The oldest A380 aircraft are now approaching the end of their first base check cycle over a 12-year period. Positive maintenance inspection results a check cycle, releasing the aircraft for longer periods of operational availability. Sandra Everest examines the A380's base maintenance inputs.

A380 MPD & base maintenance analysis

The A380-800 began operational service in October 2007 with Singapore Airlines. The oldest A380s are now approaching the end of the first cycle of maintenance inputs covering a 12-year (YE) period.

The A380 was the first Airbus to enter service on a 24-month (MO) base check interval. This equates to a six-check cycle over 12 years, rather than the more familiar 18MO base check interval, eight-check cycle. The application of modern design tools and principles in early development of the aircraft systems and construction materials played a key role in optimising maintenance efficiencies.

As of the end of 2017, airlines can escalate the 24MO base check cycle to 36MO, so that aircraft move to a four-check cycle over 12YE. This will allow even greater planning flexibility and increase in-service revenue for the fleet.

The traditional lighter structural inspection at six years, and a heavy structural check interval of 12YE, will still slot into either the four- or six-check cycle at 72MO and 144MO.

The A380 maintenance planning document (MPD) uses a variation of flight hour (FH), flight cycle (FC) and/or calendar intervals to optimise utilisation of each individual scheduled maintenance task. An increase from 24MO to 36MO for maintenance inspection tasks, therefore, requires equivalent FH escalations from 12,000FH to 18,000FH.

Base check escalations are a result of positive in-service data collection, and follow escalation of the A checks from 750FH to 1,000FH in 2016. The 24MO check cycle currently in use, the move to a 36MO check cycle, and the looming first 12YE checks are examined here.

Fleet overview

As of mid-April 2018, there are 224 A380-800s, with 220 in active service across 13 airlines, and four in storage. The stored aircraft are with Doric Asset Finance (3) and Singapore Airlines (SIA) (1), two of which are undergoing end-of-lease maintenance inputs *(see A380 table, page 37)*.

The oldest aircraft in active service is serial number (S/N) 007, just over 12 years old, which was originally listed with Airbus, and then delivered to Emirates Airline in 2009.

The highest FH aircraft is S/N 015 with 41,761FH operating for Qantas Airways, at nearly 10 years old.

The highest FC aircraft is S/N 009 with 5,824FC operating for Emirates, at nearly 11.5 years old.

Engine options for the fleet include the Trent 970-84/970B-84, referenced as A380-841; the Trent 972-84/972B-84, referenced as A380-842; and the Engine Alliance GP7270 referenced as A380-861.

Of the 13 airlines, seven have the Trent 970 engine option, one has the Trent 972 engine, five have the GP7270 engine, and only Emirates has two options in the fleet with the GP7270 and Trent 972.

From statistics available, discounting aircraft less than 1.5 years old for more accurate annual utilisation statistics, the aircraft have only a minor variation in average FH usage of 4,381FH for the Air France fleet, to 5,491FH with Etihad Airways.

The average range of annual FC usage is from 429FC, for the Qantas fleet, up to 624FC for the Qatar Airways fleet.

As always, geographical location and individual airline operational use of the fleet range/versus capacity of passenger movement results in a variation in the FH to FC ratio. The lowest average FH:FC ratio is 7.3:1 for Emirates; the highest FH:FC ratio is 11.8:1 for Qantas.

China Southern Airlines, Malaysian Airlines and SIA have incomplete FH and FC data to add to the utilisation survey.

Emirates has by far the largest fleet with over 100 aircraft. As some aircraft are configured for regional use and others for longer-distance routes, Emirates aircraft show the largest range in annual FH utilisation, from just over 3,200FH to a little more than 5,200FH.

The fleet's average annual utilisation is in the region of 4,725FH and 560FC.

A380 MPD

The A380 MPD combines mandatory repeat scheduled maintenance inspections required for continued airworthiness of the aircraft. This includes scheduled maintenance tasks in airlines' Approved Maintenance Programmes (AMP).

Revision 13 of the MPD was released on 1 February 2017, and contains the A check interval escalation from 750FH to 1,000FH. It also contains the task interval parameters supporting the current 24MO base check cycle pattern used by in-service aircraft not trialling the 36MO escalations.

The most recent revision to the MPD, Revision 14, was released in late 2017. It contains the escalation of specific task intervals to coincide with progression to a 36MO/18,000FH base check cycle.

Revision 13 of the MPD contains 1,817 tasks listed under the three main sections of Systems (including auxiliary power unit (APU) and Powerplant), Structure, and Zonal. Aircraft and component FH, FC and calendar time are used for the main threshold and repeat interval operational parameters. Calendar time is covered by Hour (HR), Day (DY), MO and YE.

