The 747-100/-200 have been dogged by a series of major ADs that escalated their maintenance. In some cases, man-hour inputs in D checks were twice the standard level. The 747-400 does not have these problems and delivers stable and predictable maintenance costs.

747-400 shrugs off heavy maintenance burden of earlier classics

The 747-400 is free of the high modification costs associated with the earlier classics. About 550 747-400s are in operation, with ages of up to 12 years. The majority are in passenger service, although sales of the freighter model have been high in recent years. The 747-400 operates the longest of all 747 routes on most airline networks, although many also fly the same sectors as did the classics in previous years. This analysis examines the 747-400's line, airframe check and component maintenance charges and their costs per flight hour (FH).

In passenger operation the 747-400 achieves utilisations in the region of 5,000FH. Flight cycle (FC) lengths are in the region of 7.5-9.0FH, thus generating 550-670 FCs per year. The oldest aircraft in the global fleet have recently had their second D check, while most will have only had their first or no D check.

Maintenance items

Analysis of total line, airframe check and component costs per FH requires subdivision of all tasks. Line checks include transit and pre-flight, daily and weekly checks. In addition to routine line tasks they also involve the exchange of line replaceable unit (LRU) components. Airframe checks include A, C and D checks. There are no major modifications, such as Section 41, in the classic series. All engine pylon modifications have been completed. Components also include heavy items of wheels and brakes, landing gear, auxiliary power unit (APU) and thrust reversers. The third component category is heavy check-related rotable components that are removed for repair during C or D checks. Some airlines opt to maintain these on an 'on-condition' basis.

An interval representative of most airlines' operation for each maintenance element is accounted for. The man-hour (MH) and material cost inputs, or typical sub-contract cost, are then amortised over the relevant interval to derive a cost per FH. The cost for each element then derives the aircraft cost per FH.

Airframe checks include routine items and consequent non-routine inspections; interior cleaning and cabin refurbishment; incorporation of Service Bulletins (SBs); paint and strip; deferred items; Corrosion Prevention and Control Programme (CPCP) inspections and removal of certain components for repair that are scheduled during checks; as well as changes of heavy items.

Items removed for repair during C or D checks include flight controls of flaps, doors and cowls (Air Transport Association (ATA) chapter 27), interior (ATA chapter 25), linear hydraulics (32), and electro mechanical components (21,22, 23, 24, 33, 74 and 77).

Maintenance schedule

All operators' maintenance programmes are derived from Boeing's maintenance planning document (MPD). Line checks are a pre-flight inspection, performed by the flight crew, while a transit check is carried out by line mechanics every FC. MPD airframe checks are an A check with a 500FH interval, a C check with a 15 month interval and D check with a 60 month and 25,000FH interval.

"The difference between the 747-400 and the classics is that the –400 is a new generation aircraft," says Sebastien Weber, 747 engineering and maintenance department manager at Air France Industries. "The 747-400 is not as advanced as the A340, and the 747-400 still has mechanical flight controls, but a computerised flight deck and CMS. The 747-400 also uses ACARs to aid reporting of faults for line maintenance. This makes identifying system failures easier than with the classic series".

Individual airlines with extensive maintenance experience of the 747-400 are able to extend check intervals from the MPD. Air France Industries and Lufthansa, for example, both have an A check interval of 650FH, while KLM has a 700FH interval.

C check intervals are 18 months for Air France, Lufthansa and KLM. D check intervals have had extensive extensions in some cases. Following its experience with a large fleet of –400s, Air France now has a D1 (first D check) interval of 80 months and 31,000FH and a D2 interval of 72 months and 32,000FH. Lufthansa Technik's interval is 66 months and 26,000FH, while KLM has a 72-month and 25,000FH interval.

Airline schedules checks vary in organisation. Air France's schedule is based on five A check package multiples of 1A, 2A, 3A, 4A and 6A items. That is 2A items have twice the interval of the standard 1A items at 650FH. "We have a choice to equalise these multiples or perform different size A checks when each multiple comes due," explains Weber. "That is, the second A check, A2, has 1A and 2A multiples, and the 6A has 1A, 2A, 3A and 6A multiples. This means each A check varies in size. The 6A package has a scheduled interval of 3,900FH. This is equal to about nine months of operation. The cycle is then repeated. The actual A check interval achieved is about every 600FH. The A3 and A6 checks are heavier, since we include light cabin refurbishment. The A6 check then gets done about every eight months."

