The oldest 757s are now nearing 30 years of age, and the majority of the fleet are at least halfway through their working life. The aircraft are still popular among operators, despite its maintenance requirements increasing with age. Its base check maintenance programme and inputs are assessed.

Assessing the 757's ageing maintenance requirements

The 757's base maintenance programme has generally had a base check interval of 18 months, and a cycle of four checks. The fourth check is a heavy inspection in most operators' approved maintenance programmes. The six-year calendar interval of this cycle, and the fact that most airlines will actually complete it about once every five years, means the oldest aircraft in the fleet, which are 29 years old, will have been through five base check cycles.Many other aircraft in the fleet will have been through three or four. This raises the issue of how the 757's base maintenance requirements change with age.

Ageing fleet

The four checks in the base check cycle comprise system and structural inspections with regular intervals. There are other inspections with high initial flight cycle (FC) inspection thresholds, and relatively short repeat intervals. The tasks with the lower initial inspection thresholds are related to structures, the corrosion prevention and control programmes (CPCPs), and special detailed inspections (SDIs). Those with the higher initial inspection intervals of 50,000FC relate to tasks that were originally listed separately in the supplemental structural inspection document (SSID).

The high initial inspection intervals of these tasks therefore increase the number of tasks to be performed in base checks as the aircraft gets progressively older, and the number of tasks remains high. The number of man-hours (MH) used for routine inspections rises in proportion.

A second issue is that the level of findings resulting from routine inspections steadily increases with each base check and base check cycle. The number of MH used for the non-routine rectification of defects also increases.

As the 757's airframe maintenance requirements increase with age and successive base check cycles, this affects its overall operating costs.

The 757's maintenance programme and maintenance planning document (MPD) has evolved since it entered service in 1983. A significant change to the MPD was in May 2010, when letter checks were abandoned so that instead of tasks being assigned to particular blocks or groups, they were assigned interval criteria. While this allows airlines to group tasks according to their pattern of operation, large numbers of tasks still have the same intervals. The task intervals are also multiples of each other, so it is still convenient for many operators to group tasks into block checks.

Fleet profile

The 757-200 active passenger fleet has shrunk by 190 units since 2005, from 826 aircraft to 637. There are also 54 active 757-300s, making a total of 691 active passenger-configured aircraft.

The number of freighter-converted aircraft has increased by 72 units to 109. There are another 79 factory-built freighters. The number of parked aircraft has increased by 58 to 84. The active and parked fleet therefore totals 963 aircraft.

Since conventional base check cycles are completed every five to six years, the fleet should be considered in blocks of age groups. Although most MPD task items have flight hour (FH) and FC intervals, the combined calendar limits on tasks are usually reached first, so are the main driver of check timing and check cycle completion. Actual check interval utilisation by airlines means that they can expect to complete first base check cycles when aircraft are five to six years old.

The fleet of 879 active aircraft is summarised according to configuration, engine types, age and base check cycle *(see table, page 35)*.

There are no aircraft younger than six years, so all have had their first heavy check. Sixty aircraft are in their second base check cycle, 256 are in their third, 391 are in their fourth, 158 in their fifth, and 14 in their sixth. Most of the fleet, 805 aircraft, and another 84 parked aircraft, are in their third, fourth and fifth base check cycles *(see table, page 35)*.

MPD development

The 757's MPD and maintenance programme used to centre round a system of four C or base checks. The aircraft's maintenance programme has also centred round a cycle for six A checks.

A and C check tasks either had FH-related intervals, or FC-related intervals combined with a calendar interval. Some tasks or groups of tasks also had a secondary calendar interval. The FH-related tasks were system-related, while FC-related tasks were for structural and corrosion inspections.

The main groups of A and C check tasks are mostly system- and structures-related tasks. System tasks mainly have FH-related intervals, while structures tasks mainly have FC-related intervals. The maintenance programme, however, has evolved over the years. "Lubrication tasks, for example, were listed separately, but have been incorporated into the FH-related and system tasks," says Sandra Everest, estimator at ATC Lasham. "Some tasks have been amalgamated with others or completely dropped.

"Major changes over the years include the incorporation of the CPCP and SSID tasks into the main body of the 757's MPD," adds Everest. "However, they are listed as separate groups on others such as the 737 Classics."

Several other additions have been made to the inspection tasks, most of which are listed in appendix C of the MPD. "These have materialised as a result of concerns over the fuel system, and include: the airworthiness limitation (AWL) items; the certification maintenance requirements (CMRs); the Electrical Wiring Interconnection System (EWIS); and Enhanced Zonal Analysis Programme (EZAP)," says Peter Cooper, planning manager at Civil Aviation Services. "The AWL items are listed in section 9 of the MPD, and can be sub-divided into three groups: structural AWLs; fuel system AWLs; and the nitrogen-generating system (NGS) AWLs. These all relate to the prevention of electrical arcing in the fuel tanks. The inspections in the EWIS and EZAP task groups are mainly physical, and relate to wiring and earthing. There are special Federal Aviation regulation (SFAR) inspections related to electrical checks and issues with resistance and earthing."

Everest adds that the 30 or so fuel-related AWL tasks can be triggered by other inspection tasks in the MPD, or have to be performed as a result of findings from routine inspections, or are standalone tasks.

The CMR tasks are listed in section 9 of the MPD, but are also routine tasks listed in appendix C of the MPD.

Cooper explains that the structural and corrosion inspections were initially in separate sections of the 757's MPD. Later, these tasks were included in the Integrated Structural Inspection Programme (ISIP), instead of having them in separate sections. The aim was to combine tasks and reduce their number, but as task intervals were also reduced, there was actually little change in the maintenance burden. This disappeared in 2010 when the items were integrated into the structural inspections in the MPD, and the tasks were re-numbered.