Additional operational parameters will be affected by the local regulatory authority the aircraft operate under, or are contained within additional vendor documentation. In this event the MPD references the threshold or interval as National Requirement (NR), Vendor Requirement (VR) or 'NOTE', which is used to reference further information,

A380 FLEET OVERVIEW - IN SERVICE & STORED FLEET AGE & UTILISATION CHARACTERISTICS*

Airline	Number of aircraft	Engine Type	Oldest active aircraft	Average age	Average annual FH	Average annual FC	FH:FC ratio	Average FH/day	Average FC/day	Highest cumulative FH	Highest cumulative FC
Air France	10	GP7270	9.2	7.3	4,381	484	9:1	12.00	1.33	32,528	3,905
Asiana Airlines	6	Trent 970	4.3	3.1	5,481	506	10.8:1	15.02	1.39	18,740	2,222
British Airways	12	Trent 970	5.4	4	4,606	446	10.3:1	12.62	1.22	19,449	2,219
China Southern	5	Trent 970	7.1	6.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Doric*	3	Trent 970/ GP7270	11.9	11.7	4,448	492	9:1	12.19	1.35	N/A	N/A
Emirates Airline	102	Trent 972	12.2	4.5	4,498	616	7.3:1	12.32	1.69	41,124	5,824
Etihad Airways	10	GP7270	3.8	2.7	5,491	569	9.7:1	15.04	1.56	16,141	1,841
Korean Air	10	GP7270	7.4	6	4,735	429	11:1	12.97	1.18	31,268	3,172
Lufthansa	14	Trent 970	8.5	6.5	4,738	487	9.7:1	12.98	1.33	31,373	3,464
Malaysia Airlines	6	Trent 970	6.5	6	N/A	N/A	No/A	N/A	N/A	N/A	N/A
Qantas Airways	12	Trent 972	10.2	8.7	5,074	430	11.8:1	13.90	1.18	41,761	3,709
Qatar Airways	9	GP7270	4.6	3	5,234	624	8.4:1	14.34	1.71	15,688	2,311
Singapore Airlines*	19	Trent 970	11.1	7.1	4,709	542	8.7:1	12.90	1.48	N/A	N/A
Thai Airways International	6	Trent 970	6.1	5.5	5,088	611	8.3:1	13.94	1.67	24,108	3,285

* FLEET HAS AT LEAST ONE AIRCRAFT LISTED AS UNDERGOING LEASE RETURN CHECKS OR IS CURRENTLY PARKED.

FH AND FC INFORMATION ONLY AVAILABLE FOR SEVEN OF THE SINGAPORE AIRLINES FLEET.

FH AND FC INFORMATION FOR AIRCRAFT UNDER 1.5 YEARS OF AGE HAS NOT BEEN USED IN ANNUAL AVERAGE FIGURES.

INFORMATION CURRENT IN MID-APRIL 2018

including interval detail contained within the individual task description.

Many inspection tasks within the MPD originate from other source documents, such as the Maintenance Review Board Report (MRBR), and the Airworthiness Limitation Section (ALS) programmes that monitor damage tolerance and certification maintenance requirements (CMRs). Information from regulatory authorities, such as airworthiness directives (ADs) and original equipment manufacturer (OEM) service bulletins (SBs) also feeds into the MPD.

The current referenced Limit of Validity (LOV) or maximum FH/FC aircraft utilisation covered by the MPD (and source documents) is 19,000FC or 140,000FH. For a high FC utilisation aircraft this equates to an operational service of 28 years, while for a high FH utilisation aircraft it equates to 25 years.

Task interval optimisation

The A380 does not use the industry familiar letter checks within the MPD. Under the MPD up to Revision 13, letter checks are large groupings of inspection at equal intervals of 24MO. They may still commonly be referred to as a cycle of C1, C2, C3, C4, C5 and C6 checks *(see table, page 38)*. The traditional style of task grouping into pre-defined checks is replaced by the concept of recognising the inherent reliability in each of the aircraft's system and structural components.

"At the beginning of the A380's maintenance programme development, a decision was made to stop using the check, and apply a usage parameter of FH and FC," explains Pierre Salles-Parfouby, head of the A380 maintenance programme at Airbus. "The aim of this was to give more flexibility to airlines in organising their maintenance planning, so that they can perform maintenance when the aircraft stops, rather than stop the aircraft to carry out maintenance."

The design of the A380 has maximised maintenance programme interval efficiencies.

"There are several examples where the aircraft's system design was a first for commercial aircraft," adds Berthold Stegerer, head of aircraft operations marketing at Airbus. "This included an integrated modular avionics system, which has reduced the number of standalone computers, a 5,000PSI hydraulic system with only two circuits instead of three, and aluminium wiring that reduced the aircraft's total weight loading on the structure."

New construction materials also helped to lighten the maintenance inspection programme. "New to the A380 was the application of GLARE," continues Stegerer. "GLARE is a composite material comprising aluminium and glass fibre, with an adhesive as a compound. Compared to aluminium alloy, GLARE provides better crack propagation and more corrosion resistance, allowing the MPD to be relatively light."

For check planning assistance Airbus provides an AirPl@n Simulator for customised maintenance planning simulation. This is accomplished using MPD man-hours (MH) based on aircraft utilisation, and is accessed through the AirbusWorld website.

The 24MO check cycle

The A380 MPD was developed to support an annual utilisation of up to 6,000FH and 1,100FC. The current average utilisation of the fleet in terms of FH and FC will fall within these parameters, so the calendar interval when listed with an FH or FC interval is met first. All other tasks with FH and FC parameters will be monitored to be inserted into the closest check, depending on access and MH requirements.