Annual utilisations of 747-400s are in the 4,700-5,000FH flight hour range in many cases. Flight cycle lengths are 7.5-9.0FH. These high utilisations are affected by longer check intervals than those allowed on the -200/-300 series.

Air France's C check interval is 18 months, and so two A check cycles are completed in every C check interval. "We prefer to lose one month of the available C check interval and perform the second A6 check with the C check," says Weber. "Our A and C checks are independent. That is, we do not have to complete an A check cycle at the C check or perform them together. An A check is, however, done at the C check to save downtime, make use of common access and avoid man-hour (MH) duplication."

Air France has two C check multiples, and again C checks are performed in blocks rather than being equalised. "The C2 items only add about 10-20% MH to the C1 tasks," says Weber. "The D check is performed independently of A and C checks, but our D check interval of 72 months is conveniently four times the C check interval. We therefore perform every fourth C check with the D check. The actual interval is about 68 months. The cabin refurbishment done during the D check provides 75% of the access required for the C check, so it makes sense to combine the two."

Lufthansa's schedule has six A check multiples of 1A, 2A, 3A, 4A, 6A and 8A tasks. "These are organised in a block arrangement. There are few 4A, 6A and 8A items, and so these are equalised into the A2 check," explains Thomas Seufert, section manager at Lufthansa Technik. "We therefore have an A3 check cycle with a scheduled interval of 1,950FH. We achieve about 90% of this interval, or about 1,750FH.

"We also have four C check multiples, and incorporate the 3C and 4C items into every second C check. We therefore have a cycle of 1C, 2C and 3C checks, and combine the A and C checks when they fall close together," explains Seufert.

Lufthansa's D1 check interval of 78 months and 30,000FH has been escalated stepwise from an original interval of 66 months and 25,000FH due to the airline's extensive experience of D1 checks. "A cycle of four C checks has to be completed at the D check," says Frank Loscheider, manager 747 aircraft overhaul at Lufthansa Technik.

Check composition

Items included in C and D checks vary by operator. Some elements can be scheduled in either check. Routine inspection job cards form the basis of C and D checks, and will generate non-routine rectifications. Other items that have to be added are incorporation of SBs, cabin cleaning, interior refurbishment, strip and painting, CPCP job cards, change of heavy components like the landing gear, thrust reversers and APU, and removal of rotables scheduled for repair during checks. Early-build aircraft had engine pylon modifications performed in their first D checks, but otherwise 747-400 D checks are free of heavy modifications.

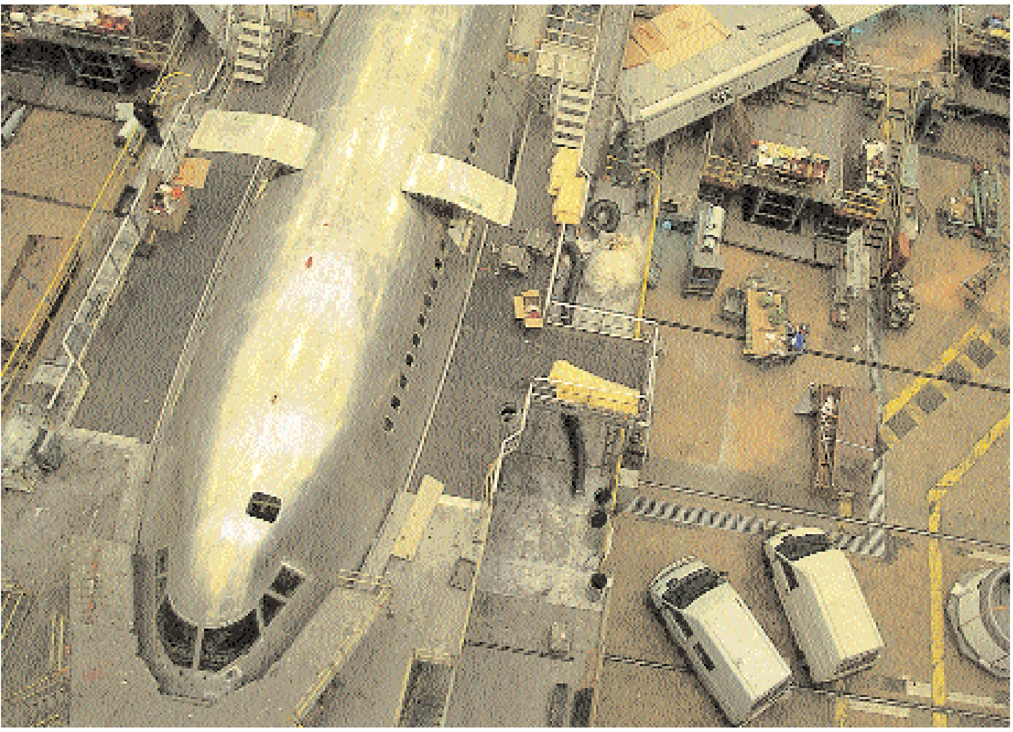
Interior refurbishment involves the removal of toilets and galleys for refurbishment, as well as side-wall panels, overhead bins and seating. "This part of a D check can use a high number of MH because first- and business-class cabins need a lot of work to maintain standards required by the airline marketing department," says Weber.

