The oldest A330-300s and A340-300s are about 22 years old, and will have been through or close to their second HMV structural checks and completing their second base check cycles. The ageing maintenance requirements and second HMV contents and inputs are examined.

Ageing A330/A340 airframe maintenance

The A340 and A330 were developed together, with both airframes sharing several structural design principles and components. The A340 entered service in March 1993, and the A330 in January 1994. This leaves the first in-service aircraft approaching an age of 21 to 22 years. The oldest aircraft are approaching or are already at the end of their second 10-year (YE) or 12YE base maintenance check cycle. The aircraft will therefore require a second major structural inspection, or heavy maintenance visit (HMV), to continue operation.

The A330 and A340 have base maintenance programmes that were originally based on a system of eight base checks. This included two structural checks, the fourth and eighth, that required access to the aircraft's primary structure. The fourth check is sometimes referred to as an 'intermediate structural' check or 'C4' check by planning engineers; while the eighth check is sometimes generically referred to as a 'C8' or HMV check.

Because of intermediate, HMV and 'C' check interval escalations, this eight base check programme can be arranged into a cycle of six checks if it suits the operator's aircraft utilisation *(see table, page 36)*. The two structural checks are then the third and sixth checks in the cycle.

The A340's and A330's major structural checks were first escalated from 5YE and 10YE intervals to 6YE and 10YE intervals in 2006. This was after the oldest aircraft in the fleet would have been through their first major structural checks in 2003 and 2004. The 10YE interval was then escalated to 12YE in 2009.

Operators of early serial number (S/N) aircraft have had to adapt to these changes by adjusting their maintenance programmes where needed. Up to 2006, the aircraft were on a 5YE/10YE structural inspection in an eight base check cycle. Older aircraft, nearing 20 years of age and that have stayed with this cycle, have been through, or are now due, their second 10YE check.

Aircraft that changed to the extended 6YE/12YE interval pattern, after 2009, are approaching the end of their second cycle of base maintenance. The oldest A330-300s and A340-200/-300s will therefore be coming due their second major structural or C8/HMV checks in 2014-2016.

Slightly younger aircraft, built from 1994 to 1997, will be due to complete their second base check cycles from 2016 to 2019.

The intermediate structural and HMV checks incur high costs, and have an increasing number of large, deep access tasks and heavy content as the aircraft gets older. The ageing structure raises the issue of the viability of performing these major airframe checks.

Unforeseen production delays affecting replacement aircraft deliveries, low fuel prices and good A330/340 spares availability, however, are keeping some of the mature fleet in service. While the A340-200/-300 fleet has experienced a lot of retirals, the A330-300 is more likely to be put through a second HMV.

Fleet profile

In addition to the A330-300 and A340-200/-300, other A330 and A340 variants followed, including the shorter, longer-range A330-200 (1998), and the larger and longer-range A340-500 (2003), and the A340-600 (2002).

Orders of all A330s variants stand at about 1,350, with more than 1,170 now delivered. Operators with large A330-300 fleets are mainly based in the Asia Pacific. For example, China Airlines has 24, Singapore Airlines 31, Thai Airways International 22, and Cathay Pacific 41. US operator Delta Air Lines has 32, and Turkish Airlines in Europe has 41. About 550 A330-300s are in active service.

Deliveries of all A340 variants stand at about 377, and the type ceased production in 2011. There were 28 A340-200s, and 218 A340-300s built.

Lufthansa is a major operator with 18 active A340-300s, and six stored. Cathay Pacific has nine active and two stored. Swiss has 15, along with Air France with 13. There are 173 A340-300s in service. These were built between 1991 and 2011.

Conviasa is the only airline with an active A340-200 passenger aircraft: S/N 31. A few A340-200s are still being operated as corporate and government aircraft.

Early-build aircraft

The older active A330-300s in service are with Dragonair, and are approaching their 22nd year. These are aircraft S/N 17 and 12. There are three 21 year-old A330-300s flying for Brussels Airlines, owned by Gladiator Leasing Ltd. These are S/N 30, 37 and 45.

The oldest active passenger A340-300s are approaching 22 years. These are operated by Mahan Air, Air France and Turkish Airlines. These are S/N 20, 29 and 25. TAP Portugal has four approaching, and just over, 20 years of age: S/N 41, 44, 79.

The oldest A340-200 listed in active service is S/N 4 at 23 years of age. It is a corporate aircraft owned by RESA Aviation UK Limited.

Aircraft utilisation

The A330-300's maintenance planning document (MPD) is based on annual utilisations of 1,667 flight hours (FH) to 5,667FH, and 367 flight cycles (FC) to 2,200FC. The A340's MPD ranges of annual utilisation are similar. This range in annual FHs and FCs reflects the variety of styles the aircraft was expected to be operated in.

Analysis of the accumulated FH and FC of the oldest aircraft illustrates the

EXAMPLES OF BASE CHECK PATTERNS WITH 8- AND 6-CHECK CYCLES

Check name	Likely main task groups	Check interval - months
8 base check cycle pattern		
C1	1C	18MO
C2	1C + 2C	36MO
C3	1C	54MO
C4/IMV	1C + 2C + 4C +6YE	72MO (6YE)
C5	1C	90MO
C6	1C + 2C	108MO
C7	1C	120MO
C8/HMV	1C + 2C +4C + 12YE	144MO (12YE)
6 base check cycle pattern		
C1	1C + 24MO/10,000FH	24MO
C2	1C + 2C + 48MO	48MO
C3/IMV	1C + 4C + 6YE + 72MO	72MO
C4	1C + 2C	96MO
C5	1C +	120MO
C6/HMV	1C + 2C +4C +6YE +72MO +8C +12YE +144MO	144MO

Note:

1) Many additional OOP tasks may or may not be planned into the base checks

2) The 5YE and 10YE tasks would have to be scheduled at the most convenient check. They would either have to be performed early, or the C4/IMV and C8/HMV checks performed early.

more common rates of utilisation of in-service aircraft.