For most of the active in-service aircraft, base check intervals as mentioned currently fall in multiples of 24MO. A large number of 24MO tasks also have a 12,000FH backstop. The 12,000FH interval is long enough for the 24MO interval to be fully utilised by all operators, since 6,000FH in 12 months is equal to more than 16FH per day, and is unlikely to be reached by any operator.

A380 MAINTENANCE PROGRAMME BASE CHECK CYCLES 24MO & 36MO C CHECK INTERVALS

C check	Calendar interval MO	MPD FH interval	Approx FH interval per avg utilisat	Approx FC interval per avg utilisa
1st or C1	24	12,000	9,000-10,500	1,100
2nd or C2	48	24,000	18,000-21,000	2,200
3rd or C3	72	36,000	27,000-31,500	3,300
4th or C4	96	48,000	36,000-42,000	4,400
5th or C5	120	60,000	45,000-52,500	5,500
6th or C6	144	72,000	54,000-63,000	6,600

C check	Calendar interval MO	MPD FH interval	Approx FH interval per avg utilisat	Approx FC interval per avg utilisa
1st or C1	36	18,000	13,500-15,750	1,650
2nd or C2	72	36,000	27,000-31,500	3,300
3rd or C3	108	54,000	40,500-47,250	4,950
4th or C4	144	72,000	54,000-63,000	6,600

Although letter checks are not used in the MPD, base check and larger line checks are still often referred to as 'C' checks and 'A' checks'. For the A380, the cycle of six C checks have been at 24MO, 48MO, 72MO, 96MO, 120MO and 144MO. These can be generically referred to as the C1, C2, C3, C4, C5 and C6 checks *(see table, this page)*.

The larger groupings of structural inspections tasks fall due at 72MO and 144MO, which fall in line with the third and sixth C check.

Line checks or A checks were initially set at an interval of 750FH, but have now been extended to 1,000FH. Using the two figures as a range matching current fleet utilisation, A checks fall due about every two to two-and-a-half months. Realistically there is not a large grouping of tasks at these intervals. Line and A checks will comprise all tasks that fall short of the 24MO/12,000FH C check interval, along with all other FH and FC tasks as utilisation limits are reached.

The aircraft's maintenance clock does not start at the same point for all inspection tasks. For most of the calendar-driven interval tasks, the clock starts at Transfer of Title (ToT) to the new operator during the delivery process. For many of the FH- and FC-driven tasks, the aircraft's first flight starts the utilisation count. For aircraft components, the first flight after installation begins the utilisation or calendar count. Alternatively, the first flight date plus 90 days may be used if ToT occurs more than 90 days after the first flight. FH and FC parameter tasks, therefore, might not be as neatly aligned as might be expected.

There are also some permitted 'maximum variations' that can be applied to listed individual inspection intervals. For example, on tasks controlled by FC, a task with an interval of more than 500FC has an allowed variation of 5% or 250 landings, whichever is least. For a calendar example, a task with an interval of more than three years has a 3MO variation allowance.

Tasking grouping

The large groups of tasks using multiples of 24MOs will often incorporate an FH and FC parameter to cover higher than average utilisation. Many tasks and task groups do not have intervals that are exact multiples of 24MO. Those with intervals between exact multiples of 24MO will be brought forward and performed early. This avoids the aircraft being frequently grounded to perform smaller groups of tasks.

For example, on a 24MO/12,000FH check interval, there are nine different task groups with the potential to be grouped into a 24MO interval: 24MO; 12,000FH; 24MO or 12,000FH, whichever comes first (WCF); 72MO or 12,000FH, WCF; 11,200FH or 24MO, WCF; 1,500FC or 12,000FH, WCF; 2,200FC or 12,000FH, WCF; 24MO or 15,000FH, WCF; and 12,000FH or 36MO, WCF. These can all broadly be included as one group with a dual interval of 24MO and 12,000FH. These tasks come due every C check, and so may generically be referred to by some as '1C' tasks. For example, there are 105 calendar-driven tasks in the C1 check that apply to all A380 variants *(see table, page 42)*. There are also other calendar-driven tasks that only apply according to the aircraft's airframe modification status (15), the variant (20 and 11), and the engine's modification status (5).

The same method is then applied for the additional tasks to be performed at a 48MO/24,000FH interval. Groups of tasks that have 48MO and/or 24,000FH intervals will form a large quantity of tasks. They may be grouped with 24,000FH or 4,400FC, WCF; 24,000FH or 72MO, WCF; 24,000FH or 36MO, WCF; 4,400FC or 48MO, WCF; and 24,000FH or 48MO, WCF. These groups of tasks might collectively be referred to as '2C' tasks, and so would be performed at every second base check.

The third and fourth groups of tasks can be referred to as the 72MO, or '3C'; and 144MO, or '6C' tasks. These are the light structural inspection at 6YE, and heavy structural inspections at 12YE.

There are also groups of tasks that are grouped into 96MO and 120MO intervals. These might be referred to '4C' and '5C' tasks.

The number of tasks described as '1C', '2C', '3C', '4C', '5C' and '6C' is not listed. Instead the total number of calendar-driven tasks that come due in the C1 to C6 checks are listed *(see table, page 42)*.

