The A330 family has been in operation for 20 years, and is due to become the most numerous widebody, twin-engined aircraft in operation. The oldest aircraft will have now completed two complete base check cycles. The base maintenance labour and material inputs are analysed.

A330 family 1st & 2nd base airframe check cost analysis

Since its entry into service in 1981, the A330 has become the second most numerous twin-engined widebody after the 767 family. There are more than 750 A330s in operation, with firm orders for another 350. When all 350 are delivered, the number of A330s built will exceed the number of 767s.

The A330 was conceived together with the A340 in the late 1980s. The two main types were designed with the same wing, tailplane, systems and flightdeck, and the same maintenance programme, although with some differences. This was the same basis as all other Airbus types, with a system of A and base checks. The system of base maintenance was a cycle of eight checks, which each had an interval of 15 months, so the full cycle of eight checks had a full interval of 120 months or 10 years. The cycle of eight checks included two sets of structural inspections, with intervals of 60 and 120 months. These coincide with the fourth and eighth base checks, making them the two largest in the cycle.

The oldest A330-300s went into service in 1991, and completed their first full base maintenance cycles after an actual interval of about nine years in 2000-2001, and their second base check cycles in 2009-2010.

The oldest A330-200s entered service in 1998, and completed their first base check cycles in a similar interval to the A330-300s. These aircraft started their second base check cycles at a similar time to the C check interval being extended to 18 months. The older A330-200s can therefore be expected to finish their second base check cycles in 2017-2018, 19-20 years after they entered service.

A330 family in operation

The A330 was originally pitched as a lower gross weight and shorter-range version of the equal-sized A340, so the A330 had a twin-engine design. Since the A330-300 first entered service, the gross weight has increased several times, while the fuel capacity has remained at 25,858 US Gallons (USG). The original maximum take-off weight (MTOW) and fuel capacity for the first A330-300s was 467,460lbs. This has been increased twice to 507,000lbs and 513,765lbs.

While it was originally intended as a regional and medium-haul aircraft for high-density operations, later variants of the -300 series have been used as long-haul workhorses by several operators.

There are 352 A330-300s in active service. The fleet is split between 69 aircraft equipped with General Electric (GE) CF6-80E1 engines, 90 with Pratt & Whitney (PW) PW4000-100 engines, and 197 powered by Rolls-Royce (RR) Trent 700 engines. There are another 158 aircraft on firm order.

The largest fleets of PW-powered A330-300s are operated by Delta/Northwest (21 aircraft), Korean (16), and Thai International (12). The largest fleets of CF6-powered aircraft are operated by China Airlines (18) and Qatar Airways (13). The largest RR-powered fleets are operated by Cathay Pacific (32), Dragonair (14), China Eastern (15), Lufthansa (15), Singapore International Airlines (19), Swiss (10), and Thai International (eight).

Many operators use their A330-300s on short- and medium-haul operations: Korean Air, Thai International, Malaysian, Asiana, China Airlines, China Eastern, China Southern and Cathay Pacific. All of these airlines use the aircraft on average flight cycle (FC) times of up to 3.50FH. Corresponding annual utilisations are 3,000-4,000FH.

Other airlines use the aircraft on long-haul services with FC times of 6.0-8.0FH, and corresponding annual utilisations of 3,800-5,000FH. These include Delta-Northwest, USAirways, Aer Lingus, Qantas, Lufthansa, Air Canada and SAS. Finnair has the longest average FC times, at 8.50FH and accumulates an average of 5,400FH per year.

The shorter A330-200 series was launched in 1995, and entered service in 1998. This -200 series has a higher fuel capacity of 36,750USG, so most -200s are operated on long-haul networks.

There are more than 400 A330-200s in operation. The fleet is split between 135 PW-powered, 96 CF6-powered , and more than 180 Trent-700-powered aircraft. The largest fleets are operated by Emirates (27), Air China (20), Etihad (18), Qatar Airways (16), Air France (15), TAM (14), Delta-Northwest (11), KLM (11), EVA Air (11), Jet Airways (10) and Air Berlin (10).

A few airlines in the Asia Pacific and Middle East operate the -200 series on sectors of 2.10-3.50FH. Corresponding annual utilisations are 2,800-4,000FH in most cases.