The A330-300's and A340-200/-300's average flight times can vary widely. The A330-300 can be used either for long-haul, intercontinental operations, or on medium-haul routes.

The average annual medium-haul utilisation is 3,000-3,500FH and 1,000FC, while long haul operations can be 4,000-4,500FH and 700FC. Most A340-200/-300 ultra-long haul aircraft usually average 5,000-5,500FH and 600FC per year.

US Airways has five A330-300 fleet leaders which have accumulated more than 67,000FH and 9,500FC. This puts the average FH:FC ratio at 7:1 over 15 years.

The A340-200 fleet leader is S/N 74, and is operated by Aerolineas Argentinas. It is 20 years old, and has accumulated more than 71,000FH and 9,200FC, putting the FH:FC ratio at 7.7:1 over 20 years.

The A340-300 fleet leaders are SriLankan Airlines S/N 32 and 33. These have accumulated more than 93,000FH and 17,000FC.

TAP Air Portugal has airframes S/N 41 and 79, which are all 20 years old. These have acquired nearly 95,000FH and over 13,500FC.

MPD development

The A330's and A340-200/-300's maintenance planning document (MPD) is designed with the Maintenance Steering Group 3 (MSG-3) principles.

The aircraft's inspection task initial threshold and repeat intervals are listed by FH, FC and/or calendar time limits. The tasks are grouped into Systems and Powerplant, Structures, and Zonal sections.

The MPD's logic is heavily driven by aircraft utilisation, which now has a large influence in determining check content.

The A330 and A340 MPDs still, however, use some of the industry traditional 'A' and 'C' check calendar-driven format for grouping the Zonal, and some of the Structures and Systems tasks.

The MPD has gone through several escalations of 'A', 'C' and structural check intervals. The basic 'C' check escalation from 18 to 24 months in 2011 is perhaps the most important, since it went from a system of eight checks, including two structural checks, to a system of six base checks, including two structural checks *(see table, this page)*.

A checks

The standard 'A' check interval was escalated from 400FH to 500FH in 1998, again in 2002 to 600FH, and extended a third time in 2008 to 800FH. The A330-300's and the A340-200/300's intervals for A check task groups are: the 1A at 800FH; the 2A at 1,600FH; 4A at 3,200FH; and 8A at 6,400FH.

MPD tasks with intervals less than the 800FH (A check interval) would have to be incorporated into line checks. Tasks between the A check interval and up to 24MO/10,000FH C check would probably be incorporated into line or A checks when required. One example is for the general visual inspection (GVI) of the landing gear and landing gear doors, as far as is visible from the ground, every 36 elapsed hours.

Each operator can develop its own pre-flight, daily, and service line check packages.

C checks

The MPD has main groups of tasks, mainly in the Systems and Zonal programmes, that coincide with the eight or six main check intervals.

The main 1C, 2C, 4C, 8C, 6YE and 12YE task groups *(see tables, page 37 & page 40)* can be arranged or grouped by planners into eight or six block checks *(see table, this page)*. To avoid confusion between the names of the task groups from the MPD with Airbus's name for the base checks, the eight base checks in the cycle are generically referred to here as the C1 to C8 checks, or as the C1 to C6 checks in a six check cycle.

The only main task group in the C1, C3, C5 and C7 checks is the 1C tasks, as well as the FH/FC tasks that fell due. The C2 and C6 checks only have the 1C and 2C tasks *(see table, this page)*.

The larger C4 or 'intermediate' check could include the 1C, 2C, 4C, 6YE and FC/FH tasks that fell due at the same time *(see table, this page)*. The largest C8 or HMV check could include the 1C, 2C, 4C, 8C, 6YE, 12YE and FC/FH due tasks.

There are also, however, several additional groups of out-of-phase (OOP) tasks from the Systems, Structures and Zonal programmes, with various intervals in FH, FC or calendar intervals, that will also be grouped into the base checks by maintenance planners. These will include 5YE and 10YE tasks.

Base check task intervals

The MPD's standard interval for the 1C group of tasks was escalated from 15 months (MO) in 1993 to 18MO in 2002, and then increased again to 24MO/10,000FH in 2011. This is the same as the C check interval through the check cycle.

The C check's 24MO calendar limit can be restricted by the 10,000FH interval. It does, however, still allow 5,000FH per year for the two intervals to be reached at the same time. Unscheduled maintenance, operator changes and lease handbacks are a few of the many reasons why even calendar maintenance can become OOP.

Aircraft will often be scheduled for maintenance visits before fully utilising the MPD interval, however. Alternatively, C checks can be brought forward to coincide with the structural checks to optimise the aircraft's downtime.

Rui Martins, A340 maintenance programme engineer at TAP Portugal Maintenance and Engineering, explains that: "For TAP on high FH:FC ratio routes, the aircraft reach the C check's 10,000FH limit before reaching the 24MO calendar limit. This means we schedule our aircraft for C checks at 21-month intervals."

The 2C task group started at 30MO, and was first escalated to 36MO in 2002. It is currently at 42MO, or 20,000FH. It is waiting approval to be extended to 48MO. This is a more convenient multiple of twice the 24MO interval for the 1C tasks, thereby alleviating the current six month gap before the repeat 24MO tasks are due at 48 months. A smaller number of 2C tasks did get their interval extended to 48MO.