In addition to calendar-driven tasks, there are FH and FC tasks with various intervals that come due during the 24MO A check cycle interval, the first 12-year base check cycle, after the first 12-year base check cycle, or are VR tasks *(see second table, page 42)*. As an example, there are 143 A check tasks that apply to all A380-800s, and 530 tasks that apply to all A380-800s in the first base check cycle. As these tasks do not have calendar intervals in exact multiples of 24MO, but will come due between one of the A or base checks depending on the aircraft's FH and FC utilisation, they are referred to as out-of-phase (OOP) tasks. These will be grouped into the appropriate A or C check according to the operator's preferences.

It is therefore not possible to summarise the number of tasks that will come due in each of the A and C checks. The number of FH and FC tasks are summarised. As an example, 530 tasks that apply to all A380-800s fall due during the 12-year base check cycle Another 26 depend on the airframe's modification status, 39 apply to the A380-841/-842, and 36 apply to the A380-861 *(see second table, page 42)*.

36 MO check cycle

Revision 14 of the MPD supports escalation of specific C check task intervals from 24MO or 12,000FH, to 36MO or 18,000FH, thereby avoiding

A380 MAINTENANCE PROGRAMME TASK CODES AND SKILL CODES VERSUS TASK QUANTITIES (MPD REV 13)

Task codes	GVI	DET	SDI	CHK	SVC	VCK	LUB	FNC	OPC	RST	DIS	Total tasks
System	140	109	23	1	12	42	24	68	199	73	57	748
Structures	113	505	260									878
Zonal	191											191

GVI: General Visual Inspection, DET: Detailed Inspection, SDI: Special Detailed Inspection, CHK: Check, SVC: Servicing, VCK: Visual Check, LUB: Lubrication, FNC: Functional Check, OPC Operational Check, DIS: Discard

Skill Codes	AF	EN	NDT	AV	CL	LUB	EL	RA	UT	
System Section	390	122	14	63	37	17	94	6	5	748
Structures Section	571	49	258							878
Zonal Section	175	16								191

AF: Airframe, EN: Engine, NDT: Non-Destructive Testing, AV: Avionics,CL: Cleaning, LU: Lubrication, EL: Electrics, RA: Radio and Communications, UT: Utilities

one aircraft grounding and C check over each six-year period. There will now be two base checks instead of three in the 72-month interval, and just four checks in the cycle *(see table, page 38)*.

The A380 C checks will move to 36MO or 18,000FH, 72MO or 36,000FH, 108MO or 54,000FH, and 144MO or 72,000FH. The larger groupings of structural inspections tasks at 72MO and 144MO will still be in line with the second and fourth C check in a cycle. That is, the C2 and C4 checks.

This check escalation has been achieved by analysing the in-service fleet findings down to individual task level.

"For the aircraft in service each individual task in terms of the escalation programme is looked at," explains Stegerer. "The reports that we get back on content of the task or the potential findings will either lead to escalation of that particular task or not."

"The path for escalating the A checks from 750FH to 1,000FH was secured in 2016," adds Salles-Parfouby. "The next step in the process was to proceed with the C check escalation programme during 2017. The result is that many of the 24MO and 24MO/12,000FH tasks are being escalated to 36MO, equal to about 18,000FH; and the 48MO tasks are being escalated to 72MO.

"There are still some 24MO and 48MO tasks where we need to collect and review more airline reports, so in the meantime the interval will not change," adds Salles-Parfouby. "This is a continuous process of information collection."

While Airbus will retrieve all the reports from across the airlines to get individual task escalations increased inside the MRB Report leading into the MPD, each airline will discuss its own reliability programme with its local authority to obtain approval on interval escalation.

"Two airlines are currently validating the 36MO base check interval through their local authorities," adds Salles-Parfouby. "Other airlines are taking into account the revised MPD, based on their needs, organisation and time constraints."

As the process of report collection is undertaken for all tasks, there is potential to extend some larger structural task groupings at 6YE and 12YE.

"We still need to collect data from the 72MO events," continues Salles-Parfouby. "After only 10 years of service there have obviously been far fewer 72MO checks than 24MO checks. Yes, the 72MO tasks could be extended with the reports we receive from the operators, but you have to keep in mind that increasing the interval of 72MO will affect the synchronisation of the 144MO check. With maintenance planning, synchronisation is key to avoid additional costs."

For operators that choose to move to the 36MO cycle after their maintenance programmes have been validated by local authorities, a bridging check would be performed at the next convenient base check that would release the aircraft onto a 36MO cycle.

"The check escalations have the potential to introduce a 10% reduction in maintenance costs when applied to the main maintenance events at 1,000FH and 36MO over the 12YE maintenance cycle," explains Stegerer.

"The main point is that the aircraft has more potential for flexibility in the maintenance programme. Its in-service behaviour so far has allowed Airbus to extend intervals at an individual task level," adds Stegerer. "There is always, however, a balance to be found. Pushing for longer intervals for the sake of it does not make sense, but it shows how easy it is to maintain the aircraft in terms of ground time and packaging."

MPD content

System tasks

The Rev 13 MPD Systems, APU and Powerplant section contains 748 tasks within about 110 different inspection interval groupings. These intervals use one or a combination of two FH, FC, and calendar parameters. AH is also used when referring to APU hour utilisation.

