The 757 and 767-200/-300 are mature aircraft, and the oldest are more than 20 years old. The first have begun to enter the secondary market. The two types have similar designs and maintenance programmes, and their airframe and component maintenance costs are economic given their age.

757 & 767-200/-300 maintenance costs

There are about 1,000 757s and 900 767s in operation in a variety of roles. The majority of 757s are the -200 series, while most 767s are –200 and –300 series aircraft. The oldest 767-200s and 767-200s are now 22 years old.

The 757 is operated in large fleets by several US majors and in a large number of smaller fleets by airlines around the globe. The 757 has only recently started to enter the secondary market, and a few have now been converted to freighter.

Only a few 767-200s have now been sold by their original operators, and some have begun to be converted to freighter. Like the 757, the 767 is beginning to enter the secondary market.

The 757 and 767 have similar designs and maintenance programmes, and entered service at the same time. This makes it appropriate to analyse their maintenance costs.

757 & 767 in operation

The 757 and 767 both operate in a variety of roles.

The majority of 757s have average flight cycle (FC) times of 2.0-3.0 flight hours (FH). A few 757s are operated in a charter role, with longer average FC times.

The annual utilisations of most are 2,500-3,000FH. Finnair has a small fleet and operates its 757 on charter routes, generating about 4,500FH annually.

The 767 is operated in a variety of short-, medium- and long-haul operations. Annual utilisations in most cases vary from 3,000 flight hours (FH) to 6,000FH. Flight cycle times vary from less than 2.0FH per flight cycle (FC) to 8.0FH. This is explained by the 767's ability to operate economically in a shuttle and domestic, or in medium- and long-haul operations, or a mixture of the two with some operators.

Examples of mixed medium- and long-haul operations are KLM and Varig. KLM uses the 767-300ER on a mixture of services from Amsterdam to London, Africa, the Middle East, the US and Canada. "Annual utilisations are 5,000FH and 1,375FC, with average FC time being 3.6FH," explains Theo Bloemendal, type project engineer 767 at KLM Engineering & Maintenance.

Air New Zealand achieves one of the world's highest rates of aircraft utilisation. "We fly our mixed fleet of 767-200ERs and –300ERs on extended range twin-engine operations (Etops) missions. These are on routes to Australia, cities across the Asia Pacific and to islands in the Pacific ocean from New Zealand. We fly at all times of the day, and consequently generate utilisations of almost 6,000FH per year. Average FC time is 7.8FH," explains John Byers, manager marketing of engineering services at Air New Zealand.

Maintenance schedule

The 757's and 767's maintenance schedule can be divided into line checks, A checks and C checks.

Line checks

Line maintenance programmes for most aircraft types follow a pattern of three main checks. The first of these is a check made at the start of each day, before the first flight. This can be referred to as a pre-flight check, although names vary between operators. A smaller line check is then performed prior to all subsequent flights in a day's operation. These can be known as transit or turnaround checks, but again names vary.

Andreas Garcia, commercial director at Aeroman TACA explains that the pre-flight check made before all flights during the day is a walk-around inspection. "This involves checking the aircraft interior and exterior for obvious damage, leaks, proper operating equipment, and security of attachments, and ensuring that all servicing has been performed."

The third type of main line check is usually performed overnight at the operator's home base, and is the largest of the three checks. This has an interval of 24 hours in most cases, but airlines are given an extension to a maximum of 48 hours so that the check can be performed at home base if the aircraft is operating away from home at night.

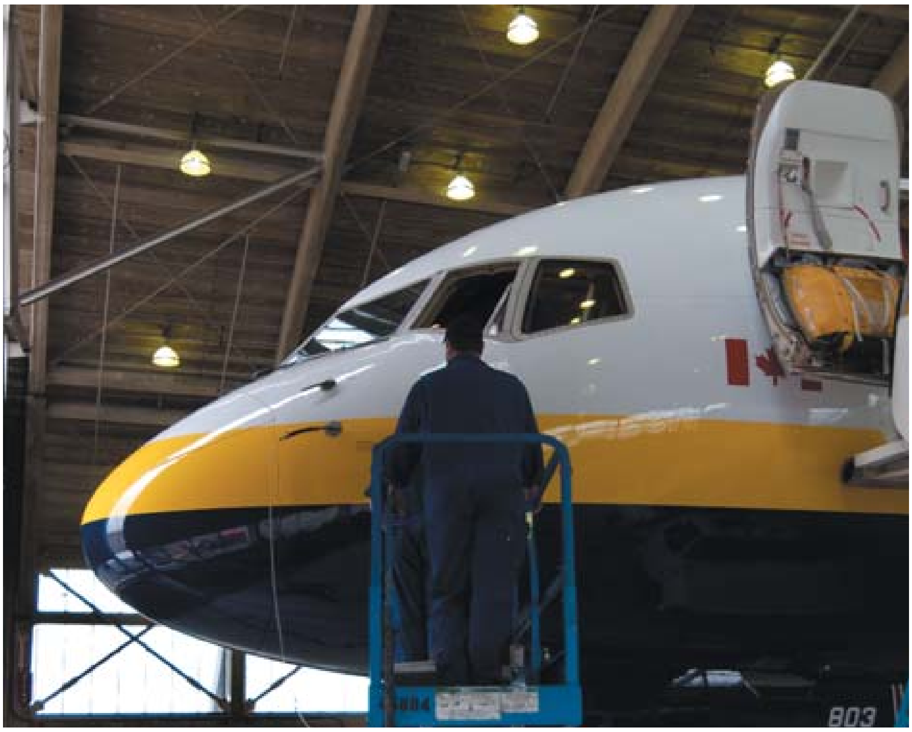
In addition to these three checks, operators may add their own checks with intervals of one or several weeks. These are often used to clear deferred defects.

The actual system of line checks used reflects an airline's operating schedule.

In the case of the 757, Finnair, for example, has a pre-flight check performed before the first flight of the day by line mechanics, and then subsequent pre-flight checks prior to all other flights in the day by pilots. "We then have a daily check," says Hannu Alanen, head of base maintenance at Finnair.