The 4C grouping of tasks originally had a 60MO interval, four times the original 1C interval. The 4C group was then escalated to 72MO, again four times the 1C interval, when the 1C interval was escalated to 18MO. The 4C interval is now at 72MO, but is only three times the 1C's 24MO interval.

The 8C group originally had a 120MO (10 years) interval; eight times the 1C interval. This was escalated to 144MO (12 years); eight times the 18MO interval. Today the 8C is at 144MO, but is only six times the 1C's 24MO interval.

With the 4C and 8C tasks now being three and six times the 1C interval, this makes it possible to arrange tasks into six block checks *(see table, page 36)*. These are referred to by Airbus as former C checks and the 4C/8C structural checks. They could be generically referred to as C1 to C6 checks. The two structural checks are the C3 and C6 checks.

The staggered 2C interval of 42MO makes it difficult to re-arrange tasks from a base check cycle of eight checks into a cycle of six base checks, however, where all the main tasks are in phase at multiples of 24 months. Many A330/A340 operators therefore still use the system of eight base checks.

In addition to the four main groups of C check tasks, there are also the two large groups of structural 5YE/10YE or 6YE/12YE task thresholds and repeat intervals groups that also have to be aligned with the 'C' checks.

When the A330/A340 went into service these two groups had the same 60MO/5YE and 120MO/10YE intervals as the 4C and 8C groups of tasks. The subsequent escalation of many of the 5YE and 10YE tasks to 6YE and 12YE intervals has made the C3 and C6 checks the intermediate and HMV checks.

While the 5YE and 10YE tasks are theoretically not in the phase with the C3 and C6 intervals, actual check interval utilisation means the C3 and C6 checks will be performed at 60 and 120 months by many airlines.

The 4C tasks and 6YE structural tasks form two large groups as the main elements of the intermediate structural check. The 8C and 12YE tasks, together with the repeat 4C and 6YE tasks, form the four main elements of the HMV check.

Many of the structural 6YE and 12YE check tasks also have FH or FC limitations that trigger the task coming due at whichever threshold or interval is reached first. Some of the structural tasks, especially around the landing gears, have remained at 10YE. Customers have the option to extend other tasks to 6YE or 12YE.

In addition to the main groups of 1C, 2C, 4C, 8C, 5YE, 6YE, 10YE and 12YE tasks, there are at least six other groups of tasks in the Systems programme, for example. These will have to be planned into checks in the most appropriate or efficient way. An example is a group of 22 Systems programme tasks at 12,000FH *(see table, this page)*. These could be brought forward to be included in every C check, which will be once every 21-24 months and every 8,700-11,000FH for ultra long-haul aircraft. They may have to be included in other checks, such as an A check, for aircraft operating medium-haul styles of operation so as not to compromise the interval of the base checks.

Other examples of additional task groups are those with 72MO and 144MO intervals. These differ from the 6YE and 12YE tasks, despite having the same intervals. Planning these 72MO and 144MO tasks into checks will be straightforward for planners.

Several other task groups would have to be planned this way, so the content of base checks could be almost unique for most aircraft and operators.

Optimising task intervals

Recent MPD revisions have made significant changes to most tasks in the structural inspection programme. This is

A330 SYSTEMS & POWERPLANT MPD TASKS LISTED BY INTERVAL

Repeat interval	Number of tasks	Notes
8DY or 140FH	8	
1A (800FH)	50	
1,000FH	9	
2A (1,600FH)	22	
3MO or NR	7	
4MO	6	
3A (2,400FH)	6	
4A (3,200FH)	25	
18MO	46	
6,000FH	8	
7,500FH	6	
24MO/10,000FH	156	1C tasks grouping
12,000FH	22	
36MO	37	
20,000FH	30	
42MO/20,000FH	83	
48MO	19	2C tasks grouping
24,000FH	7	
5YE/60MO	18	5YE tasks grouping
4C	75	4C tasks grouping
6YE	17	6YE tasks grouping
72MO	41	
8C	9	8C tasks grouping
12YE or 34,000FH	23	12YE tasks grouping
144MO	54	
VR NR	47	Replacement of items at vendor recommendation or national requirement
'NOTE'	41	Discard LLPs of engines & landing gears
Other intervals	167	The intervals for these tasks range from 36 hours to 82,700FH
Total tasks	**1,039**	

A330-300 STRUCTURAL MPD, NON FC- & FH-OPTIMISED TASKS BY INTERVAL

Maximum initial/ threshold	Maximum repeat	Number of tasks	Notes/deep access requirements
3YE	3YE	18	
5YE	5YE	7	
6YE	6YE	158	Flight control and door inspections
8,000FC	8,000FC	36	Forward engine mounts, trailing edge wing, main fuselage & thrust reversers
12YE	12YE	88	Full structural access
12YE	6YE	40	Passenger and maintenance doors
20,000FC	8,500FC	13	
17,000FC	8,000FC	18	
24YE	12YE	138	Aircraft main structure, wings pylons, fuselage and pressure bulkheads
24YE	6YE	26	Aircraft main structure, wings pylons, fuselage and pressure bulkheads
NOTE	NOTE	8	
Other task thresholds & repeat intervals		251	Intervals range from 18MO to more than 200,000FH and 39,500FC
Sampling aircraft tasks only		64	Intervals range from 17,000FC to 37,600FC or 60,000FH
Total tasks		**865**	

to aid the inspection programmes of ageing high FH and FC aircraft.

After an Airbus fleet survey revealed a wider range of FC and FH utilisations among operators than previously known, two different sets of revised initial and repeat intervals were introduced to a group of 1,260 structural inspection tasks. These tasks have a range of initial threshold intervals, and maintenance planners can either manage them as FC- or FH-optimised tasks.