The A330-200 is also used as a long-haul workhorse by many airlines, such as TAM, TAP Air Portugal, Turkish Airlines, Air France, USAirways and Jet Airways. Annual utilisations are 4,500-5,000FH.

A third group uses it for medium-haul missions of 4.0-5.5FH. Corresponding utilisations tend to be 4,000-4,500FH.

Maintenance requirements

The A330's airframe maintenance is divided into line maintenance, A checks, and base checks. Line maintenance includes all checks up to the weekly check. Base checks are the cycle of eight checks, as described.

In addition to airframe maintenance there is maintenance relating to engines, heavy components and, rotable and repairable components.

Base maintenance comprises routine inspections as described in the maintenance planning document (MPD), and an operator's own additional tasks. Several other groups of tasks are included in the routine element of a base check: out-of-phase (OOP) tasks whose intervals do not coincide with the main groups of tasks; some regular interior repair and refurbishment tasks; changing large components or engines; and lower line or A checks to zero-time all maintenance tasks once the check is completed and the aircraft goes back into service.

Before many routine inspections and tasks are performed, the aircraft will be prepared for maintenance, and access gained through panels and other openings. The preparation, access and routine tasks account for one of the largest portions of labour and material inputs in base checks.

The MPD and other routine tasks and inspections reveal and give rise to non-routine defects and rectifications. This can account for another large portion of labour and material inputs.

All base checks involve some interior cleaning, varying levels of interior refurbishment, and labour and materials for inspections relating to airworthiness directives (ADs), service bulletins (SBs) and engineering orders (EOs).

Another element of base check maintenance is the removal and replacement of hard-timed and life-limited rotable components. This usually accounts for a small portion of a base check's total labour and material input.

A final element is the regular stripping and repainting of aircraft. This is typically done once every five to six years.

The lighter base checks in the A330's cycle of eight base checks, and in all other Airbus types, will have a smaller number of routine tasks, which will consume fewer man-hours (MH), materials and parts for routine inspections and non-routine rectifications. The lighter checks also tend to include only smaller ADs and SBs, and lighter interior maintenance, and usually exclude stripping and repainting.

The two largest base checks, which are usually the fourth and eighth checks in the case of most operators, will have a larger number of routine tasks, more non-routine rectifications, the largest number of ADs and SBs to complete, the highest level of interior maintenance and refurbishment, and stripping and repainting.

Maintenance programme

The basic structure of the A330's maintenance programme, as described, is a cycle of A checks and an eight-check base maintenance cycle. The MPD was conceived for both the A330 and A340, and is updated following revisions to the maintenance review board (MRB) and other documents. Burat Yigitbasi, maintenance management engineer at Turkish Technic, explains that there have been 18 revisions to the MPD to date, with the latest issued in April 2011.

When originally issued, the basic A check interval for the 1A tasks was 400FH. There are another two groups of A check tasks: the 2A and 4A tasks. Their intervals are corresponding multiples of the interval for the 1A tasks. The original intervals were 800FH and 1,600FH.

These groups can be arranged in a system of four block checks. The A1 and A3 checks have just the 1A tasks. The A2 check has the 1A and 2A tasks; while the largest A4 check has the 1A, 2A and 4A tasks. The cycle of A checks is therefore completed at the A4 check.

"One of the major changes to the A330's MPD is that the basic 1A interval was increased from 400FH to 800FH in two escalations," says Yigitbasi.

The first extension was made in 2007, when the 1A interval was increased to 600FH. At the second extension in 2010 the 1A interval was raised to 800FH. As a result, the A4 check interval was extended from 1,600FH to 3,200FH.

"A second major change in the A330's MPD was the extension of the first group of structural tasks, sometimes referred to as the S1 tasks, from an interval of 60 months to 72 months in 2007," says Yigitbasi.