The 767's line check system is basically the same as the 757: a transit check performed prior to the first flight of the day, and pre-flight checks performed before all other flights during the day. There is then a daily or overnight check performed every 24 hours, although a maximum interval of 48 hours is permitted. This is usually performed at the operator's home overnight.

"The overnight check gives us a chance to clear deferred defects," explains Byers. Line maintenance at Air New Zealand is managed by a maintenance watch department. One of its functions is to manage deferred defects. Some can be cleared within 24 hours, while others can be cleared during A or C checks.



The 757 & 767 have the same maintenance schedule. This comprises of A & C checks with system-related and structural-related tasks. Most operators combine these tasks for simplicity in maintenance planning.

Maintenance watch also troubleshoots, reports defects for aircraft configuration management, orders parts and puts together line packages. It also clears aircraft for Etops missions and monitors parameters such as oil consumption. Our aircraft are equipped with ACARS, which transmits engine performance data and defects as they occur so they can be dealt with on the ground. This makes Etops clearance easier."

Since the 767 is operated at high rates of utilisation by many operators and in certain cases on very long routes, some airlines have added additional checks to their line maintenance programmes to allow a smooth operation.

KLM is one carrier that has additional line maintenance along with the pre-flight and daily checks. "We have a 'hangar check', which has a longer downtime than daily checks, to rectify deferred defects," explains Bloemendal. "Defects can require a significant amount of work, but we only do these when applicable and do two or three per year, or once every two A checks."

A checks

Tasks in the A and C checks in the 757's and 767's maintenance programme are system- and structural-related. The intervals stated in the maintenance planning document (MPD) are the same for the equivalent tasks and checks for both aircraft. In the case of some operators, however, intervals have been extended.

System tasks have FH intervals, while the structural tasks have FC intervals. The system and structural tasks can be performed separately, but grouping them together saves downtime. Ideally the intervals for these tasks coincide.

How operators group FH tasks and FC tasks depends on their average FH:FC ratio. The MPD's basic interval for the system-related A check items is 500FH. There are another four packages of A checks with multiples of this basic interval. These are the 2A, 3A, 4A and 6A tasks with respective intervals of 1,000FH, 1,500FH, 2,000FH and 3,000FH. The MPD has an interval of 350FC for the 1SA structural tasks. Like system tasks, there is a multiple package: the 5SA with an interval of 1,500FC.

The grouping of system and structural tasks depends on the FH:FC ratio. Aircraft with an average FC time of up to 2.8FH would reach the 500FH and 350FC intervals together. In this case, it would be most efficient to combine the system and structural items in phase. That is, the 1A with the 1SA tasks, and 5SA tasks at the 5th C check.

Aircraft with an average FC time of more than 2.8FH would reach the 1SA 350FC limit at the same time as the 1,000FH interval of the 2A tasks. In this case, it would be most efficient to combine the 1SA system tasks with the 2A structural tasks. The 5SA tasks would therefore be performed at the 10th A check, performed at 5,000FH. That is, a multiple of 10 of the 1A interval of 500FH.

Most 757 and 767 operators have an average FC time of 2.0FH or more. Those with an FC time exceeding 2.8FH could combine the 1SA tasks with the 2A items, but virtually all operators perform system and structural items in phase. This way, A1 checks have an interval of 500FH and 350FC. Only a small portion of the 350FC interval will be used, but this simplifies maintenance planning.

A checks can be arranged so that tasks with different multiple intervals are grouped in block checks, or so that packages are split to generate equalised checks that are similar in size.

Block maintenance means each multiple is performed when it comes due, so that 2A items are performed every second check, 3A items every third check, 4A items every fourth and 6A tasks every sixth. This way the size of each check varies, with the first being the smallest and the the sixth and twelfth being the largest. It takes 12 checks, to the A12 check, for all tasks to be in phase.

Equalised checks means that 2A tasks are split into halves; performed during an A check. Similarly, 3A, 4A and 6A items can be split into similar sized packages of three, four and six respectively. This way each A check is similar in size thereby simplifying planning and creating an equal downtime.

Finnair has an A check interval of 600FH for the 757. "The actual interval we achieve is about 500FH, and so the A check cycle is completed in about 6,000FH. This is equal to about 16 months of operation with our rate of utilisation. We plan to escalate our interval to 700FH," says Alanen. "We try to keep the aircraft as clean as possible, because outstations are a long way from home. We do not, however, have any additional checks between the daily and A checks, and deal with deferred defects at daily or A checks."

Ameco Beijing, the joint venture between Air China and Lufthansa and an approved maintenance organisation, maintains Air China's 767-200 and –300 fleet. "We have an A check interval of 500FH, the same as the MPD. We perform block maintenance for A checks. The A check cycle thus has an interval of 6,000FH," explains Michael Keller, manager of production engineering and planning at Ameco Beijing. "This system of block checks means the workscopes of each A check varies."

Varig similarly operates a block A check system, with a basic interval of 600FH. In contrast, KLM, which has a similar pattern of operation, uses an equalised A check system. "We have extended our A check interval several times from the MPD interval. Our current A check interval is 770FH and 250FC. Our average FC time of 3.6FH means the 250FC interval is never fully utilised. The equalisation of A check tasks results in A checks similar size, MH and downtime," explains Bloemendal. "All tasks and the A check cycle are completed at the A12 check, which has an interval of 9,240FH."