Most operators' D checks include all these items. This leaves C check composition as routine and non-routine items, cabin cleaning plus a few SBs and component removals.

CPCP items are often split between C and D checks by major maintenance operators. "Some CPCP items have limits as long as nine years, but have to be incorporated into the D check and so are done early. Others have intervals shorter than the D check and so have to be scheduled with the C checks," says Seufert. "Almost all CPCP cards are incorporated into the D check job card set."

Of the heavy check-related rotables that are scheduled for removal for repair during C or D checks, some can actually be removed 'on-condition', that is at a time different to the airframe checks. Inspections can be made on these components, and if they pass the test they are then removed for repair at a later time. These rotables include flap actuators, flap tracks, power units, fuel pumps and pneumatics. "Most of these components are scheduled for removal during a D check, but we remove all of them for repair at the time to avoid downtime after the D check for further removal of components," explains Leo Lubbe, business analyst at KLM Engineering & Maintenance. "None of these rotables are removed during line checks, except for damage and aircraft-on-ground situations. Some airlines choose to remove these rotables on an on-condition basis. Although this will mean less being repaired during a D check and the check having a lower rotable repair cost and shorter downtime, the items repaired later will still have to be paid for. Their condition will also be worse compared to if they were removed during the D check. As a consequence of delayed removal their repair cost will be higher and overall maintenance cost per FH will also be higher. This will also mean extra downtime later for removal of these components. Our policy of removing all these components for our own aircraft during the D check minimises total downtime. Downtime for our C and D checks is about six days and five weeks. Although repairing all these components during the D check increases the D check's cost, it improves the aircraft's technical despatch reliability".

"To minimise downtime we exchange many of these components, rather than reinstall the repaired items back on the same aircraft," says Lubbe. "There are, however, closed loop items which have to be put back on the same aircraft they



Most 747-400 operators achieve 15-17 months and 5,000FH between C checks and 60-68 months and 28,000-29,000FH between D checks. This compares with about 5,000FH and 22,000FH between C and D checks on the -200/-300 series.

came from. Some airlines which subcontract their D checks choose to maximise the intervals of these components to reduce the D check work package."

In addition to these standard items, A, C and D checks always include some deferred items. "This may account for several hundred MH," says Weber. "While several hundred MH for deferred items will be included in a check, there are always more that get added and it is difficult to reduce the number of deferred MH. The maintenance manual has a limit for the number of deferred items. Computerised systems exist to manage deferred items."

MH inputs

The MH inputs into A, C and D checks are dependent on several factors. Basic MH inputs first depend on the routine inspection job cards and the non-routine rectifications they generate. The number of non-routine MH is gauged by the ratio of routine to non-routine work. This ratio will increase with age, but also varies according to previous maintenance quality, organisation of maintenance with respect to minimising repetition and maximising access, style and environment of operation and level of deferred maintenance.