The system of eight base checks

A & C/BASE CHECK TASKS & ARRANGEMENT OF A & C/BASE CHECK PACKAGES

A & base check task groups and A & C check arrangement

A check task groups	Number of tasks	Task group interval
1A	47	800FH
2A	14	1,600FH
4A	16	3,200FH

Arrangement of A checks - block checks

Check name	Number of tasks	Task groups	Check interval
A1	47	1A	800FH
A2	61	1A + 2A	1,600FH
A3	47	1A	2,400FH
A4	77	1A + 2A + 4A	3,200FH

C check task groups	Number of tasks	Task group interval
1C	205	18 months
2C	175	36 months
4C	116	72 months
8C	61	144 months
S1	254	72 months
S2	326	144 months

Arrangement of C checks - block checks

Check name	Number of tasks	Task groups	Check interval
C1	205	1C	18 months
C2	380	1C + 2C	36 months
C3	205	1C	54 months
C4	750	1C + 2C + 4C + S1	72 months
C5	205	1C	90 months
C6	380	1C + 2C	108 months
C7	205	1C	126 months
C8	1,137	1C + 2C + 4C +8C + S1 + S2	144 months

combines C check tasks with structural tasks. The basic C check interval started at 15 months in the original issue of the MPD. There are four groups of C check tasks: the 1C, 2C, 4C and 8C items with corresponding multiples of the basic 15-month interval *(see table, this page)*. With tasks grouped into a block check, the eighth check in the cycle would comprise the 1C, 2C, 4C and 8C tasks, and have an interval of 120 months.

There are two groups of structural tasks: the S1 and S2 tasks, which originally had intervals of 60 months and 120 months. These two intervals conveniently coincided with the C4 and C8 intervals. The C4 check would therefore include the 1C, 2C, 4C and S1 tasks, so in total the C8 check would comprise the 1C, 2C, 4C, 8C, S1 and S2 tasks; making it the largest check in the cycle *(see table, this page)*.

The basic C check interval was then escalated to 18 months in December 2008. There was also an accompanying interval of 8,500FH for the 1C tasks so that some 1C tasks had an interval of 8,500FH, while others had both the calendar and FH interval. Similarly, the 2C tasks, which had been escalated to 36 months, have an associated interval of 17,000FH. These combined calendar and FH intervals were equivalent to 5,700FH per year, which is higher than the annual utilisation achieved by all operators.

This meant the full eight-check cycle had an interval of 144 months: equal to 12 years. The S1 tasks interval was extended from 60 to 72 months at the same time. The S2 tasks still had an interval of 120 months at this stage.

The S1 tasks could therefore still be included in the C4 check without compromising the interval of any task group in this check. The older A330s that had already completed a full cycle of eight base checks would be half-way through their second base check cycle, and gain some benefit from the extension.

The interval for the S2 tasks was extended from 120 to 144 months in 2010. This allows the S2 tasks to be combined with all other tasks in the C8 check, without any compromise to a task group's interval.

This happened before most or all of the older aircraft in the fleet were due to have their first or second C8 check. All A330s will therefore have benefited from the full cycle interval being extended to 12 years.

Airbus plans to further escalate the intervals of the 1C and 2C tasks to 24 and 48 months. Its objective was also to escalate those tasks in the group with an FH-designated interval by the same proportion. The 1C tasks would therefore have an interval of 11,333FH, and the 2C tasks an interval of 22,666FH. This extension was not possible for all the tasks, however.

The next revision of the MPD is likely to escalate the 1C tasks to 24 months and 10,000FH. Some tasks in the group will not be extended by the same amount, and will drop out to 21 months, 18 months or 8,500FH.

Similarly, the 2C tasks will be escalated to 42 months and 20,000FH. A few tasks may be escalated to 48 months, while others will drop to 36 months and 17,000FH.

The large number of different groups of tasks will probably make it easier for airlines to group 1C tasks at 21 months and 2C tasks at 42 months.

Check organisation

Grouping tasks into A and C check packages is standard for most operators, which form block checks from the groups of tasks: the A1 and A3 checks comprise only the 1A tasks; the A2 check has the 1A and 2A tasks; and the A4 check comprises the 1A, 2A and 4A tasks *(see table, this page)*.

The 1A group has 47 tasks, the 2A group has 14, and the 4A group has 16. The A2 check therefore has 61 tasks, while the A4 check has 77.

The combining and build-up of the six different task groups for the C checks is similar to A checks. The number of

The A330 has become a ubiquitous widebody workhorse. The aircraft are operated by a large number of operators in a variety of roles. The intervals for A and C checks have experienced several extensions since the aircraft operated service in 1991.

tasks in each of the groups will vary by operator. Operators can apply to extend the interval for individual tasks, and may be in a higher task group compared to the maintenance programme of other operators. Conversely, some task intervals may be de-escalated and be included in groups of lower intervals. Some tasks can also be split, with portions going into different groups. Finally, OOP tasks, whose intervals do not coincide with one of the particular groups, can be carried out at different intervals, and planned into lower checks, or be included in base checks if their intervals are de-escalated.