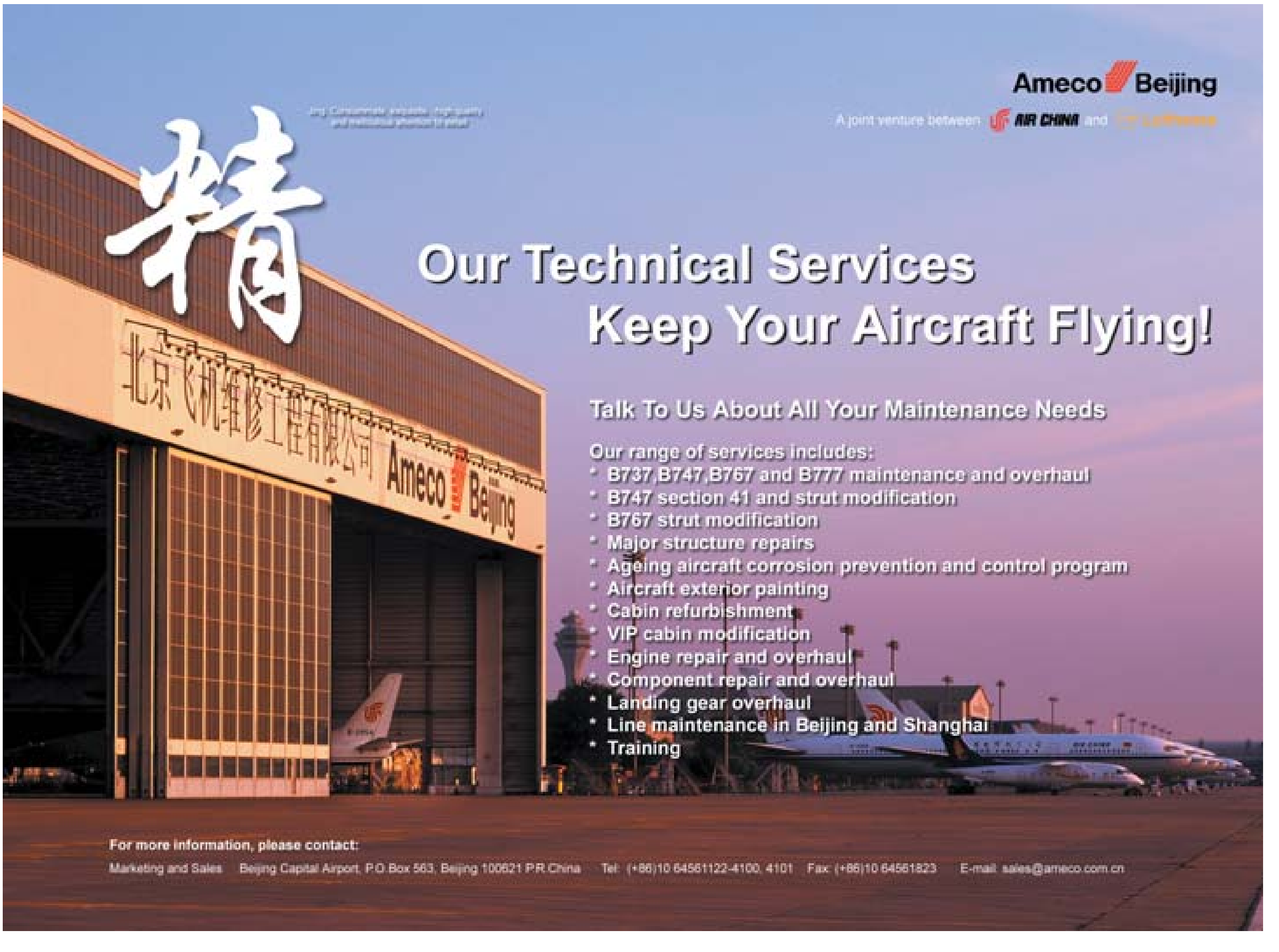
Air New Zealand also equalises its A checks. "Our A check interval is 550FH and 60 days. Our rate of utilisation means the 60-day interval is never fully utilised, and we perform an A check about every 30 days. This way deferred defects are never left too long," says Byers. "The 1A and 2A tasks are the largest. We perform half the 2A tasks every A check, but do not equalise the 3A tasks, and do them every third A check. We equalise 4A tasks and do half the 6A tasks every third A check. This results in a pattern of two smaller A checks that can be done overnight and then a heavier check every third check which has a downtime of 36 hours, and performed about every three months. This heavier A check gives us a chance to perform catch-up maintenance. The heavy rate of utilisation inevitably means the cosmetic condition of the aircraft is affected, but this heavier A check allows damage to the interior to be rectified without having to wait until the C check. The A check cycle is thus completed at the A12 check, which has an interval of 6,600FH. Actual achieved interval is about 6,000FH."