Non-routine ratio is the most important determinant of total MH used to complete each check. Although A checks have job cards totalling less than 500MH, a non-routine:routine ratio of just 0.75:1 non-routine MH per routine MH will generate another 350MH, taking the check's sub-total to 850. In comparison with the check's interval, this is a ratio of more than 1MH per FH. An approximate total MH for the first and second D check is 55,000-60,000. This is equal to about 1.7MH per FH. D check MH can rise to 80,000 if non-routine ratio approaches 2:1. This is equal to nearly 2.5MH per FH.

Docking, administration and planning, incorporation of SBs and deferred items will also add to MH expenditure. The schedules of some airlines mean that some A checks are heavier than others. The total MH expenditure for an A check is 650-1,000 MH. That is, MH rise for heavier A checks and for aircraft which incur a higher non-routine ratio.

C checks have a similar work package as the –200/-300 series aircraft. "The –400 fleet has less fatigue and corrosion than the older models. The avionics also allows easier troubleshooting for testing the systems," says Weber. "These have combined to reduce MH inputs for heavier checks. C check MH inputs are 10-15% lower compared to the older –200/-300 models. A typical C check will consume 4,000-5,000MH." Routine items total about 2,500MH, but a non-routine ratio of 1:1 will increase this. A non-routine ratio of 1:1 is typical for most aircraft, and D checks are usually the checks which that show have an increase in non-routine ratio with age and fatigue. The non-routine ratio for C checks is in the region of 0.5:1.0, and so non-routine MH account for about one-third of total MH used.

The 747-400 has a superior airframe to earlier models. This means non-routine ratio will be lower at the first D check compared to earlier models. It should also mean non-routine ratio for the –400 will increase at a slower rate for each subsequent D check compared to older variants. Only a few –400s have had their D2 checks, and none have been through their D3 checks. Although it is not known what the non-routine on D3 and D4 checks will be, there are indications that the non-routine ratio will not climb excessively in later life.

D checks in most carriers' schedules will include routine and non-routine items, A and C check items, complete cabin refurbishment, SBs, CPCP job cards, and strip and paint. The requirements of the operator's marketing department will determine the refurbishment workscope, and so total MH input.

Freighters will have less tasks to complete because of the absence of an interior. This saving will, however, be cancelled out by tasks for the cargo loading and handling system. Some freighters, also, have a higher non-routine ratio because of a higher incidence of corrosion and structural damage, because of the materials they carry, such as fish or agricultural products. Other freighters that carry small packages or electrical goods will not have problems of corrosion, and so will require a lower MH input.

At the D1 check –400s have a non-routine ratio of about 1:1. "The MH input for the –400 will depend on the workscope, but it will be about 10% less than the –200/-300 for the same D check number," says Loscheider. "This will take total MH to 50,000 for D1 and D2 checks. The MH for the D2 check will be higher than the D1, since there are more inspection items in the D2. There are also some CPCP cards with a D2 threshold. The non-routine ratio in the D1 and D2 checks is about 1:1, but we expect the non-routine to climb to about 1.2:1 in the D3 and 1.3:1 in the D4. The breakdown of MH in the D1 and D2 checks is 19,000-22,000 routine MH and a similar number for non-routine rectifications. About another 2,500 MH will be consumed by SBs, although aircraft which required the pylon modification in the D1 will have consumed about 10,000 MH. A few hundred MH will be used for minor cleaning, but in the region of 7,000 MH for interior refurbishment. Another 3,500 MH will be used for strip and paint. This will take the total 48,000-53,000 MH for the D1 and D2 checks."

If the non-routine ratios that arise in the D3 and D4 checks are as Loscheider

The 747-400's standard D check package used by most operators includes routine and non-routine inspections, CPCP inspections, interior refurbishment, overhaul of rotables and stripping and painting. This will take man-hours consumed to the region of 57,000 for the first two D checks performed.

predicts, then total MH consumption will be in the order of 57,000 and 59,000. MH inputs for a freighter aircraft are likely to be about 5,000 less than for a passenger aircraft.

Check additions

Other items scheduled with C or D checks are changes of heavy components. This is because they require downtimes longer than an A check. These include landing gear, thrust reversers, engines and the APU. Wheel and brake changes can be made during line or A checks.