Of the 748 tasks, 242 are FH-driven, 23 are FC-driven, 371 are calendar-based, and 57 are a combination of FH/FC or MO. The remaining 55 tasks are related to vendor or NOTE references for interval requirements.

The Systems section inspections outline aircraft systems and aircraft component scheduled maintenance tasks. The term aircraft component covers the engines and APU.

Of the 748 tasks, 582 apply to all A380-800s, 48 cover the A380-841/842, 35 apply to the A380-861, and 83 apply according to each aircraft's modification (mod) status.

Inspections contained in the Systems section cover 11 task codes and nine skill codes, and originate from numerous source documents. Task codes define the type of task, for example: FNC for a functional check, LUB for a lubrication task, or DET for a detailed inspection. Skill codes define the required experience or trade knowledge required for the task, for example: RA for radio and communications, CL for cleaning, or NDT for non-destructive testing. The Task and Skill code overview is detailed *(see table, this page)*.

Of the listed inspections, 726 have a 100% interval only over 95 different groupings, while 22 tasks have 100% threshold over 15 different groupings. Of the tasks with initial thresholds and repeat intervals, six groupings have

reduced repeat intervals, and two groupings have increased repeat intervals.

Systems section sampling tasks include a schedule for the operational check of the cabin escape slides, per operator's fleet per door position (either side) not to exceed 36MO.

Of the large number of different interval groupings, more than 40 intervals have only one task listing, and only eight have more than 10 task listings. So, the larger groupings of tasks fall into only a limited number of intervals forming the foundation of each base check event.

Not all tasks in the MPD apply to all aircraft. An applicability column lists the aircraft type for which the inspection is required, including the pre- or post-modification numbers, engine type and configuration differences.

Larger access and preparation requirements for inspections appear in all three Systems, Structures, and Zonal MPD sections.

For 72MO calendar-driven inspections, there are 110 tasks, 92 of which apply to all aircraft, and 18 to A380-800 per mod status. There are additional groupings of 72MO or 12,000FH, 15,000FH or 8,000FC, 36,000FH, and 24,000FH or 72MO. These groups include 10 higher access tasks to be placed at the 72MO check interval.

Access required includes removal of dado panels, floor panels (for drainage pipe inspections), ceiling and sidewall panels, wing panels and cargo bay panels.

Chapter 20 of the ATA aircraft documentation number system covers 'Standard Practices'. A large number of tasks in the Systems section that required the greatest access and preparation figures will be Chapter 20 tasks. These include restoration by cleaning of the electrical wiring interconnection system (EWIS) installed in the main deck and cargo bays, including utility areas where specified. In the 72MO check grouping there are more than 20 Chapter 20 tasks.

For the 144MO calendar-driven inspections, 60 apply to all A380-800s, one to the A380-841/842, one to the A380-861, and one to the A380-800 per mod status (applicable to crew rest compartments). Although no tasks listed in the MPD are 'at engine removal', the Systems section planning notes do appear to detail where tasks can be accomplished at the opportunity of engine removal.

In the 144MO grouping there are 34 ATA Chapter 20 restoration by cleaning cards (task code - RST, and skill code - CL). Most of the access will tie in with access gained for the Structures 144MO tasks. This includes fuel tank access for the SFAR 88 ignition source prevention programme.

The Systems section contains the largest number of VR inspection listings. There are 32 task entries, 20 of which apply to all aircraft, and 12 to A380-800 per mod status.

Most of the VR tasks relate to cabin systems, including passenger and crew oxygen hydrostatic in-shop testing, and cabin escape facilities testing per regulatory authority request.

Another grouping of tasks without a listed threshold or interval falls under the grouping of NOTE. This refers to the instruction NOTE listed in the interval column for the task. There are 20 tasks with an interval of NOTE, of which seven apply to all aircraft, eight to the A380-841/842, and five to the A380-861.

NOTE tasks range from discarding flashlight batteries and obtaining fuel tank samples, to the life-limited discard listing for landing gears, engine parts and APU components.

Interestingly, in Revision 13 of the MPD, there is already a large grouping of 15 inspections tasks at 36MO. The tasks escalated from the 24MO/12,000FH

A380 MAINTENANCE PROGRAMME - CURRENT 24Mo BASE CHECK INTERVAL

Base Check	Calendar interval - months	Approx FH interval	Approx FC interval	Base check groups	Calendar tasks applicable to all A380	Calendar tasks applicable per mod status	Calendar tasks applicable to A380-841/842	Calendar tasks applicable to A380-861	Calendar tasks applicable per eng mod status
1st or C1	24	9,000-11,000	1,100-1,200	24MO	105	15	20	11	5
2nd or C2	48	18,000-22,000	2,200-2,400	24MO + 48MO	156	19	29	20	5
3rd or C3	72	27,000-33,000	3,300-3,600	24MO + 72MO	348	50	25	22	5
4th or C4	96	36,000-44,000	4,400-4,800	24MO + 48MO + 96MO	161	19	30	21	5
5th or C5	120	45,000-55,000	5,500-6,000	24 MO	106	15	20	11	5
6th or C8	144	54,000-66,000	6,600-7,200	24MO + 48MO + 72MO + 144MO	606	62	39	38	5