SSID tasks are listed in two groups. The first of these comprises some of the tasks listed in appendix C of the MPD, with an initial inspection interval of 50,000FC. The second group is listed in section 9 of the MPD. Many of these also have initial intervals of 50,000FC, while others' initial intervals are derived from a flight-length sensitive (FLS) graph.

757 FLEET SUMMARY

Age range	Pax RB211-535	Pax PW2037	Pax PW2040	Pax 757-300	Factory freighter	Converted freighter	Total
6-10 years	40	17	3				60
11-15 years	107	74	10	39	22	4	256
16-20 years	157	77	60	15	42	40	391
21-25 years	30	62			15	51	158
25-30 years						14	14
Total	**334**	**230**	**73**	**54**	**79**	**109**	**879**

Higher maintenance tasks

The tasks with the highest intervals in the 757's MPD are those with an initial interval of 50,000FC *(see table, page 36)*. "These are structural inspections involving NDT and special detailed inspections of fail-safe structures. Some are also SSID tasks," explains Everest. "They also go deeper than CPCP tasks that inspect for corrosion."

There are 301 tasks in this group, and include structural inspections of: the fuselage skin; skin lap joints; cargo and passenger door frames and cutouts; engine pylons; the horizontal stabiliser; bulkheads; wing structures and spars; floor beams; and flap support beams and tracks.

The extent of these tasks, and the deep access needed for the inspections, mean this is likely to represent a retirement watershed for most operators. Only 60 aircraft in the entire 757 fleet have accumulated more than 35,000FC.

There are also zonal tasks, most of which have FA-related intervals, while the rest have FC-related intervals. The zonal inspections are purely visual and physical, and involve inspecting for cracks, corrosion and breakages. They require no disassembly or borescope inspections.

Line & A check tasks

The group of system A check tasks, with a basic interval of 500FH in the current MPD, is known as 1A tasks. The interval was originally 250FH when the aircraft entered service in 1983, and this steadily increased to 300FH, 400FH, and then to 500FH in 1994. Another four groups of system A check tasks are known as the 2A, 3A, 4A and 6A tasks. These have corresponding multiple intervals of the 1A tasks: 1,000FH, 1,500FH, 2,000FH and 3,000FH.

Despite these intervals with clear multiples of 500FH, a large number of other tasks have intervals that are not multiples of 500FH, for example intervals of 600FH and 750FH. These would be included together with 1A tasks for ease of check planning. There are also tasks with 4,000FH and 4,500FH intervals. which would be performed every eighth and ninth A check.

There are two groups of structural A check tasks. The basic interval of 300FC is for the S1A tasks, but the S5A tasks have an interval of 1,500FC, five times the basic interval.

The A check items do not, however, have tasks with initial intervals higher than this. A check items therefore do not have the effect of increasing the aircraft's maintenance requirements with age.

System base tasks

The group of system C check tasks, with a basic interval of 6,000FH and 18 months in the current MPD, were referred to as 1C tasks *(see table, page 36)*. These had an original interval of 3,000FH at service entry, which has risen steadily to 6,000FH and 18 months; the calendar interval being added during the interim.

"Letter checks and this type of nomenclature have not been used in the main body of the 757's maintenance programme since 2010," says Everest. "These names can still be used, however, for generic purposes. The large number of tasks that were referred to as '1C' tasks still have the same interval, and can be planned into base checks in the same way as before."

In the latest revision of the 757's MPD, there are another three groups of system C check tasks which have multiples of the basic 1C interval: the 2C tasks at 12,000FH/36 months; the 3C tasks at 18,000FH/54 months; and the 4C tasks at 24,000FH/72 months *(see table, page 36)*. The May 2010 MPD had 249, 101, 12 and 121 of these tasks.

A small number of other tasks has differing intervals to the main multiples.

757 C/BASE CHECK TASK GROUPS

System tasks	Initial interval FH/months	Repeat interval FH/months	Number of MPD tasks
1C	6,000/18	6,000FH/18 months	253
2C	12,000/36	12,000FH/36 months	107
3C	18,000/54	18,000FH/54 months	12
4C	24,000/72	24,000FH/72 months	124
6C	36,000/108	36,000FH/108 months	11
8C	48,000/144	48,000FH/144 months	15
Structure tasks	**Initial interval FC/months**	**Repeat interval FC/months**	**Number of MPD tasks**
S1C	3,000/24	3,000FC/24	81
S2C	6,000/36	6,000FC/36	88
S3C	9,000/54	9,000FC/54	16
S4C	12,000/72	12,000/72	112
S6C	18,000/108	9,000/54	4
S8C-I	24,000/144	6,000/36	5
S8C-II	24,000/144	12,000/72	21
S10C-I	30,000/180	12,000/72	8
S10C-II	30,000/180	15,000/90	2
S10C-III	30,000/180	18,000/108	2
S12C-I	36,000/216	12,000/72	29
S12C-II	36,000/216	18,000/108	7
S12C-III	36,000/216	24,000/144	6
50,000FC-repeat 3,000FC	50,000	3,000	21
50,000FC-repeat 6,000FC	50,000	6,000	25
50,000FC-repeat 9,000FC	50,000	9,000	12
50,000FC-repeat 12,000FC	50,000	12,000	243

Note: There are additional SSID tasks listed in section 9 of the MPD. These have initial intervals of either 50,000FC or that are determined from the FLS graph.

Some tasks have an interval of 7,500FH and 10,800FH, while some have an initial interval of 12,000FH with a repeat interval of 6,000FH. There are only four tasks with these three intervals, so these are likely to be grouped with the large number of tasks with an interval of 6,000FH/18 months. This takes the number of tasks in the 1C group to 253 *(see table, this page)*.

There are also six tasks with intervals of 15,000FH and 17,300FH. These are also likely to be grouped with the 2C tasks, taking the total in the group to 107 *(see table, this page)*.