The scheduling of heavy component changes may mean airlines will have to compromise on removal intervals of these heavy components. The landing gear, for example, can remain on the aircraft for eight years. KLM, however, changes the landing gear with every D check, which is only every six years. While this reduces the FH interval, Lubbe explains that this 24-month early removal will result in a lower overhaul cost for the unit, as well as allow a high technical despatch reliability (TDR) to be maintained. Air France, however, uses an interval of 105 months, and so schedules the removal with a C check. About 1,000 MH are required to remove, install and test a new unit. A labour cost of $50 per MH adds about another $1 per FH.

The MH consumed for thrust reverser, engine and APU removal, installation and tests are minimal compared to the total MH consumption used for line and hangar checks.

Check material costs

As described, rotable and repairable components fall into the three categories of LRUs, heavy check-related and heavy components. The costs of repairing heavy check-related rotables will form an element of total checks costs. In addition to repair charges for rotables, there will also be material costs.

The estimated repair cost for the heavy check-related parts is $1.9 million. About 25% of these items are used in cabin refurbishment. A freighter aircraft will therefore incur a cost in the region of $1.5 million for rotable repairs. The cost of consumable and expendable materials is about $600,000.

A and C checks will therefore incur just material charges, and not rotable repairs. These will not be dissimilar to those incurred by the -200/-300 series. These are about $10,000 for the A check, $100,000 for a passenger-aircraft C check and $50,000 for a freighter C check.

Total check costs

To summarise, the MH used for A, C and D checks are 650-1,000, 4,000-5000 and 55,000-60,000. Material costs are $10,000 for an average A check, $100,000 for a C check and $2.5 million for a passenger aircraft D check.

Total costs will depend on labour rates. While European and North American facilities have the highest labour rates, there is evidence to suggest that facilities which have lower labour rates may provide aircraft with lower TDR and consume more MH when completing the checks. European and North American labour rates are currently in the region of $50-60 per MH, since competitive forces are keeping pressure on the rates that facilities can charge.

Labour rates of $60 per MH have been used for the A check, $55 per MH for the C check and $50 for the D check.

At this rate A, C and D checks for passenger aircraft will have labour costs of $48,000, $275,000 and $3 million. Material costs will take total costs for A, C and D checks to $58,000, $375,000 and $5.5 million. C check costs for a freighter will be about $50,000 less because of a saving in interior-related material costs. A D check for a freighter will be about $650,000 less, because of $150,000 lower labour input and $500,000 smaller rotable repair cost.

Check summary

Generally, the actual A check interval most operators achieve will be about 600FH. Six of these will be performed to complete the A check cycle, and two A check cycles will be performed for every C check. The interval achieved between each C check will then be about 7,200FH *(see table, page 32)*. This is equal to about 17 months of operation for most passenger carriers.

A D check will be performed every fourth C check, at about 68 months and about 28,000-29,000FH.

The total costs per FH of these three checks is about $96 for the A check, $52 for the C check and $183 for the D check *(see table, page 32)*. These are comparable to, but less than, the costs per FH for the 747-200/-300 *(see 747-200/-300 holds its own with stable maintenance costs, Aircraft Commerce, September/October 2000, page 26)*.

Line checks & inputs

These checks have two inputs of labour and materials. In addition to these regular inputs, LRUs are continuously removed and replaced with serviceable units. The process of removing and replacing, testing, inspecting, repairing, transporting, tracking and holding in store on an on-going basis has an additional charge.

There are three levels of line checks, including the transit check performed each flight, a daily check performed every 24-48 hours and the weekly check every 7-8 days. The MH inputs into these are 1-3 MH, 25 MH and 30MH respectively.