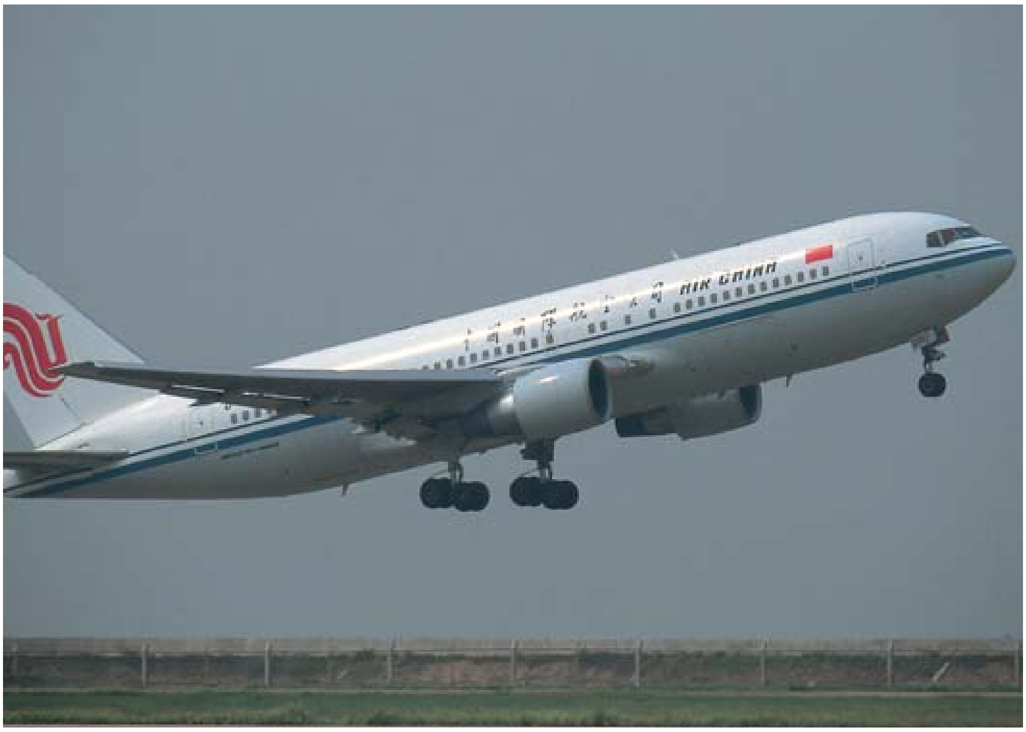
Deferred defects

As Byers has explained, Air New Zealand has a maintenance watch department to manage line maintenance. "Deferred defects are classified into A, B or C categories. A category items have to be cleared within one to three flights. For example, an inoperable auxiliary power unit (APU) has to be cleared within three flights, or during transit at Auckland. B category items have to be cleared within three days. Other items can be left until A checks, when there is a longer downtime to deal with them. The maintenance department has to report weekly on the deferred defects that each aircraft is carrying. We use the SAP system to manage this, with entries from pilot reports and technical logs entered into the SAP system. The deferred defects, and the effects on aircraft configuration, can then allow SAP to manage the fleet in respect of deferred defects, and incorporate their clearance into the appropriate line or A checks. This means deferred defects are never left too long. Examples are damage to the aircraft interior, which do not affect the aircraft's ability to operate."

Ameco Beijing has a two-tier system for classifying deferred defects. "The first system of classification is to split defects into handicap, important, minor or special items. Handicap items have to be rectified within 10 days, as these are defects that would lead to a restriction of flight operations. Important items are those that affect normal flight crew procedures, system redundancy or passenger comfort and have to be rectified within 30 days. Minor items are all other small defects, which are not classified as 'handycap, important or special' and shall be generally rectified within 120 days with possible extension to a maximum of 300 days. There are then special items, which are neither handicap or important items, and which can be left until C checks or even C4 checks to be cleared," explains Keller. "The second system is then a categorisation of defects into items that have to be cleared within a certain time period or length of operation. These categorisations are according to the aircraft's minimum equipment list. Code A items have to be rectified with one or two flights, Code B items with three days, Code C items within 10 days and Code D items within 120 days."

Defects are thus analysed with respect to both categorisations. "We manage defects in terms of resources. Quality control classifies defects and maintenance control arranges rectification after all prerequisites are fulfiled, such as ensuring sufficient parts, labour and downtime are available," explains Keller.





The A & C check tasks in the 757's & 767's maintenance programme have tasks with multiple intervals. Operators therefore have a choice of equalising A and C checks, or performing block maintenance. Some operators even equalise some C check tasks and incorporate them into A checks.

C checks

As described, the 757 and 767 have system and structural C check tasks with FH and FC intervals.

"The 1C system tasks have a MPD interval of 6,000FH and 18 months, or whichever interval is reached first," explains Garcia. "The 2C, 3C and 4C tasks thus have intervals of 12,000FH/36 months, 18,000FH/54 months and 24,000FH/72 months respectively.

"The 1SC structural tasks have an interval of 3,000FC and 18 months, whichever comes first," continues Garcia. "The 4SC tasks thus have an interval of 12,000FC and 72 months."

Combining the structural and systems tasks in phase means the aircraft would need an average FC time of at least 2.0FH if the 6,000FH are to be fully utilised before the 3,000FC interval is reached. Most operators combine the C and SC tasks in phase.

There are four C checks: the C1, C2, C3 and C4. The C1 check has an interval of 6,000FH and 18 months, and the C4 an interval of 24,000FH and 72 months. Aircraft with utilisations of less than 4,000FH per year therefore reach the 18 month calendar limit first.

Typical utilisations for 757s are in the region of 3,000FH per year, and so accumulate about 4,500FH every 18 months. The actual calendar interval between C checks has to consider the operator's schedule. While a C check may be performed in the low season, the subsequent C check may fall during the high season. Operators may only achieve intervals of 14-16 months, which would be equal to 3,500-4,000FH between checks.

Aircraft with utilisations of 4,000FH or more per year reach the 6,000FH before 18 months, and so will have a C check every 12 to 15 months.

C checks can either be performed in block maintenance or equalised. The 4C tasks form the largest group of items. Operators also usually combine all lower checks with the C checks.

"Block checks for both aircraft would be the 1C and 1SC items combined in the C1 check. The C2 check would have these items plus the 2C and 2SC tasks," explains Garcia. "The C3 check would be the content of the C1 check plus the 3C and 3SC tasks. The C4 check is the largest. This would have the 1C/1SC and 2C/2SC as well as the 4C and 4SC items. The C4 check is also the time when many operators may elect to refurbish the aircraft interior, perform out-of-phase task cards, do corrosion prevention and control programme (CPCP) tasks, take care of airworthiness directives (ADs) and service bulletins (SBs), remove and replace heavy components, and strip and repaint the aircraft."

Finnair combines the system and structural tasks in phase, and performs a 4C check on its 757s every six years.

KLM has a system to integrate the 1C items into its A checks on its 767-300s. "We divide them into six packages and add them into the most convenient A check to get an even work package," explains Bloemendal. "Our A8 check has an interval of about 6,000FH, the same as the C check. The 1C items are therefore split into six portions and incorporated into six of every eight A checks, leaving two A checks without 1C items. We then perform 2C, 3C and 4C items separately in C2, C3 and C4 checks."

Varig uses a similar system to KLM, dividing its C1 check into 10 parcels and incorporating them into A checks. The C3 check is similarly divided into the A checks. "Since the C1 interval is 6,000FH and A check interval 600FH, we complete the C1 check every 10 A checks," explains Guilherme Marroquim, senior division manager for aircraft maintenance at Varig VEM. "This leaves the C2 and C4 checks to be performed at 12,000FH and 24,000FH."