Three tasks have an interval of 30,000FH, so would be grouped with the 4C tasks for ease of planning, taking the total to 124 *(see table, this page)*.

There are also a small number of C system inspection tasks with higher intervals of 36,000FH/108 months, and 48,000FH/144 months. These could generically be referred to as 6C and 8C tasks *(see table, this page)*. There are 11 and 15 of these tasks, which could be planned into every sixth and eighth check; making the workscopes of higher checks slightly larger than lower checks. "These tasks have appeared as a result of the EWIS and EZAP, due to concerns over the fuel system," says Cooper. "The inspections in these two task groups are mainly physical, and relate to wiring and earthing. There are also SFAR inspections related to electrical checks and issues to do with resistance and earthing."

Structures base tasks

The first four main groups of structures tasks form the largest number of FC-related tasks. The basic interval for the structures tasks is 3,000FC/24 months, and they are performed at whichever interval is reached first. The calendar interval has been extended from 18 months, which was used for many years. These tasks can still be generically referred to as the S1C tasks, and total 81 inspections *(see table, this page)*.

There are three other main groups of structures tasks: the S2C, S3C and S4C tasks, with intervals of 6,000FC/36 months, 9,000FC/54 months and 12,000/72 months. These include 88, 16 and 112 inspections *(see table, this page)*. Despite the S1C's calendar interval of 24 months, the other three groups of tasks have intervals that are multiples of 18 months.

Given that the system and structures tasks both have calendar intervals that are multiples of 18 months, that most passenger-configured aircraft operate at FH:FC ratios of 1.8-2.9:1, and that the calendar interval accompanies both the FH-related and FC-related task groups, it is simplest for most airlines to plan the 1C and S1C tasks, as well as the other three corresponding multiples of system and structures tasks, together in block checks *(see table, page 38)*. This means the main cycle of base checks comprises four checks, with an interval of 18 months between checks and the cycle interval of 72 months. These are known as C1, C2, C3 and C4 checks *(see table, page 38)*.

The 18-month multiple calendar interval is the main driver of check timing. FH-related tasks also have an interval of 6,000FH, but this is unlikely to be fully utilised in the 18-month calendar period. An aircraft operating at a typical utilisation of 2,700FH per year will only accumulate 4,000FH in the check interval.

The FC-related tasks have an interval of 3,000FC, but are only likely to accumulate 1,650FC in the 18-month period.

Additional tasks

In addition to these four main groups of structures tasks, there are many other groups of structures inspections with FC and calendar intervals.

Several groups of tasks have repeat intervals that differ from initial intervals. Five different initial intervals vary from 18,000FC to 50,000FC. The first four of these have combined FC and calendar intervals.

The first group consists of four tasks, with an initial interval of 18,000FC/108 months, and a repeat interval of 9,000FC/54 months. These two groups could generically be referred to as the S6C tasks. "These tasks could originally have been some of the CPCP tasks," says Cooper.

The second main initial interval is 24,000FC, and there are two sub-sets of tasks: one with a repeat interval of 6,000FC/36 months, and just five tasks; and one with a repeat interval of 12,000FC/72 months, and 21 tasks *(see table, this page)*. These two groups could be generically referred to as the S8C tasks.

These S8C tasks are one of the largest groups of structural tasks in the MPD. The 26 S8C tasks include inspections to: the lower lobe of the fuselage barrel; the lower lobe skin; the pressure bulkhead; and wing skins. "The S8C group of tasks are especially difficult to perform, because of the deep access required for

757 BASE CHECK MAIN SYSTEM & STRUCTURES TASKS POSSIBLE GROUPING IN BLOCK CHECK ARRANGEMENT

Base/C check	FH-tasks	FC-tasks	MPD interval FH/FC/Months	Likely interval FH/FC/Months
C1	1C	S1C	6,000/3,000/18	4,050/1,650/18
C2	1C + 2C	S1C + S2C	12,000/6,000/36	8,100/3,300/36
C3	1C + 3C	S1C + S3C	18,000/9,000/54	12,150/4,950/54
C4	1C + 2C + 4C	S1C + S2C + S4C	24,000/12,000/72	16,200/6,600/72
C5	1C	S1C	30,000/15,000/90	20,250/8,250/90
C6	1C + 2C + 3C + 6C	S1C + S2C + S3C + S6C	36,000/18,000/108	24,300/9,900/108
C7	1C	S1C	42,000/21,000/126	28,350/11,550/126
C8	1C + 2C +4C + 8C	S1C + S2C + S4C + S8C	48,000/24,000/144	32,400/13,200/144
C9	1C + 3C	S1C + S3C	54,000/27,000/162	36,450/14,850/162
C10	1C + 2C	S1C + S2C + S10C + Rpt S8C-I	60,000/30,000/180	40,500/16,500/180
C11	1C	S1C	66,000/33,000/198	44,550/18,150/198
C12	1C + 2C + 3C +4C +6C	S1C + S2C +S3C + S4C +S6C +S12C + Rpt S8C-I + Rpt S8C-II	72,000/36,000/216	48,600/19,800/216
C13	1C	S1C	78,000/39,000/234	52,650/21,450/234
C14	1C + 2C	S1C + S2C + Rpt S8C + Rpt S10C-I	84,000/42,000/252	56,700/23,100/252
C15	1C + 3C	S1C + S3C + Rpt S10C-II	90,000/45,000/270	60,750/24,750/270
C16	1C + 2C + 4C +8C	S1C + S2C +S4C + S8C + Rpt S10C-III + Rpt S12C-I	96,000/48,000/288	64,800/26,400/288
C17	1C	S1C	102,000/51,000/306	68,850/28,050/306
C18	1C + 2C + 3C + 6C	S1C + S2C+ S3C + S6C + Rpt S8C-I + Rpt S10C-I + Rpt S12C-II	108,000/54,000/324	72,900/29,700/324
C19	1C	S1C	126,000/57,000/342	76,950/31,350/342
C20	1C + 2C + 4C	S1C + S2C + S4C + S10C + Rpt S8C-I + Rpt S8C-II + Rpt S12C-I + Rpt S12C-III	132,000/60,000/360	81,000/33,000/360

For an aircraft operating at an annual utilisation of 2,700FH and 1,100FC per year

several NDT inspections and heavy structural tasks," says Everest.

