400FC before replacement.

Remoulding of tyres costs about $500, similar for many other widebody types, and replacement costs about $1,000-1,200. The full cost of remould and replacement over the cycle of seven removals is thus about $4,000 per tyre. This equals $40,000 for all 10 tyres. When amortised over the 1,400FC interval, it is equivalent to about $29 per FC *(see table, page 22)*, and equal to $23 per FH for an aircraft operating at an average FC time of 1.25FH.

Wheel inspections are made at the same time as tyre remoulds, and so every 200FC. Each wheel inspection has an average cost of $800, and so equal to $8,000 for the full shipset of all wheels. This equates to a cost of $40 per FC, and $32 per FH for aircraft on an average FC time of 1.25FH *(see table, page 22)*.

Steel brakes have inspection and repair intervals only about one quarter

DIRECT MAINTENANCE COSTS FOR A300B4 FREIGHTER

Maintenance Item	Annual/Cycle cost $	Cycle interval	Cost per FC-$	Cost per FH-$
Ramp checks	$490,000	1 year		550
3-month checks	$240,000	1 year		240
24-month checks	2,800,000	7 years/7,000FH		400
Heavy components:				
Landing gear	$500,000	6,000FC	84	67
Tyre remould & replacement	$40,000	1,400FC	29	23
Wheel inspections	$8,000	200FC	40	32
Brake inspections	$56,000	400FC	140	112
Thrust reverser overhauls	$440,000	6,000FC	75	60
APU	$200,000	12,000FH		20
Total heavy components				314
LRU component support				300-350
Total airframe & component maintenance				**$1,804-1,854/FH**
Engine maintenance: 2 X CF6-50C2				$1,540/FH
Total direct maintenance costs:				**$3,344-3,400/FH**

Annual utilisation:
1,000FH
800FC
FH:FC ratio of 1.25:1.0

the length of carbon brakes. While this may contribute to lower costs per FC for carbon brakes, they can also have very high shop visit costs. This is especially if the heat stack has to be replaced.

Steel brakes have an average removal and repair interval of 400FC, and repair cost of $7,000. The full shipset of eight main brake units will therefore incur a cost in the region of $56,000. This is equal to $140 per FC, and $112 per FH for an aircraft operating an average FC time of 1.25 *(see table, this page)*.

The landing gear has an interval of eight years and 12,000FC, whichever is reached first. The low rates of utilisation of about 800FC per year for express package carriers mean that the eight-year limit is reached before the 12,000FC limit. This is after 6,000FC and about 7,500FH. Even aircraft operated in passenger mode at about 2,500FH per year, do not accumulate more than about 8,500FC between gear overhauls.

Landing gears are usually put through exchange programmes, where operators pay an exchange fee for a gear shipset and a separate charge for the overhaul. The total for this is up to $500,000. For aircraft on low rates of utilisation, this is equal to a reserve of about $67 per FH *(see table, this page)*.

Aircraft operated at higher rates of utilisation of 2,500FH per year will need a lower reserve of about $29 per FH.

Thrust reversers are an on-condition item, as for many other aircraft types. Delamination is a big issue that can force removals. Average removal intervals are in the region of 6,000FC, and a typical shop visit cost is about $110,000 per reverser half, and so $220,000 per shipset. Reserves of $37 per FC should be used for each reverser, and $75 per FC for both. This is equal to $60 per FH *(see table, this page)*.

The A300B2/B4's APU is a Honeywell model, the TSCP 700, which is reliable compared to other APU models, with an average removal interval every 5,000 APU hours. How this relates to aircraft FH depends on several factors in an aircraft's operation. APU is generally used for engine start, but also taxiing in after landing. The APU time per FC can be as low as 30 minutes, meaning the average time between shop visits will be equal to about 10,000FC. In the case of aircraft used in express package operations this will be equal to about 12,000FH. The average shop visit cost will be in the region of $200,000, and so a reserve of $16-20 per FH would result.

Heavier use of the APU during passenger operations would be equal to about 45 minutes per FC, and so a removal about every 6,500FC might be expected. This would be equal to about 9,700-14,000FH. The amortised shop visit cost over this interval would be equal to $14-20 per FH.

Rotables

Besides the heavy components described, operators have to consider the cost of rotables. Analysis of the failure rates, necessity and cost of repair or purchase of each rotable component can give an operator or spares-support provider an indication of which components can be treated as on-condition items, which require soft removal intervals and which should have repairs or overhauls aligned with airframe checks.