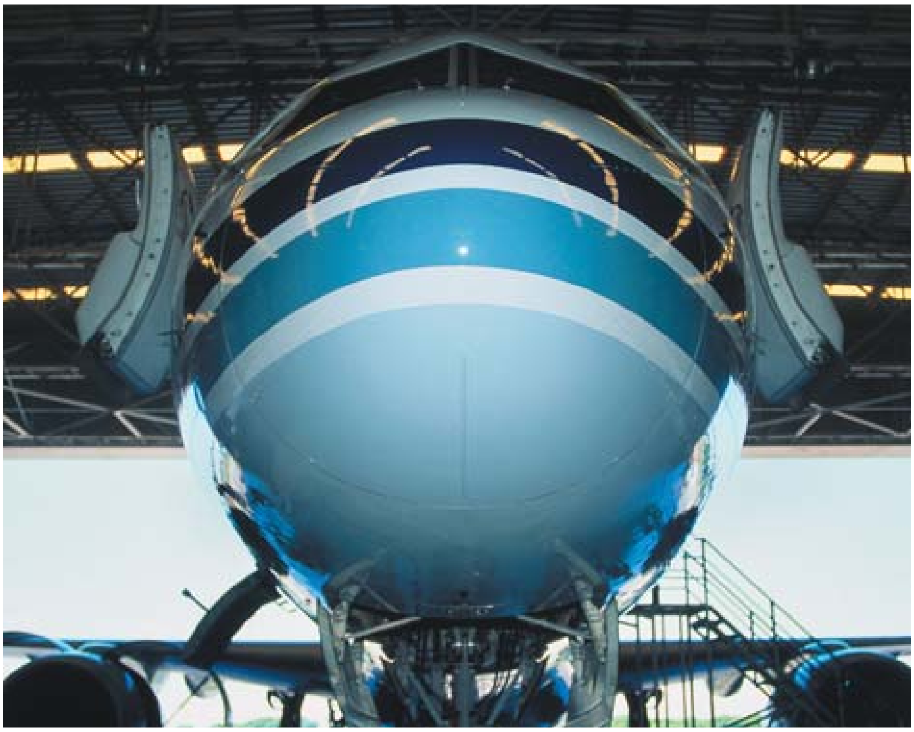
Ameco Beijing operates the MPD block system for Air China's C checks, with a C1 check at 6,000FH, C2 check at 12,000FH, C3 check at 18,000FH and C4 check at 24,000FH. "We perform block checks, with the main heavy structural check at the C4," says Keller.

"The timing of interior refurbishment depends on how heavily the aircraft is used in operation and also the FH:FC ratio. Galleys and toilets are best removed during the C4 check, since findings in structural inspections require their removal, which also makes inspections easier," explains Wolf Herholz, executive director aircraft maintenance and overhaul at Ameco Beijing. "The C4 check can also be used to do various modifications, such as engine pylons, installation of various upgraded avionics and the removal and installation of replacement landing gears. The aircraft's interior is also removed. Overall, the 4C check has about 1,200 job cards." Ameco's customers for 767 heavy maintenance include Condor, Vietnam Airlines, Asiana and Shanghai Airlines.

Air New Zealand also has a 6,000FH interval for C checks, which is reached in about 12 months with its high rate of utilisation. "We combine the 1C with the 1SC items, and also schedule our maintenance so that we complete the A12 check cycle at each C check," says Byers. "We also zero the transit and daily checks at the C check. We perform block C checks, so that the C4 check has 1C, 2C and 4C tasks, making it a large check.

Check inputs

A convenient way of analysing the inputs for checks in relation to aircraft FH is to split the maintenance into the line and A checks, and the C checks. This is because the A and C checks each have their own cycle. The A check cycle is finished at the A12 check, and includes all line checks performed up to the A12



The 757's C check has a calendar interval of 18 months, and the C4 heavy check has an interval of 72 months. Considering the utilisation of most operators and the need to have the aircraft available for busy periods of the year, most operators may only be able to achieve a C check interval of 14-16 months. Actual FH between C4 checks will be in the region of 16,000FH.

check. The C check cycle is completed at the C4 check, and includes the C1, C2, C3 and C4 checks.

The inputs for the checks in these two cycles are analysed in terms of the man-hours (MH) and cost of materials per FH accrued during the length of these cycles.

The inputs of MH and cost of materials, expendables and consumables for line checks and A checks will vary according to the tasks scheduled in each check, and the checks in to which deferred defects are incorporated.

757

The 757 has several types of operation, but this analysis assumes a utilisation of 3,000FH per year and an average FC time of 2.0FH. The aircraft would thus generate 1,500FC annually *(see table, page 32)*.

The analysis assumes an A check interval of 500FH and full A check cycle interval of 6,000FH. Utilisation of an A check interval would be 450FH, and so the A check cycle would be completed in 5,400FH *(see table, page 32)*.

With an annual utilisation of 3,000FH, a maximum of 4,500FH would be generated every C check interval of 18 months. Actual achieved interval between C checks would be 16 months, equal to 4,000FH. The C4 check would thus be performed every 16,000FH and 64 months (about five and a half years).

767

Two types of operation have been considered for the 767-200 and –300, which have a variety of operations and rates of utilisation.

The first is an aircraft with an annual utilisation of 3,000FH and average cycle time of 3.0FH, thus achieving 1,000FC per year *(see table, page 32)*.

The second is an operation with an annual utilisation of 5,000FH and average cycle time of 8.0FH, and so generating 625FC annually *(see table, page 32)*.

This assumes the same A1 and A12 check intervals and interval utilisation as for the 757. The A check cycle would thus be completed every 5,400FH *(see table, page 32)*.

The C1 and C4 check intervals are 6,000FH and 24,000FH *(see table, page 32)*.

In the first scenario, the rate of utilisation would see the A check being completed about once every 1.8 years, equal to 5,000FH. The C check would be performed at a similar interval to that of the 757: 4,000FH and 16 months. The C4 check would then be performed about every 64 months, or every 16,000FH *(see table, page 32)*.

The second type of operation, with an annual utilisation of 5,000FH, would see the A check being performed every 450FH (equal to every four to five weeks). The A check cycle would thus be completed once every 13 months. The C check would also be done about every 13 months or 5,400FH, allowing the A check cycle to be completed at the same time. The C4 check would come due about every 22,000 FH, equal to about four and a half years of operation *(see table, page 32)*.