The third main initial interval is 30,000FC/180 months, and comprises the S10C tasks. There are three sub-sets of tasks with repeat intervals of 12,000FC/72 months, 15,000FC/90 months, and 18,000FC/109 months *(see table, page 36)*. The S10 tasks include inspections to the wing-body fairing and the keel beam.

The fourth main initial interval is 36,000FC/216 months. This group of tasks could be generically referred to as the S12C tasks. There are three sub-sets of tasks with repeat intervals of 12,000FC/72 months, 18,000FC/108 months, and 24,000FC/144 months. These have 29, seven and six tasks *(see table, page 36)*. Many aircraft have not reached the initial threshold for performing these tasks.

"The S12C tasks, which come due at the C12 check, are much heavier than the S8C structural tasks that come due at the C8 and C16 checks," says Emre Apaydin, engineering and production planning director at MNG Technic. "Some of the tasks were actually moved from the C8 to the C12 check in the May 2010 revision of the MPD. Others were already in the C12 check. Many of these involve heavy inspections, and require the removal of many interior items such as galleys, toilets, overhead bins, seats and panels to gain access. They also involve inspections to the lower and upper lobe, structures in the horizontal stabiliser, engine strut fittings, and flap spars and carriages.

This uses a lot of MH. Many S12C tasks have a repeat interval of every fourth check, and so occur again at the C16 and C20 checks.

Cooper adds that these last three groups are also probably the original CPCP tasks that have been incorporated into the MPD in more recent years.

The fifth main group has an initial interval of 50,000FC, and comprises 301 tasks, representing a major maintenance event and possibly a retirement watershed for aircraft. These tasks can be divided into four sub-sets, with repeat intervals of 3,000FC, 6,000FC, 9,000FC and 12,000FC.

Base check arrangement

While the MPD no longer terms blocks of tasks as letter checks, the grouping of a large number of tasks means many 757 operators are still likely to group tasks into checks in the traditional block format. Some operators, however, split groups of tasks into smaller packages, and plan base checks in an 'equalised' format. Equalised checks with smaller work packages require short periods of downtime, which will suit some operators.

To illustrate the gradual rise in the number of routine tasks over successive base check cycles and overall age of the aircraft, the different task groups and number of MPD tasks can be analysed by using a block check system of base maintenance planning over five successive base check cycles. This analysis would be based on a generic aircraft achieving an annual utilisation of 2,700FH and 1,100FC, equal to a FH:FC ratio of 2.5:1.

The analysis assumes that all the task groups remain in phase over the series of 20 base checks, so the 1C and S1C tasks will be performed every check, and the 2C and S2C tasks will always be carried out together with the 1C and S1C every second check. "In fact, as the aircraft ages, task groups get out of phase because of aircraft operating schedules and achieved rates of utilisation, and smaller checks often have to be scheduled to perform tasks that were not included in previous checks," says Cooper.

The MPD task groups, MPD interval, and the likely FH and FC the aircraft will have accumulated at the time of the check for each of the 20 base checks are summarised *(see table, this page)*.

The 1C and S1C are therefore the

The 757's base check tasks have either FH- or FC-related intervals. Both types of tasks also have calendar intervals that are mostly multiples of 18 months. The 18-month interval is the main driver of check intervals, and tasks arranged into block checks often conform to a cycle of four checks, with a total interval of six years; the fourth check including heavy structural inspections.

only task groups to be included in the first base check, which can be referred to as the C1 check. These total 334 tasks. These task groups will be included in all subsequent checks.

The C2 check at 36 months will have the 1C, 2C, S1C and S2C tasks, since all come due at this interval, and total 529 tasks.

The C4, the heaviest check in the first base check cycle, will have the same tasks as the C2 check, plus the 4C and S4C tasks; taking the total number of inspections to 669.

The second base check cycle will thus be the C5 to C8 checks. The C5 check will have the same task groups as the C1 check *(see table, page 38)*. This check will come due at 90 months.

The C8 check is the second heavy check the aircraft has to go through. With a calendar interval of 144 months, it will have the same task groups as the C4 check, plus the 8C and two groups of S8C tasks. At this check 499 FH-related tasks come due, and 297 FC-related ones. "The S8C group of tasks include a lot of heavy inspections to do with NDTs in the fuel tanks. These need a lot of MH for deep access, and so overall have a high MH requirement," says Everest.

The third base check cycle will be the C9 to C12 checks. The C9 check will be relatively light, because it will only include the 1C, 3C, S1C and S3C tasks.

The C10 check is the first in the succession of checks to have a group of repeat tasks of FC-related inspections. The first group of S8C tasks (referred to as Rpt S8C-I tasks) is repeated for the first time at this check, and every two checks thereafter. The C10 check will therefore have six different task groups, generating a total of 546 inspections.

The C12 check is the largest check the aircraft has undergone up to this point. It has 13 different task groups *(see table, page 38)*, including two sets of FC repeat tasks. The number of inspections totals 875, compared to 764 for the C4 and 805 for the C8.

"The S12C tasks include two that involve a visual inspection of the engine pylons, and the removal of both the engines and the pylons," says Everest. "It takes 900MH to remove and reinstall both engines and both pylons, while the inspection itself, according to the MPD, only uses four MH per pylon.