A380 MAINTENANCE PROGRAMME - REMAINING GROUPING OF 'A' CHECK FH/FC TASKS, AND VENDOR OR 'NOTE' TASKS

	Calendar interval	Task FH interval		Task FC interval	Applicable to all A380-800	Applicable per mod status	Applicable to A380-841/842	Applicable to A380-861	Applicable per eng mod status
A checks	24	9,000FH	And/Or	1,100FC	143	4	1	1	
FH/FC OOP tasks (within first base check cycle of 12 years)	144	9,000FH-66,000FH	And/Or	1,100-7,200FC	530	26	39	36	
FH/FC OOP tasks (beyond first base check cycle of 12 years	144	66,000FH	And/Or	7,200FC	214				
VR or 'Note'	Various	Various		Various	42	12	8	5	

groupings fall due with this group.

There are 112 systems tasks that will most likely fall due before the C checks. The largest quantity grouping is the 750FH group of nine tasks. The lowest frequency tasks are at 48 hours.

Structures

The Revision 13 MPD Structures section contains 878 tasks with 530 different threshold and intervals groupings using calendar, FH or FC parameters or a combination of interval parameters. By far the most are FC and FH combinations.

Of the 878 tasks, three are FH-driven, 83 are FC-driven, 243 are calendar-based, and 545 are a combination of either FH or FC and MO. The remaining four tasks are related to Vendor or NOTE references for interval requirements.

Of the 878 tasks, 801 apply to all A380-800s, 26 to the A380-841/842, 32 to the A380-861, and 19 apply according to the A380-800 mod status.

Inspections contained in the section cover only three task codes (DET, SDI and GVI) and three skill codes (AF, EN and NDT). Numerous source documents are referenced *(see table, page 40).*

As well as monitoring the aircraft structure for fatigue and accident damage, the purpose of the Structures inspections includes controlling corrosion to a level 1 or better.

As a guide, if corrosion is found on inspection of the aircraft structure, it is given a level of 1-3 for defect reporting. Level 1 corrosion can be blended out within the permitted limits by the aircraft's Structural Repair Manual (SRM) or per inspection documents used. Level 2 corrosion is reported if the area to be blended out exceeds the permitted limits requiring repair or replacement, while Level 3 corrosion is determined to be of an airworthiness nature and requires potential fleetwide inspection.

All structures tasks use an initial threshold and repeat interval apart from one task that has only a 100% interval.

Most of the tasks have reduced intervals in comparison to the initial threshold. This can vary from as little as 100FC less than the original threshold, to more than halving the initial threshold.

Unlike older Airbus types, the A380 MPD was not released with a separate set of thresholds and intervals for sampling aircraft which often represented a percentage of the oldest aircraft in the operator's fleet.

"There are no tasks in the A380's MPD relating to the MRBR fatigue-sampling programme as in the case of previous aircraft maintenance programmes," explains Salles-Parfouby. "Instead, a fatigue-monitoring programme has been developed. Operators have benefited from more than a 90% reduction in the number of MRBR sampling tasks which feed the MPD."

Landing gears, however, are involved in a fleetwide sampling programme controlled independently of the MPD. For maintenance planning purposes, landing gears are to be removed for 'off

The 14th revision of the A380's MPD has seen a change in its base check programme from a cycle of six to four base checks. Two structural inspections are performed at six and 12-year intervals.

aircraft' restoration at 144MO/12,700FC. For sampling purposes, gears from different climate regions are being removed at an earlier interval for initial inspections.

"We have begun a controlled sampling programme of the landing gears at the request of authorities," explains Salles-Parfouby. "The first MSN landing gear has been inspected with no significant findings to report that could amend the current proposed interval of 144MO/12,700FC. The second gear for sampling was removed from another MSN in March 2018, and was in very good condition, and another is due in August 2018. With no significant findings, that part of the aircraft is behaving as predicted."

Deep access requirements for cabin and freight bays will be driven primarily by the structural section 72MO and 144MO task groupings.

For 72MO calendar-driven inspections there are 132 tasks: 106 apply to all aircraft, five to the A380-841/842, 11 to the A380-860, and 10 to the A380-800 per mod status. Additional task groupings are two tasks at 72MO/3,800FC/28,000FH, and one task at 72MO/6,300FC.

Access for the 72MO inspections includes, for example, removal of: wheels and brakes; ballast weights and insulation at specific locations; lavatories and galleys; and interior ceiling and sidewalls. Engines and pylons also have heavy access requirements.

For the 144MO calendar-driven inspections there are 86 tasks: 73 apply to all aircraft, three to A380-841/842, five to the A380-861, and five to the A380-800 per mod status. Additional task groupings at the interval of 144MO are 144MO/11,700FC /86,800FH with one task, and 144MO/3,800FC/28,000FH with two.

The 144MO deeper access requirements include gear retract actuator removal, insulation displacement for interior inspections, further floor panel and crew rest compartment removals, flight controls and wing access requirements, and removal of windshield retainers from the flightdeck.