The 1C is one of the larger groups, with 205 tasks. The 2C, 4C and 8C are smaller, and have 175, 166 and 61 tasks respectively *(see table, page 36)*. The S1 and S2 are also large groups, with 254 and 326 tasks, making a total of 1,137.

The number of tasks in each group varies by operator. Lufthansa Technik's programme for Lufthansa's A330-300s, for example, has 1,260 tasks. The 1C has 161, the 2C 155, the 4C 158, the 8C 130, the S1 283 and the S2 373 tasks.

Using the programme with 1,137 tasks as an example, grouping these tasks into block checks means the C1, C3, C5 and C7 each have 205 tasks, and are all the smallest in the series of eight checks. The C2 and C6 checks are the second largest, each with 380 tasks. The C4 is the second largest, with a total of 750 tasks, but the C8 has more than 1,100 *(see table, page 36)*.

There are differences in the type of tasks in the different groups. Many of the 1C and 2C tasks are system checks and inspections, while tasks in the higher multiples and structural S1 and S2 tasks require deeper access and consume more MH. The C8 check will consume up to 10 times more MH to perform the routine inspections than the C1 check, even though the C8 check has about five times the number of tasks.

Base check contents

Base checks comprise as many as nine elements. The inputs for all eight checks in the full base check cycle can be analysed for two consecutive cycles that have been completed by the oldest A330s. During the first base cycle, the C check interval was 15 months, and the full cycle interval 120 months. Actual interval utilisation means the whole cycle is likely to be completed after eight-and-a-half years, which means an average interval of 13 months between C checks.

For an aircraft operating at a utilisation of 4,500FH per year, the full cycle will be completed over an interval of 38,700FH. An average FC time of 7.0FH means that 5,500FC will have been completed in the same interval.

Older aircraft will have had C check and full cycle interval escalations to 18 and 144 months. The operators will only have realised a small gain from this, because these extensions were only made in 2008 and 2010. The full cycle would therefore probably be complete after nine years: an average interval between C checks of thirteen-and-a-half months. This check cycle interval is equal to about 40,500FH and 5,800FC.

Routine inspections

Routine inspections comprise the first element of base checks. Most will be the MPD tasks, although the routine element of a C check will also include inspections added by the operator, such as OOP tasks and changing large components.

There are three types of labour for the routine element of each check: a labour allowance for gaining access to the areas to be inspected; the labour used to carry out routine inspections; and the labour used for administration, supervision, docking, aircraft preparation and testing.

The MH required for gaining access vary according to the depth of inspections. A budget of 250-300MH for each of the six lighter checks in the cycle can be used, while each of the two heavy checks will need 1,600MH. Each base check cycle therefore totals 4,900MH.

Routine inspections for the six lighter checks in the cycle are relatively light, comprising either just the 1C, or 1C and 2C task groups. In terms of labour, 1,100-1,200MH is required for checks with just the 1C tasks, and 1,400-1,500MH when the 2C tasks are added.

The C4 check with the additional 4C and S1 task groups requires a larger input of about 6,500MH, reflective of the larger number of inspections.

The C8 check, with a further two large groups of 8C and S2 tasks, requires up to 10,000MH for routine inspections. The total for the eight checks in the cycle is therefore about 24,000MH.

The labour for access and routine inspections in the first cycle will therefore be about 29,000MH.

The labour required for docking, aircraft preparation, supervision and testing will be a percentage of total MH used for the access, routine inspections and non-routine rectifications that arise out of the routine inspections.

The MH required for access and routine inspections in the second base check cycle will be similar to the number used in the first cycle: 29,000MH.

Another element of routine inspections is the structural sampling inspection programme (SSIP). This is a group of deep inspections that only affects the oldest 20% of A330-200s and A330-300s in each operator's fleet.

Non-routine rectifications

The MH required for non-routine rectifications that arise from routine inspections can account for a substantial amount of labour and material input of base checks.