"There is also an airworthiness directive (AD) that requires modification to the engine pylons," continues Everest. "This modification is usually combined with these routine inspections. Although the major pylon inspections have the S12C interval, which require the pylons to be removed, they can often be scheduled on a C8 check as out-of-phase tasks. This is because there are many structural tasks in the S8C group, and a lot of operators find it convenient to combine the two groups. There are also some S10C tasks that require the floor to be lifted, so because they require a lot of access they are often scheduled into the C8 check for convenience."

The fourth base check cycle includes the C13 to C16 check. Provided the task groups fall into a neat sequence according to their calendar intervals as illustrated *(see table, page 38)*, the C13 check will be light and have just the 1C and S1C tasks. The C16 tasks, which have a calendar interval of 288 months/24 years and a FC interval of 48,000FC, comprise the fourth heavy check.

The tasks coming due at the C16 check are the same as the C8 check, plus three additional groups of FC-related repeat tasks. This takes the total number of tasks to about 830; about 160 more than the C4 check.

If all tasks are still in phase, then the C17 check will be light with only the 1C and S1C tasks coming due. The C18 check has four FH and four FC task groups on phase, which generate a total of 562 inspections. Twenty repeat FC tasks come due at this check, taking the total to 582.

The C20 check, with an MPD interval of 360 months/30 years, is likely to come due when the aircraft is 26-27 years old, and has accumulated about 30,000FC. There are three FH and four FC task groups in phase at this check that generate a total of 777 inspections. There are also about 56 repeat FC tasks coming due at this check, taking the total to 833.

Base check inputs

The total labour, material, consumable parts and rotable component cost inputs for the base cheeks comprise several elements. The first of these is routine inspections or tasks, as detailed in the aircraft maintenance manual (AMM). "The routine portion of an airframe check includes labour and material input to prepare the aircraft for its check, as well as all the access required to make the inspections possible," explains Apaydin.

The second element will be the rectification of non-routine defects arising from the routine tasks or inspections. The MH used for non-routines is often expressed as a percentage or ratio of MH used for routine inspections.

The sub-total of MH for the routine and non-routine elements of airframe checks accounts for most of the labour input.

Other elements include: interior cleaning; interior refurbishment; the completion of engineering orders (EOs), ADs and service bulletins (SBs); heavy component and rotable component changes; and stripping and repainting.

Associated with the labour used for these elements will be the cost of: materials and consumables; life-limited parts, and those that can be expected to fail functional tests during the check; materials and consumables used for interior refurbishment; and the cost of any stripper and paint used.

The 757 has an AD which involves a large modification to the engine pylons. This requires the removal of engine cowls, engines and pylons. It consequently uses a large number of man-hours and requires a check with a long downtime. This AD is often planned into a heavy check; often a C12 or C16 check.

Routine inspections

As described, the MH used for the routine inspections will comprise the three main elements of aircraft preparation, access and performance of the actual tasks.

"The task cards detailed in the MPD specify estimated MH to complete the inspection, but these figures have to be escalated by a factor to arrive at a realistic number of MH," says Apaydin. "This is because the MPD MH do not give an estimate for preparing the aircraft or gaining access to allow the inspection.

"The escalation factor is higher for tasks that require deep access, such as some of the deeper structural inspections," continues Apaydin. "It is difficult, however, to get an accurate escalation factor to arrive at an accurate estimate of what MH will be required for the routine inspections in the workpackage. Taking the groups of tasks specified for each of the 20 base checks *(see table, page 43)*, the escalation for the heavy checks (the C4, C8, C12, C16 and C20), is a factor of up to 7. The escalation factor of the three lower base checks in each base check cycle is lower, but can be between 5.0 to 6.0."

Cooper explains that some tasks can require several hundred MH. "For example, a structural inspection that requires the lifting of the floorboards therefore involves the removal of the seats, carpet, and other interior items that can include closets and toilets, all before the floorboards can be lifted," explains Cooper. "These have to be put back, and can involve a lot of MH to get the in-flight entertainment system to work after reinstallation. The number of MH for access can thus be several hundred for some task cards. Another example is inspection on the lower and upper fuselage lobes.

"Four main elements have to be considered when estimating the MH used for routine inspections," continues Cooper. "These are: aircraft preparation and docking; gaining access to inspection areas; the labour for the actual inspections; and a technical clean of some components, such as flap tracks and doors, to remove grime and dirt that has accumulated so that the inspections can be made. The escalation factor to use is therefore not easy to calculate."

The MPD MH for the C1 check, and all others with the same group of tasks is 180-260MH. The larger C9 and C15 checks require 190-280 MPD MH. The C2/6/14/18 checks are still larger, and use 350-450MH for MPD tasks. The C10 is the largest check of the light C checks, and uses 385-470MH for the MPD tasks.

Once escalated to actual MH required for the whole of the routine inspection process, the lightest C1 checks will use 1,000-1,300MH. This can increase up to 1,900MH once the later light checks in the series of 20 base checks are reached. These are the C15 and C19 checks.

Larger checks like the C2, C6, C14 and C18 will use 2,000-3,500MH; although the workscopes will vary.

MPD MH for the four heavy checks in the C4, C8, C16 and C20 checks are similar at 600-750, although even the actual amount will vary between estimators. The MPD MH for the C12 check are higher at 800, since this includes the largest number of task groups and tasks.

In addition to MPD base check tasks, base checks will include the tasks for smaller line and A checks, as well as the clearing of technical defects that have accumulated during operation.

Assuming that the tasks scheduled in the workscopes of these five checks are as specified, the C4 is the smallest and will require 4,000-5,000MH. The C8, C16 and C20 checks are of a similar size, and will use 5,500-7,000MH, depending on escalation factor, customer-specific tasks and labour efficiency.