This choice allows maintenance planners to optimise these tasks according to the aircraft's operation by choosing: the extended FH-optimised intervals if the majority of the fleet is used as long-haul utilisation; or the extended FC-optimised intervals if the fleet is utilised on short-haul operations.

These two methods of optimising this group of structures tasks are based on a trade-off between the original FC and FH intervals. It is better for an aircraft accumulating a large number of FC per year to use the extended FC intervals, and shorter corresponding FH intervals. The system of optimising these intervals is reversed for aircraft operating on long cycle times and accumulating a large number of FH.

An example of an 'optimised' structures task for an ageing aircraft is the inspection on the inboard leading edge of the wing joint straps. For an aircraft using a FH-optimised system, the task initial threshold has been revised to 24 years, 15,800FC, or 108,500FH.

For a FC-optimised aircraft the initial threshold has been changed to 24 years, 23,900FC or 71,900FH. This details that if the aircraft is not already 24 years old, for example, it would have to undertake the inspection at 108,500FH if FH-optimised, or 23,900FC if FC-optimised. These two sets of intervals illustrate the difference between FH and FC intervals, according to which system is chosen.

The MPD gives three methods for planning this group of optimised tasks.

The first method requires airlines to optimise all tasks either with the FC intervals, or with the FH intervals, depending on average fleet utilisation.

The second method is described as a 'semi-optimised'. It allows the operators to select either the FC-optimised or FH-optimised system for a group or sub-fleet in an operator's fleet. This system provides flexibility for sub-fleets with mixed rates of utilisation.

The third option is listed as the 'fully-optimised' method. Maintenance planners can choose between the FH- or FC-optimised system for each aircraft in a fleet, to provide full flexibility and optimise thresholds and intervals.

MPD tasks

Although the MPD is often a focus of discussion, behind the scenes the document itself comprises maintenance tasks required by other documents like the maintenance review board (MRB) report, Configuration Maintenance and Procedures (CMP) documents, airworthiness directives (ADs), service bulletins (SBs) and the Airworthiness Limitation Section (ALS).

Compliance with all of these source documents is required for the continued airworthiness of the aircraft. All tasks listed in the MPD will have their source information listed next to the threshold and interval information.

Systems & powerplant

The systems section provides the scheduled maintenance tasks defined as Maintenance Significant Items (MSI), and their intervals. This includes inspections of installations for proper attachment, security and general condition. The systems section uses many different intervals of FH, FC and calendar time for tasks. Some have a combination of two intervals. Only some task groups are aligned with the A or C checks.

The A330's MPD has 1,039 inspection tasks in this chapter. These systems section inspection requirements include visual checks (VC), GVIs, detailed inspections (DI), functional checks (FN), operational checks (OP), and lubrications (LU).

The A340-200/-300 MPD has the same format, but 1,178 systems tasks listed. The larger number compared to the A330-300 is mainly because the A340-300 has more engine-related and associated systems and structures, and an additional landing gear.

The systems and powerplant tasks for an A330-300 are summarised *(see table, page 37)*. These are the largest groups of tasks, where there are more than five tasks with the same interval. This provides an idea of where the large numbers of tasks fall, and shows the larger C and structural task groupings. There are 872 of these tasks.

Another 167 tasks are listed with 'other intervals'. These comprise small numbers of tasks with a wide range of intervals. The tasks with the shortest interval are three-day line maintenance tasks of the tyre pressure checks. The task with the highest interval is at 82,700FH, for the operational check of the main fuel transfer system. This group of 167 'other' tasks also includes five major structural tasks that still have the original 10YE interval, and have not been escalated to 12YE. Many tasks in this group have unique intervals to be planned into the maintenance visits at the closest opportunity to the interval requirement or at closest A check or 'C' check multiple.

Some 12YE tasks also have secondary intervals. An example from the MPD, is to be 'carried out at 12 years, 6,500FC or 29,000FH whichever limit is reached first'. The tasks are therefore likely to

TAP Air Portugal has two A340-300s which are 20 years old and have accumulated 95,000FH and more than 13,500FC. These are some of the oldest A340-300s in active service.

come due about once every five to nine years in the case of most operators. They may probably be planned into the intermediate structural check.

Some high interval tasks have higher initial threshold intervals than the 8C interval. They therefore come due for the first time during the second base check cycle, between the second C1 and C8/HMV checks. These high interval tasks include: the forward engine mount bolt replacements, which require the engines to be removed at 11,000FC; the detailed inspections of the cockpit instrument panel brackets at 16,500FC; the removal of the ram air turbine (RAT) for overhaul at 20 years; and the operational check for both dual flapper check valves for leaks on the inert gas system (nitrogen) at 60,000FH. This last task alone needs more than 100 man-hours (MH) according to the MPD.

Structures tasks

The A330-300 structures section has 865 inspection, non-optimised tasks with standard initial threshold and subsequent repeat intervals *(see table, page 38)*. These are listed in groups where there are 10 or more inspection tasks with that threshold requirement to show the larger groupings of tasks.

Most of these tasks have calendar intervals, and so can be grouped relatively easily into base checks by the aircraft operator's planning engineers. In particular, these are the 5YE, 6YE, 12YE and 24YE tasks *(see table, page 38)* which have heavy access requirements of removing interior furnishings and wing flight controls, for example.

Another large group of structural inspection tasks is the 67 tasks with 8,000FC, 17,000FC and 20,000FC intervals. Like Systems programme tasks, these would have to be slotted into a base check at the most convenient point according to aircraft utilisation. The 8,000FC tasks, for example, would come due about every eight years on an aircraft flying medium-haul operations of 1,000FC per year, or about every 11 years for aircraft flying longer haul flights accumulating about 700FC per annum.