Most operators find that the non-

There are several elements of base checks which make up the full labour and material input for the aircraft. Total labour inputs for the eight checks of the base check cycle can exceed 95,000MH.

routine ratio steadily climbs during the first base check cycle, and continues into the second base cycle. Non-routine ratio is partly influenced by corrosion and structural fatigue. Checks with a high level of access for deeper inspections tend to have high non-routine ratios.

In the C1 to C3 checks, the non-routine ratio is 50-70%, which generates a requirement for an additional 600-1,000MH in each check.

In the C4 check, which is the first heavy check that the aircraft undergoes, the non-routine ratio can be 80%. On a check of this size and importance, the non-routine rectifications would generate a need for another 5,000-5,500MH.

The second half of the first base check cycle saw a steady climb in non-routine ratios, with some reaching more than 100%. The labour for non-routine rectifications would be 1,200-1,800MH for the three lighter C5, C6 and C7 checks. The final C8 check, with a large number of structural inspections, has a non-routine ratio of 90-100%, which has generated a need for another 9,000-10,000MH.

The total labour for non-routine rectifications for all eight checks in the first base check cycle would therefore be 20,000-21,000MH. This is partly affected by the aircraft's operating environment. For example, aircraft operating in more humid environments will have higher non-routine ratios.

This would take the total for access, routine inspections, and non-routine rectifications to about 50,000MH for the first full base check cycle.

The MH used for preparation, docking, supervision and testing would be 250-400MH for each of the smaller checks, 1,300MH for the C4 check, and 2,000MH for the largest C8 check. This would total 5,000MH for all eight checks. The overall total for these four elements of the base checks would therefore be 55,000MH.

The overall total for the first three lighter checks is 2,300-2,900MH for each of the C1, C2 and C3 checks; up to about 15,000MH for the C4 check; 2,800-3,000MH for the C5 and C7 checks; 4,000MH for the C6 check; and up to 23,000MH for the C8 check.

Many operators have had a steep climb in the non-routine ratio during the second base check cycle, partly due to the age of the aircraft, which is now already 10 years old. The incidence of corrosion also increases steadily, and non-routine ratios rise to 140-170% in the first half of the second base check cycle. Labour required for non-routine rectifications in the C9, C10 and C11 checks (same as the C1, C2 and C3 checks in the first base cycle) is 1,800-2,200MH per check.

The non-routine ratio has been at least 100% for many aircraft in the C12 check (same as the C4 check in the first base check cycle), and so generates a requirement for 6,500-7,000MH.

The non-routine ratio has continued to climb in the second half of the second base check cycle to as much as 200% in certain operating environments. This generates a labour requirement of 2,300-2,700MH in each of the lighter checks.

The C16 (same as C8 check in the first base check cycle) has climbed more steadily than in the lighter checks, but has still exceeded 100%, and generated about 11,000MH for rectifications.

The total for non-routine rectifications for all eight checks of the second base check cycle is 30,000-32,000MH. The sub-total for access, routine inspections and non-routine rectifications would therefore be about 60,000MH for all eight checks in the cycle. This is about 10,000MH more than the first base check cycle.

The additional fourth element for preparation, docking and supervision adds another 6,000MH, taking the overall total to 66,000MH. The totals for the four lighter checks with just the 1C tasks are 3,500-4,300MH. The total for the larger C10 and C14 checks with the additional 2C inspections is 4,400-5,000MH. The overall labour requirement for the C12 (C4) check is 16,000MH, and 25,000MH for the largest C16 (C8) check.

The associated cost of materials and consumables will be $30,000-50,000 for each of the six smaller checks, and proportionate to the number of MH used. The consumption of materials and consumables for the C4 check will be much higher at about $240,000, and $360,000 for the C8 check.

The consumption of materials and consumables for the full cycle of eight base checks will be about $825,000. This rises by $150,000 for the second base check cycle, in line with the increase in the non-routine ratio.

A small allowance also has to be made to replace or repair a small number of rotable components. This are either hard-timed parts, or those that reveal malfunctions or problems during routine inspections. This can be limited to the C4 and C8 checks, and a budget of $100,000 and $200,000 respectively is needed.

Component changes

Changing hard-time and life-limited components accounts for a small amount of the base check budget.

The functional testing of system components during routine inspections can reveal malfunctioning components and rotables that have to be changed.