The C12 is the largest, and will use 7,000-8,500MH for routine tasks and inspections. "The C16 is theoretically larger than the C12, because of the C16's tasks. The C12, however, requires a lot more MH for access, and so is bigger than the C16," says Apaydin.

The routine MH for each check and each base check cycle are summarised *(see table, page 43)*.

Defects & non-routine

The routine inspections inevitably result in defects and non-routine rectifications. The labour needed to rectify defects is used in relation to the routine tasks. "The amount of defects can be expressed either as a ratio to the MH used for just the inspections, or as a ratio to the total MH for the routine portion," says Apaydin. "If expressed as a ratio to the total routine MH then it looks small. What is ultimately important is the number of MH used for the rectifications. This will gradually increase with age and successive base check cycles. It reaches a peak at each heavy check, and then drops again for the first light check of the next base check cycle."

The causes of defects and non-routine rectifications also have to be appreciated. "One main cause is corrosion, especially in the seat tracks which get wet due to spillage of drinks, and in engine pylons and in the flap spars," explains Everest. "Cracks are another cause of defects, as well as ramp damage, foreign object damage, moisture, erosion in door boxes, and general wear."

Non-routine ratios will have been low for aircraft in their first base check cycle. Although all 757s are now beyond their first base check cycles, defect ratios started low at 0.25-0.30 of all routine MH at the C1 check. They will have then steadily increased to as much as 0.75 for the C4 check.

The non-routine ratio drops at the

The 757 has some structural tasks with high initial and shorter repeat intervals. These intervals are FC-related, and they involve deep inspections. They consequently have the effect of driving up the aircraft's maintenance requirements.

following C5 check, and steadily rises over the second base check cycle to the C8 check. The non-routine ratio rises by a factor of 0.10 for each successive base check cycle, so that it reaches 1.0 by the C12 check, and can be 1.0-1.2 by the C16 and C20 checks.

The resulting number of MH required for the non-routine rectifications, and the sub-total of routine inspections and non-routine rectifications for each check and each base check cycle are summarised *(see table, page 43)*. The MH required for freighter configured aircraft will be lower because fewer routine tasks will apply.

Interior work

Interior work is sub-divided between cleaning and refurbishment. Few items are specified in the MPD, so as these are customer-specified tasks, the inputs for interior work vary widely between customers and individual aircraft.

"Interior cleaning will include hand-washing and chemical cleaning sidewall panels and bulkheads, cabin carpets, overhead bins, and galleys and lavatories. This is done to maintain a clean interior appearance," says Apaydin. "About 200MH can be allowed at each C check for this type of cleaning. This does not include the regular cleaning of the seat covers, since this is regarded separately."

Interior refurbishment also varies by operator. Many refurbish main items such as galleys and lavatories, galley equipment, bulkheads, panels, closets, passenger service units, carpets, and flooring in service areas. "This does not have to be done during heavy checks, and some of this work will be done on an as-required basis during lighter C checks," says Apaydin. "Many major items need to be removed during heavy checks like the C8, C12 and C16 because of the deep access required for structural inspections. This gives an opportunity to refurbish major cabin items. An allowance of 2,000MH can be used per base check cycle for interior refurbishment."

The labour required for interior work on freighter-configured aircraft will be a fraction of that required for passenger-configured aircraft.

EOs, ADs & SBs

Labour and material inputs for EOs, ADs and SBs are variable. The first issue is that ADs and SBs are issued at random, and only affect particular line numbers. Aircraft built during the latter years of production will have had progressively fewer ADs and SBs issued against them than the oldest aircraft.

Many are issued on a regular basis, and are relatively small in terms of their labour and material input requirements. An allowance or budget can therefore be made for these smaller items.

Relatively few major ADs have been issued against the 757. "The most notable one is the pylon modification. Its AD numbers are: AD 2004-12-07, which includes SB 757-54-0035 for RB211-powered aircraft; and AD 2003-18-05, which includes SB 757-54-0034 for PW2000-powered aircraft," says Apaydin. "The threshold for completing the modification is at an age of 20 years or upon reaching 37,500FC, whichever is reached first. As most of the fleet has not reached either of these thresholds, it does not have to be modified. A larger number of aircraft have incorporated the AD.

"The AD requires the removal of the engine, the engine cowls, the thrust reverser units, and the engine strut or pylon," continues Apaydin. "As many as 2,000MH are used for this whole process. The AD requires a re-work of the lugs in the pylons, and uses at least 600MH to do both pylons on the aircraft. It can even reach 800MH. The modification also requires a lot of downtime, which prolongs the check that it is planned into. The checks most often chosen to do the modification are the C8 and C12. We feel the C12 is the best, because it has a calendar interval of 18 years, a heavy workscope and a long downtime. Some airlines do the pylon modification at the C8 check. This is earlier than necessary, but may suit the operator, especially if the workscope is large and some of the S12C tasks have been included. The heavy C checks on the 757 have a downtime of one month when a single shift of 10-12 hours per day is worked. It is hard to do the pylon modification in less than 25 days, so the check will be longer than 30 days because of this."

Another major AD affecting the 757 is related to the replacement of insulation blankets in the aircraft walls. "AD 2008-23-09 was issued for this because the AN26 material that was originally used loses its inflammability properties after a period," says Everest. "An operator has six years from 2008 to comply with the modification, which gives them up to 2014. The AD is large, because it requires a lot of access to remove many cabin items, as well as removing the old blankets and putting in new ones. It takes 2,500-3,000MH on a heavy check to complete, and has a high material cost."