There are 251 further tasks that are of smaller quantity or unique intervals to be planned into checks. These range from 1,000FC to well over 100,000FH.

There is also a wide range of threshold intervals for the 1,260 tasks that are FC- or FH-optimised, as described.

The non-optimised and optimised task groups include some structural inspection tasks that are used in the sampling programme. These tasks are designed to detect, by visual or non-destructive inspection (NDI), structural defects that arise early in an aircraft's life. They are performed on each operator's five oldest aircraft to detect in advance the systematic deterioration of an operator's oldest aircraft in its fleet. These could be relatively young compared to other airlines' fleets. Non-sampling aircraft do not have these tasks performed. The five oldest aircraft in a fleet therefore have more structural tasks to perform than the rest of the fleet.

The A330-300 MPD structures section therefore has a total of 2,125 tasks specified in a mix of combination FC, FH and calendar-based intervals.

This comprises 801 non-optimised inspections and 64 non-optimised sampling tasks, and 710 FC- and FH-optimised tasks and 550 FC- and FH-optimised sampling inspection tasks. The 614 sampling tasks apply to all A330 variants and configurations. The number that applies to each aircraft may be nearer to 150.

Most of these come due around the 12 year mark in calender time, but also have FH and FC thresholds.

Since many of the 2,125 structural tasks do not apply to each particular aircraft, each operator will create a maintenance programme out of the full list of tasks to match each aircraft.

The A340 MPD structures tasks are similar to the A330-300.

High threshold structures tasks

The structures section has the heaviest addition of tasks for the high FC/FH and ageing aircraft, and those in their second base check cycle. These tasks will greatly influence how much larger the second C8/HMV check is, compared to the first HMV check, and therefore the second HMV's economic viability.

For the A330-300, there are 164 non-optimised or standard tasks that have an initial 24YE threshold interval *(see table, page 38)*. Not all of these apply to every aircraft. The tasks come due for the first time in the second 12YE or C8/HMV check. The inspection alone accounts for 119MH via the MPD. Some 26 tasks come due again thereafter every 6YE at the third intermediate 'C4' check.

For the A340-200/-300, the extra 263 24YE tasks, performed at the second 12YE check, add 206 MPD inspection MHs. Again, not all of these tasks apply to every aircraft.

Many of these 24YE tasks require NDI specialists, which charge at higher MH rates. They need specialised equipment to carry out checks to detect defects not visible to the naked eye.

The 24YE tasks also require deep access for tasks to be performed. This would already be partly gained, however, in the same area for a 6YE or 12YE check.

The 24YE tasks go deeper into specific areas for detailed inspections. Examples are ribs in the fuel tanks and surface areas normally covered by other structures, or components like flap tracks over the lower wing skins.

Additional access for these tasks would relate to the removal of specific

A330-200/-300 ZONAL MPD TASKS BY INTERVAL

Interval	Number of tasks	Notes	Deep access tasks
1A	23		N/A
18MO	4		N/A
24MO	30	1C check interval	N/A
36MO	3		N/A
42MO	23	2C check interval	N/A
48MO	5	2C check interval	N/A
4C	48	6YE check interval	Cargo bays
8C	65	12YE check interval	Upper & lower lobe and wings
Total	**201**		

fasteners and the NDI of the related holes at the various thresholds, sealant removal over the fasteners in the fuel tanks at 13,000FC or 62,800FH, plus the usual access for the removal of interior furnishings like galleys and ceiling panels. The tasks would create little impact if planned into the closest structural check, where access is already gained or would require minimal additional MH to do so.

The high FH and FC task interval extremes shown demonstrate the MPD's readiness to handle ageing aircraft inspections, and for operators to see in advance what work has to be planned.

At the extreme end of the scale, Airbus has already incorporated inspection tasks at 250,500FH into the A330's MPD. This is for a special detailed inspection of the fuselage external structure longitudinal joint at stringer 39. This task has no MH listed in the MPD and is listed as 'TBD' (to be determined).

Similar inspection tasks up to 192,000 FH appear in the A340-200/300 MPD.

Zonal tasks

The zonal section provides the GVI requirements for the general condition and security of systems and structural items contained in a specific zone. It has 201 inspection tasks.

This is done by looking for signs of accidental damage, corrosion, cracks and for the accumulation of any kind of contamination (including potential combustible material) for Enhanced Zonal Analysis Procedures (EZAP) concerns, along with Electrical Wiring Interconnect System (EWIS) inspections. These in general are to be carried out within touching distance, unless otherwise stated in the inspection card.

The zonal section task intervals are conveniently grouped into seven different intervals. They are only expressed as 1A, 18MO, 24MO, 36MO, 42MO, 48MO, 4C and 8C *(see table, page 40)*. These are also the standard repeat intervals, and so do not alter greatly for the ageing fleet. Most of these intervals conveniently coincide with the base check intervals.

Focusing on the A330-300 MPD, the zonal section of the MPD has 201 tasks *(see table, page 40)* specified in calendar time, 'A', or 'C' check intervals. The A340 has the same format, but 273 zonal tasks listed. This larger number for the A340 is again due to the aircraft having two more engines and related systems.

High threshold zonal tasks

The 48 tasks in the 4C group, which would fall at the 6YE interval, consist of both internal and external GVIs over most of the aircraft.

They have numerous access panel removal/refit requirements, but not the removal of major structural items, such as interior furnishings or flight controls.

Floor panels will have to be lifted in the lower lobe in the cargo bays, and on cargo aircraft on the main deck cargo compartment. Freighter configuration aircraft have earlier inspections on the upper lobe floor structure due to weight loadings and the moisture/leakage brought in from the freight that causes early stress and corrosion on floor beams.