An allowance of 150-200MH should be made for each of the six smaller base checks, and 300MH for the two larger checks. The total for the cycle is therefore 1,650MH.

ADs, SBs & EOs

A major element of base checks is the inputs required for airworthiness directives (ADs), service bulletins (SBs) and engineering orders (EOs). ADs and

SBs are issued at random, and can involve major work, so the materials and MH required vary widely. In addition, ADs and SBs apply not to all aircraft, but to certain line numbers and aircraft configurations. Moreover, airlines apply SBs to their fleet at their discretion.

EOs, issued by airlines themselves, often involve major refurbishment to the interior, and the installation of in-flight entertainment equipment (IFE) and new avionics. EOs being implemented by one airline will not affect another, while the inputs used for many EOs issued by airlines may be seen as a marketing, rather than a maintenance, cost.

The A330 has been affected by several large ADs and SBs.

The first example is AD 2001-070. This involved the inspection and modification of frame 40 of the fuselage. The fuselage modification is encompassed in SB A330-53-3093. All A330s that did not have the modification incorporated on the production line are affected, and the compliance deadline is before the aircraft have accumulated 7,300/9,700FC and 26,000/28,800FH. Keith Curran, engineering director at Monarch Aircraft Engineering explains that it is estimated the modification uses about 1,400MH and $25,000 of materials.

The second major AD, AD 2007-0148, relates to cracking of the sixth wing rib. Some aircraft were modified on the production line, but all other A330s are affected. The compliance thresholds are 25,000FH and 8,000FC. Curran says there are modification kits for the left and right wings, and the modification is estimated to consume about 400MH, plus additional labour required to defuel the aircraft and gain tank access.

A third major AD, AD 2007-0269/-0284, concerns the reinforcement of the rear fuselage. The modification is described in several SBs, and Curran comments that estimates are that 200-300MH are used to make the modification. The compliance threshold for one SB is 25,400FC; suggesting that there are a large number of aircraft still to be modified.

A fourth, and possibly the largest AD, is AD 2007-0278. "This involves the inspection and replacement of P-clips in the centre and wing fuels tank. The modification is encompassed in SB A330-28-3092," says Curran. "Compliance date is 31 December 2011. Estimates are that the inspection and modification will use about 570MH to complete, and require a a large number of kit numbers and consumables."

Another major AD is AD 2006-0125, and includes the alert SB A330-54A-3025. This concerns the engine pylon modification, and is mandatory to terminate at 10 years old, so it is most likely to be included in the C8 check. Curran estimates it uses about 1,000MH.

There are several smaller ADs that also affect the A330. One example is AD 2007-16-02, and applies to all A330 variants. This is a small modification to the keel beam skin panel, and uses up to about 40MH and $400 of materials.

There are several large SBs. One of the largest is SB A330-25-3289, which involves modifying the dado panels. This is estimated to use about 500MH.

These six large ADs consume up to about 4,000MH, and would be completed during a single base check cycle in the case of most aircraft. Most of these are also likely to be incorporated in the workscopes of the two larger checks in the cycle.

In addition to this, smaller ADs and SBs will consume MH and materials.

Budgets of 3,000-3,500MH can be used for either or both of the two heavy checks in the base check cycle, and smaller allowances of 1,000-1,300MH can be used for each of the six smaller checks. Total labour for ADs, SBs and EOs can be in the region of 14,000MH for the eight checks in the cycle.

Cosmetic maintenance

Cosmetic maintenance involves interior cleaning, interior refurbishment, and stripping and repainting.

Interior cleaning only covers washing and vacuum cleaning carpets and seating areas. This is performed during A and C checks, while other interior-related work