In addition, the failure rates and cost of repair and overhaul or purchase allow the rotables to be divided into four categories: those that need to be held in an inventory at an airline's base of operation; those that can be borrowed or exchanged at short notice; those that can be acquired from a third-party supplier several days after a failure; and those that will be acquired only when emergency situations arise.

With many aircraft types, there are several specialist rotables suppliers that will analyse an airline's fleet and operation, determine the quantity of stock it requires at its home base, and then contract to supply the remainder to the airline as required. The provider will guarantee and manage the supply and repair of components for the airline when required, charging a fixed rate per FH for this service, as well as a monthly lease rate for the homebase stock. The supplier takes the risk of dealing with peaks of component failures, and also deciding whether to borrow, exchange, buy or lease each part number in the inventory.

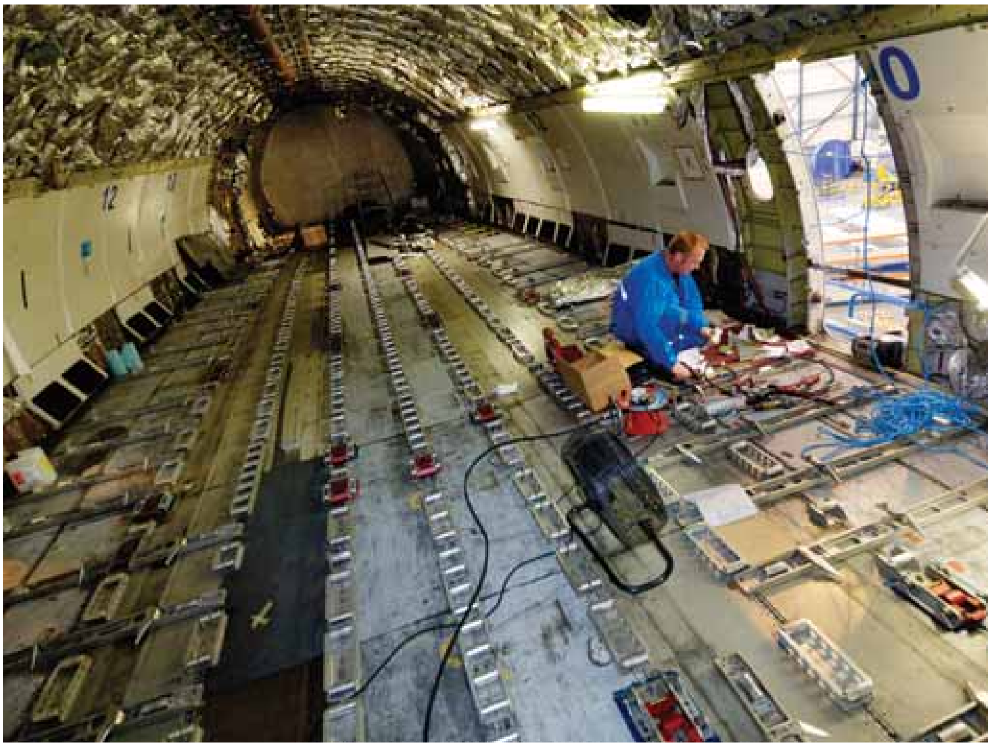
The large number of A300B2/B4s that have been retired and broken for parts has resulted in a high supply of rotables on the aftermarket, making it economic to acquire an increasing number of them through purchase or exchange programmes on the aftermarket.

Some rotable items, such as the drive trains in flap units, are becoming increasingly harder to find, however. Shortages force operators to buy units from Airbus, which is more expensive than buying them on the used market.

The overall effect is that the cost of supplying rotables is becoming more variable and so less predictable for airlines. MNG Airlines, for example, has bought two stored aircraft for breakdown into parts.

The overall effect is that the resulting cost per FH of all rotables will be highly variable. Airlines operating average FC times of 2.0-2.5FH and achieving annual

It is estimated that a total of 50,000MH will be consumed in the four checks of the base check cycle for aircraft operating at low rates of utilisation. Amortised over a likely interval of just 7,000FH for many aircraft results in a base check reserve of up to $400 per FH.



utilisations of 2,000FH per year can expect the cost per FH for rotables to be in the region of $200-250. Aircraft on lower rates of utilisation and flying on shorter average FC times should have $300-350 per FH budgeted for rotables *(see table, page 22)*.