Checks performed

In the case of all aircraft, it is assumed that 340 days of operations are possible each year. All aircraft thus require 340 daily checks and 340 overnight checks per year.

The 757 generating about 3,000FH and 1,500FC per year would then have another 1,160 pre-flight checks done each year. The A check cycle would be completed in about 5,400FH or 22 months. The aircraft would thus have 2,090 pre-flight, 610 daily and 610 overnight checks completed in the A check cycle, as well as 12 A checks *(see table, page 32)*.

The four C checks would be completed every 16,000FH and 64 months.

The 767 generating about 3,000FH and 1,000FC per year would have 660 pre-flight checks each year. The A check cycle would be completed about every 22 months, and so about 1,200 pre-flight checks, 610 daily checks and 610 overnight checks would be completed every A check cycle *(see table, page 32)*, as well as the 12 A checks. The four C checks would be completed every 16,000FH or 64 months.

The 767 generating about 5,000FH and 625FC each year would have about 285 pre-flight checks each year. The A check cycle would be completed in about 13 months, and so so about 310 pre-flight checks, 370 daily checks and 370 overnight checks would be completed every A check cycle *(see table, page 32)*. This is in addition to the 12 A checks. The four C checks would be completed in about 22,000FH and 64 months.

A & line check inputs

Inputs for pre-flight and daily checks are variable, and depend on additional line checks in an operator's maintenance programme and the way in which deferred defects are handled.

757-200

Inputs for the daily check performed prior to the first flight of the day and pre-flight checks prior to all other flights can be relatively small. Daily checks may use up to about 5MH. "We consume about 2MH plus additional work for defects," says Alanen. About $60 can be budgeted for cost of materials. Pre-flight checks consume about 1MH on average, plus a small amount for materials.

Overnight checks are the largest and

about 15MH should be expected plus in the region of $150 for materials.

In total, the 757 will use about 15,500MH and $160,000 in materials, consumables and expendables in all the line checks performed in the A check cycle.

A checks vary in size if performed in block maintenance. Lighter A checks use an average of 250MH, while heavier checks use in the region of 400MH. Average cost of materials, expendables and consumables is in the region of $6,000.

This will take total MH used in the A check cycle to about 19,000 and material expenditure to $230,000 *(see table, page 32)*. At a labour rate of $70 per MH, all inputs for the line and A checks equate to a cost of about $290 per FH *(see table, page 32)*.

767-200/-300

Keller says that under Ameco's line maintenance system for Air China's 767s, pre-flight or daily and transit checks each consume about four MH, while its after flight checks use about 20MH.

Varig, which has a similar system to Ameco, uses a similar number of MH. "We use about 12MH in the daily check prior to the first daily flight, but only up to 1.5MH in each pre-flight check. The overnight check consumes 15-20MH," says Marroquim.

Other operators use a lower number of MH for their pre-flight and daily checks, but a higher number for their additional checks. "We consume about 80MH in a hangar check, which comes due every two of three A checks," says Bloemendal.

Consumptions of 1.5MH and $ 20 for materials in pre-flight checks, 5MH and $60 for materials in daily checks and 20-25MH and $150 for materials in overnight checks will generate a total consumption of about 17,000MH and $152,000 materials costs for all line checks performed in an A check cycle for aircraft with an average annual utilisation of 3,000FH, and about 9,700MH and $83,000 for materials for all line checks for an aircraft with an average utilisation of 5,000FH. The higher consumption for the aircraft with the lower utilisation is explained by the fact that it has to complete more than twice the number of line checks in its A check cycle compared to the aircraft with the lower rate of utilisation.

A check inputs are also variable, depending on scheduled tasks. Ameco Beijing performs block A checks, as in the MPD. "We use a total of about 175MH for the smaller A1 checks and up to 500MH in the larger A12 checks. Consumption for other A checks varies between these two levels due to the different composition of each," says Keller.

Air New Zealand's system of two lighter A checks followed by a third heavier check results in a high MH consumption, although this has to be considered against its high rate of utilisation. "We consume about 425MH in each of the first two A checks, and then an average of about 1,300MH in the third heavier check," says Byers.

A checks for all maintenance programmes will consume a total of between 3,300MH and 4,500MH for the complete 12 checks in the cycle, or an average of 300-400MH for each check.

A check material, consumable and expendable costs vary with A check size, but will average $6,500.

Aircraft with a utilisation of about 3,000FH per year will thus consume in the region of 22,000MH and $230,000 in materials for all line and A checks in the complete A check cycle. At a labour rate of $70 per MH, this is equal to about $320 per FH *(see table, page 32)*.

Aircraft with the higher rate of utilisation of about 5,000FH will consume a lower total of about 14,000MH and $161,000 in materials for all line and A checks in the complete A check cycle, equal to about $215 per FH *(see table page 32)*.

C checks

C check inputs also vary. First, non-routine ratios will vary with FH:FC ratio. Inputs also depend on how well non-routine items were dealt with in previous checks, the aircraft's operating environment and age and how frequently

757-200 & 767-200/-300 HEAVY COMPONENT REPAIR COSTS

Aircraft type	757-200	767	767
FH:FC	2.0	3.0	8.0
Number main wheels	8	8	8
Main tyre retread interval-FC	300	180	180
Nose tyre retread interval-FC	350	200	200
Retread $/main tyre	350	400	400
Retread $/nose tyre	300	400	400
Number of retreads	3	3	3
New main tyre-$	1,000	1,100	1,100
New nose tyre-$	900	950	950
$/FC retread & replace	**16**	**31**	**31**
Main wheel inspection interval-FC	300	180	180
Nose wheel inspection interval-FC	350	200	200
Main wheel inspection-$	1,250	1,400	1,400
Nose wheel inspection-$	900	1,000	1,000
$/FC-Wheel repair	**38**	**72**	**72**
Number brakes	8	8	8
Brake repair interval-FC	2,000	2,000	2,000
Brake repair cost-$	40,000	45,000	45,000
$/FC-brake repair	**160**	**180**	**180**
Landing gear interval-years	8	8	8
Landing gear interval-FC	12,000	8,000	5,000
Exchange fee & repair cost-$	350,000	400,000	400,000
$/FC-landing gear repair	**29**	**50**	**50**
Thrust reverser repair interval-FC	12,000	10,000	10,000
Repair & exchange fee-$/unit	170,000	170,000	225,000
$/FC-thrust reverser repair	**28**	**36**	**36**
APU hours repair interval	3,800	2,700	2,700
Shop visit cost-$	225,000	225,000	225,000
APU HR/FC	1.5	1.5	2.0
$/FC-APU shop visit	**89**	**125**	**167**
Total-$/FC	**361**	**494**	**566**
Total-$/FH	**181**	**165**	**71**