Another major AD for the 757 relates to a sealant modification in the fuel tank. This is covered by AD 2008-23-19; a similar number to the insulation blanket AD. "The AD incorporates SB 757-57-0064," says Everest. "It requires the fuel tank to be emptied, cleaned and sealant applied inside. It also has to be included in a heavy check. Compliance for the original AD is within 60 months of 30th September 2008. A supplemental AD, issued in March 2011, was for additional fasteners to be installed in the fuel tanks. The modification uses 500-600MH."

Budgets for ADs and SBs should

SUMMARY OF MH USED FOR FIVE BASE CHECK CYCLES - PASSENGER-CONFIGURED 757

Check	MPD MH	Routine MH	Defect ratio	Non-routine MH	Sub-total MH	Interior clean MH	Interior refurb MH	ADs, SBs & EOs MH	Heavy comp change MH	Strip & paint MH	Total MH	Total material costs-$
C1	180-260	1,000-1,300	0.25-0.35	250-450	1,250-1,750	200		300			2,250	40,000
C2	350-450	1,900-2,300	0.35	660-820	2,600-3,200	200		500			3,900	55,000
C3	190-280	1,400-1,550	0.35-0.50	560-700	2,100-2,200	200		300			2,600	45,000
C4	600-700	4,000-5,100	0.40-0.75	1,950-3,000	7,000-7,100	250	2,000	1,050	300	2,000	12,700	450,000
Total 1st base cycle		**8,500-10,000**		**4,000-4,700**	**13,000-14,000**	**850**	**2,000**	**2,150**	**300**	**2,000**	**21,400**	**590,000**
C5	180-270	1,350-1,500	0.35-0.40	470-570	1,800-2,100	200		300			2,600	45,000
C6	350-450	2,600-3,200	0.40-0.60	1,200-1,550	4,100-4,500	200		700			5,400	65,000
C7	180-260	1,350-1,700	0.40-0.60	660-800	2,200-2,350	200		400			3,000	50,000
C8	600-850	5,200-5,900	0.50-0.90	2,400-4,500	8,300-9,950	250	2,000	1,300	500	2,000	14,300	890,000
Total 2nd base cycle		**10,500-12,000**		**4,800-7,500**	**17,000-18,000**	**850**	**2,000**	**2,700**	**500**	**2,000**	**25,200**	**1,050,000**
C9	190-280	1,400-1,500	0.40-0.45	570-620	2,000-2,050	200		360			2,600	45,000
C10	385-470	2,600-3,000	0.45-0.60	1,200-1,800	3,800-4,800	200		660			4,700	60,000
C11	180-260	1,350-1,800	0.50-0.70	800-1,000	2,400-2,600	200		450			3,200	55,000
C12	800	7,000-8,900	0.60-1.00	4,400-7,000	13,250-14,100	300	2,000	3,500	800	2,000	21,850	1,80,000
Total 3rd base cycle		**12,800-14,500**		**7,000-10,400**	**22,000-23,000**	**900**	**2,000**	**5,000**	**800**	**2,000**	**32,400**	**1,240,000**
C13	180-260	1,350-1,700	0.40-0.50	550-900	1,900-2,600	200		500			3,300	55,000
C14	350-450	1,900-2,800	0.50-0.60	1,100-2,100	3,000-5,800	200		1,100			7,150	75,000
C15	190-280	1,400-1,900	0.60-0.80	1,100-1,200	2,600-3,100	200		600			3,900	55,000
C16	600-850	5,200-7,000	0.65-1.00	4,500-5,200	10,500-11,500	300	2,000	2,100	800	2,000	18,750	1,130,000
Total 4th base cycle		**10,000-14,000**		**8,000-8,600**	**18,000-23,100**	**900**	**2,000**	**4,300**	**800**	**2,000**	**33,100**	**1,315,000**
C17	180-260	1,350-1,600	0.50-0.60	700-950	2,000-2,500	200		400			3,100	50,000
C18	350-450	2,600-3,000	0.65-0.75	1,900-2,000	4,500-4,900	200		750			5,900	65,000
C19	180-260	1,350-2,000	0.70-1.00	1,300-1,400	2,700-3,400	200		500			4,100	60,000
C20	600-750	4,000-6,800	0.80-1.20	4,800-5,400	8,900-12,200	300	2,000	1,700	1,000	2,000	19,200	1,350,000
Total 5th base cycle		**10,000-13,500**		**8,800-9,800**	**18,100-23,000**	**900**	**2,000**	**3,350**	**1,000**	**2,000**	**32,300**	**1,525,000**
Overall total		**50,000-64,000**		**33,000-41,000**	**88,000-101,000**	**4,400**	**10,000**	**17,500**	**3,400**	**10,000**	**144,000**	**5,700,000**

clearly be smaller for light C checks than they are for heavy checks. "These can be 300MH for the smaller checks like the C1 and C3, but can be 450-650MH for the medium-size checks such as the C2, C6, C10 and C18 checks," says Apaydin. "A larger workscope like C14 can use 1,000-1,300MH.

"The smaller heavy checks like the C4, C8 and C20 can use 1,000-1,700MH, while 2,100MH should be allowed for the C16. If the pylon modification is included in the C12 check then about 3,500MH should be allowed for all ADs and SBs," adds Apaydin.

Component changes

Two categories of components have to be considered in base checks. The first is the removal of heavy components for their own maintenance, including: engines; engine cowls; thrust reversers; the auxiliary power unit; wheels; brakes; and landing gear. "One engine removal and installation uses 150MH, while landing gear removal and installation use 200-400MH," estimates Everest. "The use of special tools for heavy component removals also has to be charged for."

The second category is the labour used to remove and replace on-condition rotables that fail functional tests in the system tasks. "While the cost of repairing and managing these items is separate from the labour and material costs of the base check, the labour cost for removing and replacing them is included as part of the base check," says Apaydin. "The labour used in the first base check cycle is relatively low at 300MH, since the aircraft is young. Few rotables will fail tests and few heavy components will have to be removed. This rises to 500MH in the second base check cycle and reaches 800MH in the third. A budget of 800-1,000MH should be used from here."