There are thus 550-670 transit checks performed each year, depending on

PASSENGER & FREIGHTER 747-400 FLIGHT HOUR (FH) AIRFRAME AND COMPONENT MAINTENANCE COSTS

Maintenance Item	Maintenance interval	MH used	MH cost ($)	Materials & rotables ($)	Total cost ($)	Cost per FH ($) 8.0FC
Pre-flight	Every FC	3				
Daily	24-48 hours	25				
Weekly	7-8 days	50				
Total annual MH		8,500	550,000	350,000	900,000	180
A check	600FH	650-1,000	48,000	10,000	58,000	96
C check-passenger	7,200FH	4,000-5,000	275,000	100,000	375,000	52
C check-freighter	7,200FH	4,000-5,000	275,000	50,000	325,000	45
D1/2 check-passenger	28,500FH	53,000-60,000	3,000,000	2,500,000	5,500,000	183
D1/2 check-freighter	28,500FH	50,000-55,000	2,750,000	2,100,000	4,900,000	172
Landing gear change	40,000FH	1,000	50,000			1
Heavy components						
Tyre remould	200FC x 3				21,000	
Tyre replace	800FC				19,000	4
Wheel rim inspection	200FC x 3				5,400	
Wheel rim overhaul	800FC				7,200	4
Brake repair & overhaul	1,800FC				240,000	17
Landing gear exchange & repair	40,000FH				730,000	18
Thrust reverser repair	12,000FH				200,000	17
APU shop visit	9,000FH				360,000	40
LRUs/Rotables						
Lease rate						40-60
Fixed FH repair cost						375
Tot al cost per FH-passenger						**1,040**
Tot al cost per FH-freighter						**1,020**

aircraft utilisation. About 200 daily checks and 50 weekly checks will be carried out each year. Combined, these will consume in the region of 8,500MH each year. Line labour rates will vary, since a portion of the checks will be performed by third party agents or other airlines at the outstations across the operator's network. Line labour rates for western carriers are $65 per MH. This will generate an annual labour cost of about $550,000, equal to a cost of about $110 per FH.

A further $7,000 per week, or $350,000 per year, can be used in material expenditure. This makes the annual material and labour cost equal to $180 per FH.

Heavy components

This category includes the four components of wheels and brakes, landing gear, APU and thrust reverser. The removal intervals for the last three of these have been described above.

The landing gear will be removed at any time between a D check interval and every nine years. This will be 3,300-6,000FCs, and 30,000-45,000FH. Most airlines now have exchange repair programmes with specialist gear overhaul shops. The removal interval chosen by an airline will affect the percentage of parts that is scrapped. The highest cost parts and those with the largest influence on the overhaul workscope are the bushings, which are susceptible to corrosion. Incidence of corrosion increases exponentially after an eight-year interval, as will repair cost. An eight-year removal interval is therefore advisable to get the lowest cost per FH. Independent gear shops offer exchange programmes to airlines. Three cost elements are involved. The first is a fixed exchange fee, which effectively covers the cost of ownership and inventory. This is in the region of $130,000. The second is a fixed repair charge, which is about $480,000. The third is an element to cover the unpredictable element of replacing scrapped parts. This will vary, but is estimated to average $120,000. Total cost will therefore be about $730,000. Amortised over an eight-year interval this will be equal to $18 per FH.

The PW901A may have a removal interval equal to about two years , or 9,000FH. Average refurbishment cost for the PW901A is about $360,000, thus resulting in a cost of $40 per FH.

A thrust reverser will be removed removed for repair on average every 12,000FH, while each one will have an interval in the region of 48,000FH. Repair workscopes vary, and consequent shop visit costs are $140,000-220,000 for each unit. The cost for all four units will be about $15 per FH.

The 747-400 is equipped with carbon brakes, which will have a longer life between repairs than steel units. Wheels are removed during line maintenance if there is damage or wear to tyres. Wheel rims can then be inspected once tyres are removed for remoulding. Brake discs can be measured with callipers on the line, and removed for repair or overhaul. Brakes also have a wear pin, used to indicate the level of wear.

Tyres can be remoulded a few times before they must be replaced. Tyres on the 747-400 can be remoulded up to four times before they are replaced, but the average number is lower since some are damaged by foreign objects and have to be scrapped. Wheel rims are inspected with non-destructive testing (NDT) techniques. They are disassembled, *Non-routine ratio for C and D checks is about 1:1. This is only expected to rise to about 1.3 by the fourth D check, at an age of 24-26 years. This ratio will raise man-hour consumption to about 60,000.*

cleaned and inspected. The first shop visits for a new wheel are just visual inspections. Workscopes then get higher with eddy current NDT. As wheels get older ultrasound NDT is used. Wheels can last a lifetime, but some have to be scrapped.

Brakes can also last the lifetime of an aircraft, although certain damage will force replacement.