The 144MO threshold 72MO repeat interval grouping has 23 tasks: 21 apply to all aircraft, and two to the A380-800 per mod status. These tasks will impact the third 6YE check at aircraft age of 18 due to the 72MO repeat interval. These require detailed inspections of the fuselage internal structure at specific locations including passenger cabin and freight bays.

Engine removal for structural inspections can be referenced in the description of the MPD task or in the preparation column of the XL version of the MPD, and description column of the PDF MPD. An example of a 'with engine removed' inspection is the special detailed inspection using high frequency eddy current (HFEC) of the rear engine mount assembly on a Trent engine. MPD preparation MH for the task is listed as 35.40MH.

For A check task groupings, 14 structures tasks will most likely fall due before and between C checks. The largest quantity grouping is the 200FC group, which comprises four tasks.

Zonal

The Revision 13 zonal section of the MPD contains the smallest quantity of inspection tasks with 191 entries, all with only calendar intervals. Of the tasks, 156 apply to all A380-800s, 14 to the A380-841/842, 14 to the A380-861, and seven to the A380-800 main- and upper-deck utility areas if galley and lavatories are installed.

Inspections contained in the section are allocated task code GVI and skill codes AF and EN. The MRBR is the source document for all tasks. As referenced by the title of the section, the inspection requirements apply to zones of the aircraft to check for security of installations, general condition, accidental damage, and accumulation of any combustible materials covered by the enhanced zonal analysis procedure (EZAP). EZAP inspections are used to identify maintenance and inspection tasks that minimise accumulation of combustible materials and detect EWIS component defects.

In the 24MO check cycle, zonal section tasks fit into 10 different parameter groupings, using 100% interval only (no threshold listings). The interval groupings are 3MO, 6MO, 12MO, 18MO, 24MO, 36MO, 48MO, 72MO, 96MO and 144MO. Tasks that were originally under a 1.5MO grouping have been escalated to both 3MO and 6MO.

The four interval groupings that fall due consistently between C checks will form part of the line maintenance packages. These are six tasks at 3MO, 12 at 6MO, four at 12MO, and one at 18 MO. These tasks only have minor panels and door opening requirements, as well as flight control positioning. Another small grouping that sits occasionally outside of the 24MO C check grouping is the 36MO tasks, of which there are eight. These inspections require specific wing access panels removals and flaps/slap extended, and will most often be slotted into the C checks.

The remaining 160 tasks fall into five groupings, all in line with calendar C check intervals in multiples of 24MO.

There are 38 tasks for the in-service fleet at 24MO: 34 apply to all aircraft, four to the A380-841/842, and four to the A380-861. These tasks cover external inspections of the lower third of the fuselage, wing and body gear bays, aft cabin and rear fuselage compartments, empennage and wing inspections. A large quantity of wing, flight control and engine panels requires removal.

The oldest A380s in the fleet are at about 12 years old, and so undergoing their first heavy 12YE checks that complete the first base check cycle. Full 12YE checks are expected to consume about 50,000MH for the main elements of preparation, access, routine inspections, and defect rectifications.

There are another 29 tasks at 48MO intervals: 15 apply to all, seven to the A380-841/842 and seven to the A380-861. These cover deeper access requirements, including access gained for internal cockpit, avionics compartment and pylon inspections. Engine inspections are listed only once in the MPD if the inspection applies to all four engines. The four engine zones listed against the MPD will confirm if inspections apply to all. A large percentage of these tasks have been escalated to 72MO in Revision 14 of the MPD.

There are 38 tasks listed at a 72MO interval: 31 apply to all aircraft, and seven to the location of galleys and lavatories. Twenty-eight of these inspections require access to specific areas of cabin and cargo compartment equipment, furnishings, and floor panel removals.

The 96MO task grouping has only four tasks: two apply to all aircraft; one to the A380-841/842; and one to the A380-861. These tasks have wing, pylon and body fairing access requirements.

There are 47 144MO tasks, of which 45 apply to all aircraft; one to the A380-841/842; and one to the A380-861.

Like the 72MO grouping, there are extensive cabin, cargo compartment and fuel tank access requirements.

A380 base checks

Man-hours

The MPD shows MH in decimal format within each Systems, Structures and Zonal section. In the Excel version of the MPD there is a labour calculator that collates all MPD inspection information into one place. The MH information supplied is in the usual Airbus format of Task, Prep and Access.

The Task, Prep and Access MH listings cover aspects of inspection requirements: Task MH for the actual technical performance of the required MPD listing; Access MH for panel removal/re-fit and door opening/closing; and Prep MH for specific area or component preparation needed to correctly complete the inspection.

Preparation hours require close attention. Details of aircraft interior furnishing, galley/lavatory removals, landing gear, engine, even insulation blanket removal, will be covered by the Prep MH. Large MH tasks will be found here.

One example of a preparation requirement with guide MH figures supplied is the Zonal GVI of the main deck's forward mid-cabin and utility area. To complete this, floor panels, insulation, lavatories and galleys, seats and sidewall panels must be removed. Preparation areas are listed within the tasks content, and a guide of 91.82MH provided.

Panel removal requirements are listed next to each MPD task where required, along with associated MH. Appendix 6 of the MPD lists all 1,340 panel numbers and doors on the aircraft with guide removal/refit MH.