Stripping & painting

The aircraft is stripped and repainted every five to six years, so the interval approximately matches the length of the base check cycle. The heavy check at the end of each base check cycle is the best time for stripping and repainting the aircraft. This process uses 2,000MH, while paint materials cost $30,000.

MH summary

The total labour used for the additional elements of interior cleaning, interior refurbishment, ADs and SBs, heavy component changes, and stripping and repainting reaches 500-1,300MH for the lighter C checks. The total reaches 5,500MH for the C4, and climbs up to 6,000MH for the C8, mainly because of a higher requirement for ADs and SBs.

The C12 check uses about 8,600MH for these additional elements, due to the pylon modification which is assumed to be completed in this check.

The total for the C16 and C20 checks is about 7,000MH; being smaller than the C12 because of a lower incidence of major ADs in later heavy checks.

The total labour for these additional items is therefore 7,300-10,700MH for each of the five base check cycles. It totals 45,000MH for the five base check cycles.

The total labour input for light C checks is thus in the order of 2,250-7,200MH, depending on workscope. The total for heavy checks, including stripping and repainting starts at about 12,700MH for the C4 check and rises to 22,000MH for the C12 check.

The total labour input for the first base check cycle is therefore 21,000MH *(see table, page this page)*. This climbs to 25,000MH for the second base check cycle, and to 32,000MH for the third base check cycle *(see table, this page)*.

There is a small climb to a total of

Many of the 757's structural inspections require deep access. That is, they require the removal and reinstallation of the aircraft's entire interior. Heavy checks consequently use a large number of routine MH, that include a significant element of the labour to gain access so that inspections can be made.

33,000MH for the fourth base check cycle, due to no large ADs being present in the C16 check. This is offset by the higher non-routine ratio in the fourth base check cycle.

The fifth base check cycle uses a similar amount of labour to the fourth base check cycle, since there are fewer routine tasks in the four checks compared to the fourth cycle. This is because the 8C and S8C are included in the C16 check, but the C20 is not. However, the fifth base cycle has a higher non-routine requirement, and a smaller consumption for additional check elements.

Total labour consumption for the five base check cycles and the 20 base checks thus reaches 144,000MH. A steady rise is seen in labour from the first to the third base check cycle. The rise is modest to the fourth base check cycle because the C12 has an overall larger routine workscope than the C16 and C20 check. This is because the C12 uses a large amount of labour for access, and comprises the largest and heaviest modifications.

Materials & parts

Four main elements of costs for materials, parts, rotables and other items have to be considered in base checks.

The main element is the materials and consumable parts used in the base check routine inspections and rectifications. "One way of budgeting for this element is to use a factor of a number of $s per MH, but this does not provide a realistic or accurate figure," explains Apaydin. "A heavier check has a higher consumption of materials and consumables. A reason for this is the higher rate of rotable removal and replacement. There are also some heavier inspections. The cost of materials and consumables depends on the disassembly and access ratio of the workscope. If a large number of panels, components and interior items has to be removed then the ratio of material and consumable consumption will be higher.

"The type of consumables that are used in high quantities are fasteners, nuts, rivets and washers," continues Apaydin. "The type of materials that are used include additives, seals, o-rings, chemicals and primers. A budget for materials and consumables used, in association with the MH detailed for the workscopes, is $40,000-75,000 for the light C checks which use 2,200-6,500MH. The first heavy check, the C4 check, can use about $110,000 in materials and consumables. This increases to $130,000 for the C8 check, which uses 1,500MH more than the C4 check. The C12 check is a really heavy check. This uses about 22,000MH, so up to $190,000 should be budgeted for materials and consumables. A similar allowance of $180,000 should be given for each of the C16 and C20 checks."

The second element is the replacement and repair of some of the aircraft's rotable components. "Some rotables can be expected to fail, while others have life limits that must be replaced at base checks, in particular the heavy checks," explains Apaydin. "An allowance of $250,000 can be made for the first base check cycle. Most of this cost will be incurred in the C4 check, but some will be consumed in the three earlier and lighter checks.

"The budget or allowance will increase in the second base check cycle as more life-limited parts reach their life limits, and others fail," continues Apaydin. "The allowance should then rise to $600,000-700,000 per base check cycle for the second and third cycles, and increase to $800,000 for the fourth base check cycle. It will steadily rise with age in the fifth base check cycle to more than $1 million."

The third main element of materials and parts relates to interior refurbishment. Although there are no fixed schedules for refurbishing the interior, the larger items are likely to be removed during heavy checks to allow deep structural inspections.

"The cost for actual interior hardware such as decorative foils, new galleys and toilets, seat covers, galley equipment, and carpets and flooring material is not included in this budget, and should be considered separately," says Apaydin. "The cost of primers, cleaners and many of the consumable items used in the interior refurbishment process should be budgeted for. A budget of $40,000-50,000 can be used for the C4 check, and this steadily increases with each successive heavy check up to $100,000-120,000 by the time the C16 and C20 checks are reached."

The fourth element of paint for re-painting the aircraft uses $30,000-50,000 per repainting event as described.

Total cost for materials, consumables, parts and components reaches about $600,000 for the first base check cycle. This steadily increases to $1.0 million in the second base cycle, $1.25 million in the third, $1.3 million in the fourth, and $1.5 million in the fifth base check.

Summary

The steady climb in base maintenance requirements between the first and third base checks is clearly illustrated. The large rise is partially explained by the pylon modification AD, which uses a lot of labour. It is also explained by an increase in the routine inspections.

The routine labour requirements reach a steady level in the fourth and fifth base checks, and so increases in labour expenditure are explained by a higher non-routine ratio, large ADs coming due and more heavy components having to be changed. AC