757 & 767-200/-300 FLIGHT HOUR AIRFRAME AND COMPONENT MAINTENANCE COSTS

Aircraft	757-200	767	767
FH/Year	3,000	3,000	5,000
FC/Year	1,500	1,000	625
FH:FC	2.0	3.0	8.0
Annual pre-flight checks	1,160	660	285
Annual daily checks	340	340	340
Annual overnight checks	340	340	340
A check interval-achieved	450FH	450FH	450FH
A check cycle interval-achieved	5,400FH	5,400FH	5,400FH
A check cycle interval-months	22	22	13
A check cycle pre-flight checks	2,100	1,190	310
A check cycle daily checks	610	610	370
A check cycle overnight checks	610	610	370
Total MH A check cycle	19,000	22,000	14,000
Total materials A check cycle-$	231,000	230,000	161,000
Line & A check MH & material costs-$/FH	**290**	**320**	**215**
C check cycle interval-achieved	16,000FH	16,000FH	22,000FH
Total MH C check cycle	34,000	39,000	39,000
Total material costs-$	500,000	600,000	600,000
C check MH & material costs-$/FH	**135**	**160**	**130**
Heavy components-$/FH	**181**	**165**	**71**
LRU & rotables-$/FH			
Rotable home base capital cost	25	27	16
Pooling fee	60	65	55
Maintenance & repair	150	155	145
Total LRU & rotable cost-$/FH	**235**	**247**	**216**
TOTAL AIRFRAME & COMPONENT-$/FH	**841**	**892**	**632**

and thoroughly deferred defects are dealt with during operation and the A check cycle.

757-200

The total MH inputs for all four checks in the C check cycle will increase from the first to the second cycle as the non-routine ratio increases with age.

The total number of MH for the first C check cycle is in the region of 19,000-24,000, but this increases to 30,000-35,000MH for the second cycle.

"The MH input for a C1 check on mature aircraft with MPD items will be about 4,500," explains Garcia. This increases to about 5,100MH for a C3 check which has the additional 3C and 3SC items. The C2 check is heavier at about 6,200MH. The heavy C4 check uses in the region of 8,700MH.

"Additional MH will be used for other items, which include interior cleaning or refurbishment, out of phase tasks, CPCP items, ADs and SBs and stripping and painting," continues Garcia. "High inputs for all of these items will be required for the C4 check. Interior refurbishment will use 1,800MH, CPCP 1,000MH, ADs and SBs about 2,000MH and stripping and painting another 2,000MH. This will take the total for the C4 check to about 16,000MH.

"Smaller inputs for the interior, CPCP items, and ADs and SBs will add about another 1,500MH to each lighter C check," says Garcia. "This will take the total for all four C checks to about 36,000MH."

Paddy Ryan, head of engineering and planning at Shannon Aerospace estimates inputs for a mature 757 at about 3,600MH for a C1, 4,000MH for a C2, 7,000MH for a C3 and in the region of 18,000-19,000MH for a C4. This takes the total in the C check cycle to about 34,000MH, similar to Garcia's estimates. This amount of MH consumption is equal to 2.0-2.1MH per FH over the complete C check cycle of 16,000FH.

Cost of materials, expendables, consumables and component repairs will increase from the first C check cycle to the second and third C check cycle. A mature aircraft will use $70,000-80,000 in lower C checks, about $150,000 for the C2 check and in excess of $200,000 for the C4 check. Total material and component repair cost in the C check cycle will be $500,000 or more.

At labour rate of $50 per MH, the cost of labour and materials is equal to about $135 per FH *(see table, page 32)*.