One of the largest tasks, in terms of access MH and due at the C4 or intermediate check, is the inspection of the air conditioning compartment and fairings. The MPD has 41.21MH listed for access alone, and just 0.6MH for the related inspection. These 48 tasks have relatively high access requirements.

The 65 tasks in the 8C group, which would come due every 12 years or every C8 or HMV check, include numerous passenger door, fuselage, wing and fin inspection tasks. The deeper inspection levels now reach the main passenger cabin compartment and fuel tank structure, which require the internal furnishings including lavatories, galleys and seats to be removed.

There are extensive GVIs down to structural level. This requires the removal of all equipment, including insulation blankets throughout the aircraft. One of the largest zonal inspection tasks due in the C8/HMV check, is on the inner fuel tank with 6MH for inspection, and 33.6 MH for access.

These 65 tasks also have relatively high access requirements.

Additional tasks

A lot of the OOP tasks are not FC- or FH-based, but are items listed as National Requirement (NR) or Vendor Recommendation (VR). The NR tasks are a group of tasks with intervals that fall due in accordance with the operator's national regulatory authority, or the manufacturer's life limits placed on the item. Examples include portable fire extinguishers and oxygen bottles.

Tasks that are listed as VR have interval values dependent on the particular component's manufacture (vendor) recommendation as to when a shop visit is required.

Routine maintenance

Unlike Boeing aircraft MPDs which list access separately, the A330/A340 family MPDs for each task list up to three sets of MH. These are the estimated labour requirements for the three elements of preparation, task and access for routine inspections.

Therefore, when collating an estimate of MHs for each check, it is important not to duplicate the preparation and access MH for several tasks. If the rear lavatory, for example, has to be removed so that five different inspection tasks can be performed, then when summing up the Airbus MPD MH, there will be five sets of galley removal/refit MH in the same check package. The total MHs need to be adjusted when the final maintenance work pack is evaluated. This is especially key to evaluating the C4/Intermediate and C8/HMV check inputs where extensive access is required.

It is important to note that the MH referenced in the MPD are regarded as base figures that need a 'reality' factor applied to them. Additional MH need to be added to source equipment and to set up inspection staging and gantries, for example. Many maintenance providers and operators multiply the Airbus MPD MH by a factor of 3.0 to 4.0 to give a realistic figure that they can use to plan manpower coverage for routine maintenance tasks.

Turkish Technic uses a multiplier of 2.0. Both TAP Maintenance & Engineering and Lufthansa Technik use their own independent database to determine MH requirements when planning checks.

Defects & non-routine

The defect rectification ratio required for non-routine maintenance, often called

Airbus has evolved the MPD and no longer refers to numbered C checks. Many tasks and task groups no longer have intervals that coincide with calendar-based letter checks, and instead have FH and FC intervals.

the non-routine (NR) ratio, will generally increase with age and successive checks in the base check cycle.

High FH and FC and calendar time, old aircraft will need a higher allowance for defect ratio when calculating MH.

The check size and level of inspection must also be taken into consideration. For example, the first C check at the start of the base check cycle, or after the aircraft's 6YE or 12YE structural check, is likely to have a lower NR ratio than the preceeding check. This is because the aircraft would have had all the major structural, system and cosmetic defects rectified in the previous large check. The defect ratio should then gradually increase with each base check as the aircraft approaches its next major structural inspection every five to six years.

For the older aircraft approaching the second C8 structural check, at up to and over 22 years of age, an NR ratio of up to 55% to 65% of defect hours to routine inspection hours is a guide. The implications of this are that the second C8/HMV check will have a relatively small increase in MH and material input compared to the first C8/HMV check.

The actual NR rate will always vary with each aircraft's operation, and with the operator's maintenance standards. Maintenance providers bidding for work will evaluate the history of each aircraft prior to finalising the NR ratio to use. An aircraft that has had numerous owners around the world and a disjointed history of servicing, will have a high NR ratio applied in the expectation of more defect findings per inspection MH.

Guide figures for the NR ratios for a C check on A340s (A330s will be similar), supplied by Feray Gunseli Demiral Ozgumus from Turkish Technic production planning and control department, are: "60% for an aircraft of five to 10 years of age, 62% for 11-15 years, and 63% 16-20 years. The NR ratio guide for structural checks would be 50% for an aircraft aged nine to 10 years, and 53% at 14-15 years."

Ageing maintenance

Listing specific aircraft type design limitations is complicated by each aircraft's individual modification status, weight and utilisation. In general, however, the original guide for the A330-300 design limit was 33,000FC to 40,000FC, and 60,000FH to 100,000FH. The equivalent limits for the A340-200/-300 were 20,000FC to 31,000FC, and 100,000FH to 156,000FH. These are maintenance programme limits, and linked to the manufacturer's design limits. The aircraft is therefore only airworthy up to these limits.

This range of FH and FC figures are also known as the aircraft's Limit of Validity (LOV). These can be extended on the A340-200/300 in two steps. This was to deal with aircraft that are approaching the initial design limits.

The first step is the intermediate service goal (ISG), which allowed the aircraft to a maximum utilisation of 100,000FH/20,000FC with no modifications required. The ISG was just a mix of revised and new inspection tasks to be added to the maintenance programme. In the case of revised tasks, the repeat intervals are shortened.

The second step, which is the extended service goal (ESG), allows the aircraft to operate to a maximum 156,000FH/31,000FC.

Several modifications, inspections and component replacements are required for this second extension. Many older Airbus maintenance programmes and aircraft are going through these changes. These tasks are generated from the ALS, and are constantly being re-evaluated to allow operation of aircraft systems beyond their original design life limits.