SUMMARY OF BASE CHECK INPUTS FOR A330-200/-300

Check	Routine MH	Non-routine MH	Interior MH	ADs, SBs & EOs MH	Strip & repaint	Other MH	Total MH	Total materials $	Total inputs $
1st base check cycle									
Light C checks	1,640 -2,200	600 -1,750	700	1,300	0	200	4,500 -6,150	32,000 -52,000	257,000 -360,000
C4/S1 check	9,500	5,300	3,650	3,300	3,000	300	25,000	505,000	1,755,000
C8/S2 check	13,600	9,000	9,150	3,000	3,000	300	38,050	790,000	2,690,000
Total for 8 checks	**34,000**	**21,000**	**17,100**	**14,100**	**6,000**	**1,800**	**94,000**	**1,530,000**	**6,200,000**
Reserve for interval of 38,700FH - $/FH									**161**
2nd base check cycle									
Light C checks	1,750 -2,300	1,750 -2.750	720	1,300	0	200	5,800 -7,200	48,000 -66,000	338,000 -431,000
C4/S1 check	9,600	6,750	3,650	3,300	3,000	300	26,600	530,000	1,860,000
C8/S2 check	13,900	11,000	9,150	3,000	3,000	300	41,000	823,0000	2,840,000
Total for 8 checks	**35,100**	**31,300**	**17,100**	**14,600**	**6,000**	**1,800**	**106,000**	**1,685,000**	**7,000,000**
Reserve for interval of 40,500FH - $/FH									**173**

is also carried out during C checks. Up to 350MH should be allowed in the lighter C checks, and up to 850MH in each of the two heavier checks, taking the total to 3,800MH for the eight checks in the cycle.

Some interior refurbishment is included in every base check. The main elements include: carpets; seat covers, cushions and frames; overhead and ceiling panels; galleys, toilets and bulkheads; and servicing areas.

The aircraft carpet is treated in two parts: the aisle area; and the seating area. Carpets are cleaned and vacuumed during A checks, but aisle carpets experience a high level of wear, so they are replaced at every C check, while the carpet in the seating area generally lasts for four to five years on most aircraft. This coincides with the interval of the C4 and C8 checks.

The labour required to remove, cut and replace the aisle carpet will be 35-50MH. About 35-40 square metres will be needed, at a cost of $55-60 per square metre, so new carpet will cost about $2,000 for an A330-200, and $2,300 for an A330-300.

The labour used to replace seating area carpet will be about 160MH for an A330-200, and 200MH for an A330-300. Carpet material costs $9,100 for a -200, and $11,200 for an A330-300.

Seats comprise covers, cushions and frames. Covers are regularly cleaned and replaced, while cushions have a legal life limit of four to five years, at which point replacement is mandatory. Seat frames have to be removed for maintenance.

Seat covers are removed for dry cleaning about once every C check by most operators. Removal and reinstallation uses 300-400MH for the complete shipset on A330-200s and -300s, while an allowance of $3 per cover can be made for dry cleaning.

Seat covers are replaced once every third or fourth C check. The same amount of labour is required as for cleaning, while new covers can cost about $120 per seat. This is equal to $30,000 of material for an A330-200, and $35,000 for a -300 series aircraft.

Seat cushions come in three parts: the headrest, seat base, and seat back. The headrest and base have to be replaced once every five to six years, and the back every four years. Replacing a shipset of seat covers uses about 375MH for an A330-200, and 450MH for a -300. A shipset of cushions costs $70,000-90,000, depending on the number used.

Seat frames are typically overhauled during C4 and C8 checks. Removing and reinstalling seats requires 1MH per seat, while 3MH of labour and $2 of parts per seat should be allowed for maintenance.

There are several panels in each aircraft, including: sidewall and ceiling panels; bulkheads, dado rails and panels; toilet and galley walls; cabin door linings; closet walls; and slide raft boxes. These all receive a clean and any repair or decoration as required during the C4 check, while they receive a full refurbishment during the C8 check.

Cleaning and light refurbishment will use 400-800MH for a C4 check, and a small allowance should also be made for materials. The full refurbishment during the C8 check will use 4,000-5,000MH, and $20,000-30,000 should be budgeted for materials and parts.

Most A330s are configured with eight or nine toilets, and five or six galleys. These have to be removed to allow structural inspections during the C4 and C8 checks. This provides an opportunity for them to be refurbished. Removal and reinstallation is estimated to need 1,000MH, while refurbishment requires another 400-500MH. A small allowance of $5,000-10,000 of materials, consumables and parts should be made.

Servicing areas are the areas around the galleys and toilets. These have a non-textile floor (NTF) material that has to be replaced at every C8 check, and uses about 300MH. Replacement material costs $25,000-30,000.

The inputs used for interior refurbishment work therefore vary from 350-400MH and $3,000 of materials for each of the six lighter checks in the base check cycle, to 3,000MH and $120,000-140,000 of materials for the C4 check, and up to 9,000MH and $180,000-

Interior refurbishment accounts for a large portion of total inputs used in base checks. Removal of large interior items occurs during C4 and C8 checks so that structural inspections can be performed.