Wang Xue Min, senior engineer & deputy manager subdivision component overhaul at Ameco Beijing says the approximate removal intervals for wheel removals during a line check for tyre remoulding and wheel rim inspections is about 200FC. "Tyres can be remoulded three times before being replaced. Remould cost is $300 for a nose tyre and $400 for main". This generates a remould cost of $7,000 for the entire shipset. Xue Min says new tyres cost about $900 for a nose and $1,050 for a main, with a cost of about $19,000 for a shipset. These three remoulds and replacement cycle will occur over an interval of about 800FC, with a resulting cost of $32 per FC, or about $4 per FH.

Wheel rims are inspected at removal at a cost of about $300, and overhauled every fourth removal at a cost of $400. Wheel rim inspections for a shipset therefore costs $5,400 and overhaul about $7,200. The cost for this inspection and overhaul cycle is about $24,000 every 800FC, equal to $30 per FC, or $4 per FH.

Removal intervals for brake repairs are 1,200-2,500FCs. The variation in interval depends on the use of thrust reverse, flap settings and runway length. Lufthansa Technik has established a shop visit pattern of a cycle of four workscopes. These are a visual inspection, an o-ring change, a visual inspection and a complete overhaul. This cycle is repeated, and will be modified subject experience. An average interval of about 1,800FCs means this repair cycle will be completed about every 7,000FCs; equal to about 10-12 years of operation.

A budget for a typical third party brake repair cost is in the region of $15,000. This is equal to $9 per FC for each unit. There are 16 units on the aircraft, so cost per FC is $133, equal to $17 per FH.

LRUs

Inventories of parts held at line stations can include consumables, rotables and repairables. Consumables are mainly used during airframe checks, but will also have to be kept for minor maintenance. Rotables are items with serial numbers, and have to be held in stock or be available in order to maintain operating schedule. Rotables include avionics and generators. Repairables are items without serial numbers, and include ducts and cables.

If an airline is totally self-reliant for all these three categories then up to 4,000 line items would have to be held for the 747-400. Since consumables can be acquired easily at outstations and replacement of many repairables can be deferred until hangar checks, the number of line items can be reduced to about 800. The total stock that has to be held will be about 2,250 units for 15 747-400s. Stock held per aircraft reduces as fleet size increases. Investment will be about $20 million for 10 747-400s, but only another $6 million for 20 aircraft.

Inventory can be acquired by leasing stock and then paying a fixed cost per FH for repair and management. Lease costs will be in the order of 1.2% per month. Inventory for $20 million will cost $240,000 per month, equal to $60 per FH for aircraft generating 5,000FH per year. This will reduce to $38 per FH for a larger fleet of 20. A fixed cost per FH of $375 can be secured for repair and management, taking total cost to $413-435 per FH.

Inventory that is owned will simply be depreciated. Repair charges can still be incurred on a fifxed cost per FH basis, or incurred as in-house expenses.

Cost summary

Total component, line and hangar check costs for a 747-400 passenger aircraft are $1,040 per FH, based on a 8.0FH average cycle *(see table, page 32)*. This includes all maintenance costs except for engine shop visit charges. This total compares to about $1,340 per FH for the 747-200/-300.

With the same annual utilisation, the 747-400F has $20 per FH lower total maintenance cost.

The -400's lower cost is first attributable to the lease charge for the LRUs. The lease rate factor for the -200/-300's components will be higher and aircraft utilisation lower. This difference between the older aircraft and -400 series therefore arises from treatment of the ownership costs of both types.

Airlines which own their components will have a lower cost because they will have depreciate them, and in some cases will have completely written them off,particularly for the -200/-300. Book depreciation of LRUs will bring total costs for the -400 and -200/-300 series closer together.

The 747-400's main advantage over the -200/-300 series is that while it has similar costs to complete A,C and D checks, the -400 has longer intervals and so costs per FH to complete these checks is lower compared to the -200/-300. The -400 series may also consume less MH in its line checks. MH consumed for line checks are more subjective, however, and the -400 may have similar labour consumption to the -400.

With more favourable treatment of the -200/-300's LRU finance costs, the difference between the -200/-300 and -400 will be $100-200 per FH.