TAP's long-haul A340 fleet, with an average total time of 95,000FH, is still far from reaching the LOV (for the ESG). Martins, however, notes that: "It is important to retain the LOV as a limitation applicable to the aircraft maintenance programme, and not to the aircraft itself."

"In terms of TAP's A340 extension of service goal, Airbus requires certain SBs to be carried out before the ESG programme is implemented," continues Martins. "An example of these is SB 28-4124 for the introduction of a modified fuel pump to the main fuel system, in order to eliminate ice formation behind an electrical connector."

Repairs also require further attention to extend aircraft LOV. "There are some defects that due to their nature (type of defect and dimension) have been repaired in accordance with the structural repair manual (SRM). The original repair needs re-evaluation for the aircraft to continue beyond the LOV limits, and the repair approval now has to be done by means of an Airbus Repair Design Approval Sheet (RDAS)," says Martins.

Major ADs & SBs

With focus on the ageing airframe continued maintenance, one of the more recent ADs issued by European Aviation Safety Agency (EASA) is AD 2014-0136 released in June 2014. This AD follows the continuing inspection and modification/strengthening programme for the Frame 40 fatigue damage first noted by AD 99-448-126.

This new AD focuses on S/N aircraft from 0176 to 0915 on the A330/A340 production line. It results from the recent rototest inspections of a removed, retrofitted internal strengthening strap for a local repair. This indicated that the holes in the strap for the fastener installation had cracks. A repetitive rototest inspection of the fastener holes on strengthened aircraft is therefore now

1ST & 2ND BASE CHECK CYCLE C4/IMV & C8/HMV MH & MATERIAL INPUTS

Check name	Cycle in use	Aircraft age	Routine MH	N-R ratio	Defect MH	Sub-Total MH	ADs & SBs MH	Comp MH	Cabin work MH	Total MH	MH $	Mats $	Clean $	Total $
1st C8/HMV	5YE/10YE	9-10	16,500	55%	9,075	25,575	500	250	300	26,625	1,996,875	559,125	6,500	2,562,500
2nd C4/IMV	5YE/10YE	14-15	10,500	53%	5,565	16,065	600	400	200	17,265	1,294,875	362,565	65,00	1,663,940
2nd C8/HMV	5YE/10YE	18-19	17,500	63%	11,025	28,525	750	500	400	30,175	2,263,125	633,675	6,500	2,903,300
2nd C8/HMV	6YE/12YE	20-21	17,000	63%	10,710	27,710	750	500	400	29,360	2,202,000	616,560	6,500	2,825,060

Notes:

1) The total MH for each of the checks do not include inputs for interior refurbishment

2) The 1st C8/HMV check has all the structural tasks included. The two variants of the 2nd C8/HMV check have either the 5YE/10YE tasks, or the 6YE/12YE tasks. Neither variant of the 2nd C8/HMV check has all the 5YE/10YE and 6YE/12YE tasks in the same check.

required, and a repair to be installed if needed. The compliance time for the A330 is within 2,400FC or 24 months of the effective date of the AD (June 2014). It is within 1,300FC or 24 months for the A340. A crack found would require corrective action before the next flight.

An example of further modifications needed on older aircraft due to post-design accidents, which trigger new maintenance practices and component improvements, is included in AD 2014-0148 (also released June 2014). This AD requires all maintenance light bulbs that are not qualified as explosion-proof to be removed as a result of the Special Federal Aviation Regulation (SFAR) 88, which monitors and prevents fuel ignition sources. Various compliance times are listed against the current modification status to the systems installed to be followed, but in general are within 14 to 26 months of the AD being issued.

Ageing aircraft composite repairs are under close scrutiny, with records now being investigated on repairs made on rudders due to the loss of a flight control surface on an A310. Within 24 months after the effective date of the AD 2014-033 (issued Feb 2014), maintenance records have to be searched to see if any composite side shell panel repairs have been carried out on the rudder surface in order to check for water ingress. If records cannot be found, then a thermography inspection is needed. This is where the rudder is heated and pictured to expose where any water may be in the rudder as a result of disbonding of poorly installed repairs.

Interior refurbishment

Keeping the aircraft modern in entertainment set-up, along with the passenger comfort levels in furnishings, is another stress placed on ageing aircraft.

To be competitive in the market and to attract customers in, and back again, cabin comfort will be hard to match for the older fleet against the new quieter, more modern fleet they are flying against.

Cabin refurbishment programmes can appear at any time, however, irrespective of the maintenance due. The modification and overhauls of the cabin would of course still be convenient at the 6YE and 12YE inputs, purely because of the available downtime and access. Full interior refurbishments will be up to 8,000-10,000MH of labour and about $250,000 for materials and parts. This will include the refurbishment of seat frames, servicing areas, galleys and lavatories, and panels and overhead bins. An aircraft strip and re-paint would incur further cost.

In addition, tens of thousands of dollars are needed for the design approvals, which is hard to justify if the aircraft is not going to be operated long past the 22-year mark. There is a balancing act between market competition, comfort and longevity.

Second base cycle costs

With the option of different optimised structures tasks incorporated into the MPD, there is such a large number of possible permutations of task groupings to place into a series of checks that it is difficult to summarise. Operators, however, have budgeting figures to use for pre-planning.

Focusing on the older aircraft structural checks, there are several ways to organise the task groups of 5YE/10YE and 6YE/12YE into base checks.

TAP Maintenance & Engineering, for example, on its A340 fleet has noted two options for arranging calendar tasks on aircraft approaching their second C8. Martins notes that: “In this case, the structural tasks had calendar intervals of 5YE or 10YE in the first check cycle, so the first C4 would include the 5YE tasks, and the first C8 would include the 5YE tasks and the 10YE tasks.