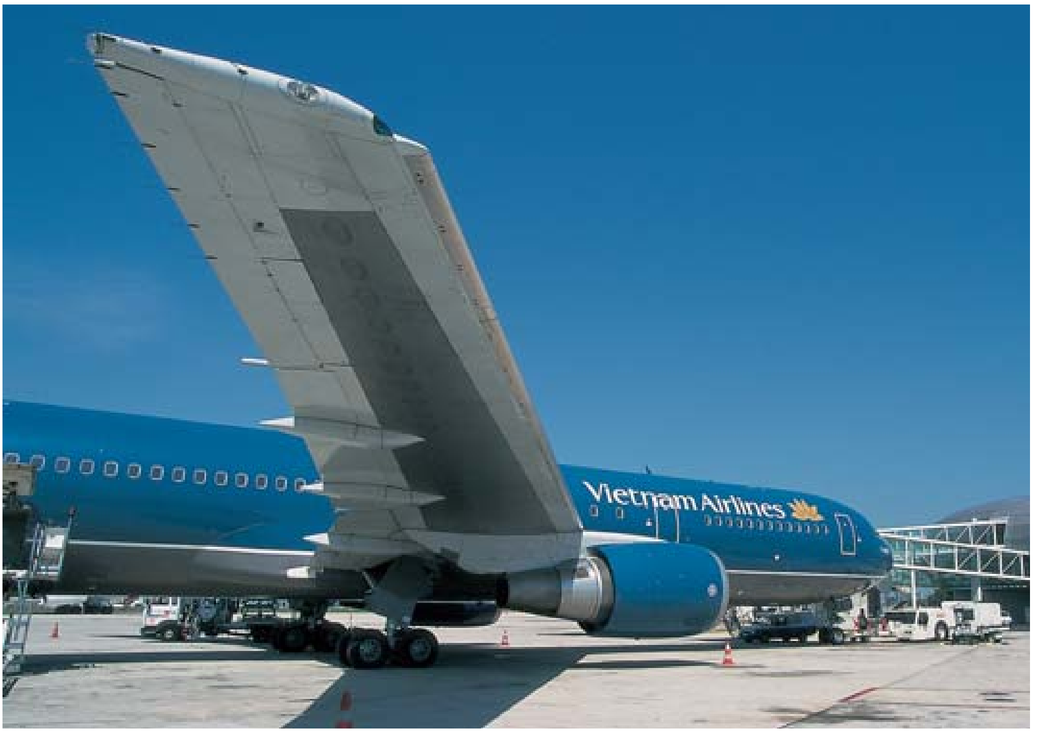
767-200/-300

Most 767s are mature, with few still in their first C check cycle. Garcia explains that the MH inputs for MPD checks for mature 767-200s/-300s are only marginally higher than for 757-200s. "Inputs for MPD checks for mature aircraft are about 3,500MH for the C1, 6,000MH for the C2, 4,500MH for the C3 and 9,200MH for the C4," says Garcia.

"The inputs for the additional items such as interior refurbishment and cabin work, out-of-phase items, CPCP tasks, ADs and SBs, and stripping and painting are slightly higher than for the 757," continues Garcia. "The C1 check therefore uses about 5,000MH, the C2 check about 7,500MH, the C3 check in the region of 6,000MH and the C4 about 16,500MH."

Experience with other maintenance providers is similar. "The C4 check, which includes refurbishment of the interior, uses up to 20,000MH. We do not perform our own strip and paint, however, which would require further MH," says Byers.

"A customised C4 check will consume about 22,000MH in total for a mature aircraft when routine and non-



Most 767s are past their first C check cycle and have reached maturity. Total man-hours used in the four C checks on the C check cycle will be 35,000-40,000 once additional items of interior refurbishment, ADs and SBs, CPCP, heavy component replacement and stripping and painting have been included.

routine tasks, modifications, component changes, ADs/SBs and interior refurbishment are included," says Herholz. Stripping and painting will add a further 2,500MH.

Total consumption for the four C checks in the cycle will be in the region of 35,000-40,000MH for a mature aircraft *(see table page 32)*.

Cost of materials, expendables, consumables and component repairs for C1, C2 and C3 checks will be similar but higher than for the 757. The C4 check will use in the region of $400,000 of total materials.

A labour rate of $50 per MH takes total input to about $160 per FH for aircraft operating at 3,000FH per year and with a C4 check interval of 16,000FH *(see table, page 32)*.

Aircraft with higher rates of utilisation and a longer C4 check interval will have a MH and material consumption equal to $130 per FH *(see table, page 32)*.

Heavy components

Heavy components include wheels, brakes, thrust reversers, landing gear and APU.

Removals for repair for the wheels, brakes, thrust reversers and APU are all on-condition. This implies intervals can be variable, but averages can be used to make an estimate of likely costs per FC.

Average repair and replacement costs can be used to estimate costs per FC for each type of component for each aircraft. Costs per FH are influenced by average FC time time.

Average intervals and repair costs have been used for tyre remoulds, tyre replacement, wheel inspections, brake repairs and APU shop visits.

Landing gear intervals are a maximum of 10 years, but many operators remove these close to eight years. These are combined with typical exchange fees to derive a cost per FC.

Costs for all components are closely related to FC intervals. Total costs per FH then depend on average FC time. Typical removal and repair intervals and repair costs result in a total cost for all components of $361 per FC for the 757, $494 per FC for the 767 operating at about 3,000FH and 1,000FC per year and $566 per FC for the 767 operating at 5,000FH and 625FC per year. This translates to $181 per FH for the 757, $165 per FH for the 767 operating at 3,000FH per year and $71 per FH for the 767 operating at 5,000FH annually *(see table, page 31)*.

LRUs & rotables

The final element of maintenance costs are those associated with line replaceable units (LRUs) and rotables. The stocks of these are often owned by the operators, and many also have their own repair facilities. To get true visibility of actual costs related to these components the equivalent costs associated with acquiring these components and having them repaired and managed by a third party provider are analysed.

The typical method is for an airline to own a home base stock. These will be high failure rate and insurance items; all of which need to be readily available. The remainder of LRUs are provided from a pool by the third party provider. All parts are repaired and managed by the pool provider.

The capital cost of the home base stock will be about $7.5 million for 10 757s, and about $8.0 million for 10 767s. The capital investment would not be much lower for a smaller number of aircraft. Financing this stock over 15 years at an interest rate of 6% results an annual cost per aircraft of $75,000 for the 757 and $81,000 for the 767. This is equal to $25 per FH for the 757, $27 per FH for the 767 operating at 3,000FH per year and $16 per FH for the 767 operating at 5,000FH per year *(see table, page 32)*.

The second cost element is the access pool fee. This is typically charged on a fixed fee per FH basis. Rates for the 757 are in the range of $60. Rates for the 767 operating at a similar utilisation will be a little higher at $65 per FH. Rates for the 767 with higher annual utilisation and longer average FC time will be $55 per FH *(see table, page 32)*.

The third cost element is the repair and management fee, which is also charged on a fixed fee per FH. This will be about $150 per FH for the 757 and $155 per FH for the 767 with a similar level of utilisation. It will be about $145 per FH for the 767 with a higher annual utilisation and longer average FC time *(see table, page 32)*.

Summary

The total for all elements of maintenance are summarised *(see table, page 32)*. The 757, operating short cycles, has a total cost for airframe- and component-related maintenance costs of $841 per FH. This is explained by the high number of line checks and high cost per FH of heavy components, which are FC-related.

The 767 operating at a similar rate of utilisation but longer average FC time of 3.0FH has a slightly higher cost per FH. The higher line, A and C check inputs slightly offset the lower costs per FH of FC-related maintenance items, such as the heavy components.

The 767 operating at a high rate of utilisation and long average FC time of 8.0FH has a lower cost of $632 per FH *(see table, page 32)*. The main reasons for this are the fewer line checks performed and the dilution effect per FH of FC-related costs of heavy components. AC