210,000 of materials for the C8 check.

A total of 13,000-14,000MH and $330,000 of materials are therefore required for the eight checks in the cycle.

Stripping & repainting

The third element of cosmetic maintenance and the final element of base checks is the stripping of the aircraft and repainting. This is done every five to six years, depending on airline policy. It is assumed here that it is done during the heavy checks, because of the opportunity that the downtime gives to do the job.

Stripping and repainting an aircraft the size of the A330-200/-300 can consume up to 3,000MH and use about $40,000 of paint and materials. This is performed twice in the base check cycle, so total consumption is 6,000MH and $80,000 of materials.

A small amount of paint work may be required during the six light C checks because of findings. Up to 200MH and $20 per check should allowed for this.

Total inputs

In addition to the main elements of access, routine inspections, docking and non-routine rectifications, the other elements of interior cleaning and refurbishment, stripping and repainting, component changes, and ADs and SBs add another 40,000MH to the labour requirement of the eight base checks.

The total labour for each of the six lighter checks, in the first base check cycle, is 4,500-6,100MH. Labour used in the C4 check is 25,000MH, while the C8 check consumes about 38,000MH.

The total inputs used in the first base check cycle are 94,000MH. The total for materials, consumables and expendables is about $1.53 million.

The consumption of labour and materials rises during the second base check, mainly due to the increase in non-routine ratio. The inputs required for routine inspections, interior refurbishment, ADs and SBs, component changes, and painting hardly change.

The total labour used for each of the six lighter checks is 5,800-7,200MH, depending on workscope. Consumption for the C4 check rises to 27,000MH, while the labour used in the C8 check climbs to 41,000MH. The eight checks of the cycle use a total of 106,000MH in labour, about 12,000MH higher than the first base check cycle. Most of this additional labour is accounted for by a higher non-routine ratio. The associated total for materials, consumables and parts is about $1.7 million.

Maintenance reserves

Reserves for base maintenance will depend on the average labour rate for all elements of maintenance. *Aircraft Commerce* uses a generic labour rate of $50 per MH for base maintenance, which takes into consideration global variations in labour rates.

At $50 per MH, the cost of labour for the first base check cycle is $4.7 million. Taken together with materials and consumables, the total inputs for the first base check cycle are $6.23 million. As explained, the total aircraft utilisation during this base check could be about 38,700FH. When amortised over this interval, the inputs for the first base check cycle are equal to a reserve of $161 per FH *(see table, page 42)*.

At the same labour rate, the total inputs for the second base check cycle are about $7 million. Total aircraft utilisation for this second cycle is about 40,500FH, and the inputs amortised over this interval are equal to a reserve of $173 per FH *(see table, page 42)*.

Consideration also has to be given for aircraft operated on short- and medium-haul operations. These achieve utilisations of 2,750-3,500FH per year. The calendar time limits of base checks means these aircraft will accumulate a smaller number of FH over the full length of the base check cycle. The total will be 25,000-32,000FH.

This will be partially offset by the lower consumption of labour and materials. The only elements that will realise any savings are the non-routine rectifications, on account of the aircraft having accumulated fewer FH, and the interior refurbishment. The saving from these two elements will be small, however. Total labour used in the whole base check cycle may only be about 10,000MH less. Associated savings in materials and consumables may only be up to $100,000. Total cost of inputs for the first base check cycle will therefore be about $5.6 million. Amortised over the interval of 25,000-32,000FH, this is equal to a reserve of $175-225 per FH.

One prospect for reducing base check reserves for all aircraft is the possibility that the basic C check intervals will get extended to 21 or even 24 months. In either case, if all C check tasks can be grouped into checks with intervals that are multiples of either 21 or 24 months, the operators are likely to change to a programme of six base checks. The S1 tasks would then be included in the third base check, and the S2 tasks would be included in the sixth check.

This development would realise a significant reduction in MH consumption, especially in the elements relating to access, routine inspections, resulting non-routine rectifications, and docking and supervision. It is possible that the 55,000-66,000MH used in total for these elements of base checks for the whole of the cycle could be reduced by as much as 15,000-20,000MH. AC