Engine maintenance

All A300B2/B4s still in operation are powered by CF6-50C/C2 engines. Engine maintenance costs for the A300B2/B4 are its Achilles' heel. Removals for this engine are generally related to FCs. Most planned intervals are in the 1,800-2,200FC range. The engine is sensitive, however, to operating environment, rate of de-rate and average FC time.

Express package operators generally have short cycle times, which might be expected to have a negative impact on removal intervals. These airlines can, however, offset the impact of this with relatively high rates of de-rate, plus the advantage of a cool operating environment when flying at night.

Express package operations take place at night, when ambient temperatures are cool. This prolongs on-wing life. There are large differences in removal intervals between aircraft that operate in cool environments and those that fly where ambient temperatures are high. High ambient temperatures can reduce on-wing times to as low as 1,500-1,800 engine flight cycles (EFC).

Express package operations also often provide the opportunity for relatively high levels of engine de-rate. De-rate ultimately is mainly governed by aircraft take-off weight. Express package operations have short average FC times, and so a relatively low fuel load requirement. Load factors and the low packing density of express packages means full payload capacity is rarely reached. Take-off weights are consequently low in relation to maximum take-off weight (MTOW), and engine de-rates are consequently high.

Typical engine removal intervals can be up to 2,000-2,500EFC for low utilisation and short cycle operations. At an average cycle time of 1.25FH, this is equal to 2,400-3,000 engine flight hours (EFH).

The CF6-50 is usually managed in a pattern of alternating light and heavy shop visits. Life limited parts (LLPs) have lives varying from as low as 12,000EFC to as high as 30,000EFC. Most, however, have lives of 20,000-30,000EFC. Shop visit intervals mean that most parts are replaced at least once every eight to 12 shop visits with such removal intervals, so the cost of replacing LLPs is not a consideration for most shop visits.

A light shop visit requires 3,500-4,000MH, about $600,000 in materials and $500,000 for sub-contract repairs, taking the total cost to about $1.4 million. A heavy shop visit can consume 4,500-5,000MH, $800,000 in materials and another $800,000 in sub-contract repairs, with a total cost of $2 million.

Two shop visits amortised over a total interval of about 5,000EFH will thus result in a maintenance engine reserve rate of about $680 per EFH.

LLP amortisation has to be added to this. A full set of LLPs for the CF6-50C2 has a list price of about $2 million. LLPs' lives vary between 20,000EFC and 30,000EFC. Replacement will be after an average of 12 removals, equal to about 26,000EFC. This results in a reserve of $77 per EFC, or $62 per EFH, taking the total cost to about $760 per EFH. Both engines therefore require a total reserve of about $1,500EFH *(see table, page 22)*, which is by far the highest element of total maintenance costs for the aircraft.

Engines can be built for longer intervals of 3,500-4,000EFC. Average shop visit cost is in the region of $2 million, resulting in a lower maintenance reserve of about $475 per EFH.

In the case of aircraft operating longer average FC times of 2.0-2.5FH, average removal intervals are about 2,200EFC and equal to 4,400-5,500EFH. Shop visit input costs of about $1.5 million will result in a lower engine reserve rate of about $270 per EFH.

Summary

The combined effects of low rates of utilisation, a short average FC time and high engine costs result in a total aircraft maintenance cost in the region of $3,300-3,400 per FH *(see table, page 22)*. This cost would be considerably less for an aircraft operated at higher rates of utilisation and longer average FC times.

As described, the A300B2/B4's engines are its weak point. The short removal intervals that result from the short cycle time result in engine reserves that total over $700 per EFH when LLPs are included. Engine costs therefore account for almost half of this amount, while all other costs are escalated by the short average cycle time. These maintenance costs have to be considered against the aircraft's lease rates and other direct operating costs by operators when they are considering the viability of the aircraft.

Line and ramp maintenance, 24-month checks, heavy components, rotables, and engine reserves would all have lower costs per FH if longer average cycle times were operated. In the case of some of these elements, rates per hour would be half, or even one-third, of what they are for an aircraft operating short cycles at low rates of utilisation. On this basis, total costs could be in the region of $1,700-2,200 per FH for a passenger aircraft generating 2,000-2,500FH per year. This makes the A300B2/B4 highly economical when considered in combination with its lease rate. AC