“During the second check cycle, some of the 5YE/10YE tasks were escalated to 6YE/12YE intervals. For the next C4, TAP Maintenance & Engineering therefore decided to perform all the tasks at the same time (5YE tasks when due and the 6YE tasks brought forward a year for convenience),” continues Martins. “When it came to the second C8, TAP Maintenance & Engineering decided to split the 5YE/10YE tasks from the 6YE/12YE tasks, and perform them in two separate checks.” This method creates two structural inputs that can be aligned with C checks to reduce overall downtime. This highlights the fact that most tasks in the Airbus MPD are calendar, FC- and FH-driven, rather that scheduled ‘C’ check intervals.

In budgeting for checks, the addition of component changes and a customer’s own tasks to the MPD tasks and related NR defect rectifications will make up a more realistic picture of the total check input. Martins adds: “For the TAP A330 and A340 fleet the number of tasks for component changes can be 6.3-13.5% for all the component-related tasks. Customer tasks are harder to define per ‘C’ check, but at TAP they make up 2.75% of the maintenance programme.”

Other operators like Lufthansa have noted that the scattering of customers’ own tasks is large, comprising 10-40% of total tasks. It is important to note that many operators will incorporate MPD tasks into their own inspection cards, so how each airline develops its maintenance programme will affect the portion of maintenance that is its own.

To add to the equation, material costings are needed and are highly

The escalation of some structural tasks means that not all groups conveniently coincide at the same intermediate and heavy maintenance checks. Structural tasks will either have to be performed early, or split over two consecutive base checks.

unpredictable due to possible major defect rectifications required like skin repairs. Material check budgeting is therefore often disproportionate to the MH consumption. In general for standard A check packages all consumables and materials could be in the region of $26 per MH, and C check materials $21 per MH. This is due to the small number of MH used in an A check in relation to parts and materials required, such as a filter change. This is in contrast to a larger C check, where for the larger amount of access MH only small cost consumable items like sealant and tape are used, which brings down the general material cost to labour MH ratio.

This effect can also bring the 6YE/12YE check material cost ratio down. Of course there are always the material caps (not to exceed figures) in contracts to consider. This affects pricing with third-party maintenance inputs as the provider protects itself against defect-hungry aircraft.

This is supported by Martins' comments on budgeting for materials. "Material rate per MH is mainly used for budgetary purposes, in order to produce third-party customer check quotations," he says. "We have multiple values, based on several variables, namely fleet, aircraft age, type of check and the cap value used (limit by single item or line item), and we therefore cannot pinpoint a standard value."

From supplied MH for HMV checks, a guide summary of the second base check structural inputs is provided *(see table, page 42)*. A guide figure of $75 per MH has been used for the labour rate. The figures do not include any interior refurbishment costs. Two examples of the second C8/HMV check are displayed, together with guide costings supplied of the first C8.

The second C8/HMV check with 5YE/10YE has the inspection/access and defect MH, along with material costings, for the check completed just before the aircraft reaches 20 years old. This would be carried out on an aircraft whose operator chooses to maintain it on the original 10YE HMV interval, with just the 10YE tasks performed. It may have decided that the aircraft will not be in operation long enough to justify doing the 12YE repeat and 24YE threshold tasks just two years later, or may have split the work pack for convenience.

The second example for the second C8/HMV contains the 12YE repeat option for an aircraft approaching an age of 22 years. The 12YE repeat and 24YE new tasks are therefore performed. The 5YE/10YE inspections will have already been completed in a previous check.

Neither of these two options for the second C8/HMV check therefore have all the 5YE, 6YE, 10YE and 12YE structural tasks. Neither of these options provides a direct comparison with the first C8/HMV check, which does have all the structural tasks. If the second C8/HMV check did have all four groups of these structural tasks, then the total MH required would be up to 1,000MH more than shown.

The costs of the second C8/HMV checks are not completely comparable to the first. These guide figures show that airlines are not predicting the second structural C8/HMV check to have a significant amount of additional defects as a percentage of the check's inspection MH. Martins adds that: "From the available data we have, it seems that there is no direct relation between the aircraft's increasing age and an increase in NR or defect ratio in terms of MH. This may be a consequence of the efficient preventive maintenance that TAP Maintenance & Engineering strives to achieve."

Summary

The A330 still has an active presence in today's skies as an increasingly versatile aircraft, although newer products are now testing its future role. The A350 and 787 are re-directing the A330's long-term role. The A350 family is the natural successor to the A330 and A340, while also being part of Airbus's competition to the 777 and 787 families.

The A330-300 is still in production and has over 100 back orders, which show that the current model type is still in demand. The older design, but newly-built, A330s still have a fight to prove to be the better purchase, since the base check intervals of aircraft like the 787 are one-and-a-half to two times longer than that of the A330.

The A340's four-engine design and related higher maintenance costs, less appealing cabin, and fuel efficiency concerns are now hurting its desirability.

While they await deliveries of the new aircraft types, operators are putting at least some of the oldest A340-300s through a second C8/HMV check. The current ESG limits, spares availability and comfortable defect ratios allow this. Operators like TAP are conscious, nevertheless, of its place in a competitive market to win over the flying public with the older fleet. José Almeida, fleet engineering and projects manager at TAP Maintenance & Engineering, states that "TAP plans to phase out the A340 fleet in 2017 following the deliveries of the A350. There will be a transition period during which the A330/A340/A350 will temporarily co-exist."

Putting A340-200s/-300s through second C8/HMV checks generally appears to be a necessity in the industry. This is due to market needs that can be easily managed, rather than a plan to continue the A340s at least deep into the third base check cycle. AC