The MPD still has tasks with MH listed as to be determined (TBD) where Airbus is yet to list the MH requirement. Under Task, 95 inspections are listed with MH as TBD. Two are listed under Access requirements, and 82 under Prep requirements. Often these tasks have FC or FH intervals, and require NDT inspection or unique access.

Where N/A is quoted, MH do not apply to the task. This is the case where the task MH may only apply to the workshop environment, but MH can be listed for Access or Prep.

Routine

Multiplying the OEM's estimated MH by a reality or conversion factor has been an accepted method over many years to determine actual inspection MH figures to resource base maintenance checks. In previous Aircraft Commerce A380 articles, *(see The A380's & 747-8's design & maintenance requirements, Aircraft Commerce, February/March 2012, page 45)*, operators noted a conversion factor of up to 7 is being used, while experience was being obtained on the aircraft type.

While during the initial few base checks this may have been the case, industry feedback has determined that a task-by-task MH evaluation is instead taking place. "Such a factor is of course only a rough guideline; we evaluate every single case during first accomplishment," explains Christian Rieckborn, fleet manager (A380) at Lufthansa Technik.

Of course, routine check figures will vary according to the internal cabin layout of each fleet. Access MH figures will account for a large proportion of MH calculations. In a three-class interior configuration, 16 lavatories, 17 galley modules, and additional wet floor areas where bars are located, typically must be removed on the structural checks.

Crew rest area maintenance will also cause variation in base routine inspection and access figures. In the MPD 18 tasks apply to crew rest areas and modules.

The airline's own inspection cards will add MH on top of base routine requirements. Operators will use the MPD, Aircraft Maintenance Manual (AMM), specific national regulatory requirements, and their own specific requirements to form their own AMP. For Lufthansa's fleet, about 100 additional personalised tasks are included in aircraft maintenance programmes, of which 40% are cabin-related.

Non-Routine

Non-routine (NR) ratios for base routine figures will vary depending on check size, condition of the aircraft, and inclusions of any customer cards partially associated with rectifying the cosmetic appearance of the aircraft and interior.

In general, for the first base check cycle the ratio of defects to routine inspection MH starts at 0.3:1 for the C1 check. It increases throughout the check cycle, and is expected to reach 0.7:1 to 1:1 for the 12YE check. Some operators represent this ratio as a percentage.

There are 89 A380 aircraft in active service that are more than six years old, and so will have accomplished their first structural check at the 6YE interval. Defect findings from the in-service aircraft have been reported as on par with other aircraft types, or lower.

"Based on a 72MO check, our experience is that NR findings are lower than for other fleets," adds Rieckborn. "Usually corrosion of the seat tracks is a major issue, but the use of titanium tracks means this does not apply to Lufthansa aircraft. Many issues have been addressed by modifications prior to the layover, however, so there are no surprises."

"The ratio of routine to NR work for the A380 is no different to any other Airbus aircraft," adds a spokesperson for Etihad Airways Engineering (EAE). "With the scale of the aircraft it is important to hit planned inspection targets early. In our maintenance check plans we have what we call a Critical Determination Point (CDP), which is where all the critical inspection requirements of the check are targeted to finish. By completing these critical inspections as early as possible, you have a better chance to obtain all the support you need from Airbus for parts procurement to get the aircraft back together in time."

Check totals

Some tasks in each maintenance check will include clearing inspections ahead to minimise maintenance ground time between checks.

An example of this is a base check at 24MO that may include both 18MO and 24MO calendar tasks, tasks between 9,000FH and 19,000FH, and tasks due at 1,200-2,400FC. Using an optimised check format, some FH and FC tasks may be moved to small line checks to gain full utilisation of the inspection parameter. In an FH- and FC-optimised maintenance programme, such as the A380's, few base checks will be the same.

Since the A380 entered service, Airbus has collected in-service MPD MH data from various operators to use as guide estimates for checks. For the routine MPD tasks only including access and preparation, this is as follows: C1/24MO check is 1,500MH, the C2/48MO check is 2,100MH, and the 6YE check (which can be referred to as the C3 or 72MO check), is up to 16,000MH.

Industry feedback for the base routine with adjusted MPD MH that includes access and preparation MH, customer-specific tasks and aircraft handling is as follows: C1/24MO check is 5,000-6,000MH; the C2/48MO check is 7,000-8,000MH; and the 6YE check (often referred to as a C3 or 72MO check) is 25,000-27,000MH. The large rise in the 6YE figures includes the overhaul of the cabin furnishings and seats.

Using an escalating NR ratio for the base routine, preparation and access MH figures supplied by the airlines, the check total at 24MO, the labour required is 6,500-7,800MH. This is using 0.3 defect MH for every routine inspection MH.

The C2 check total at 48MO is 9,100-10,400MH, using a defect ratio of 0.3MH per routine MH. The 6YE, often referred to as a C3 or 72MO check, has an NR guide ratio of 0.4:1, with a labour requirement of 35,000-37,800MH.

For a more detailed look at the C2 at 48MO, a routine figure across all trades with the MPD-factored and customer-specific cards included is 5,000MH, with 1,300MH for access and preparation, and another 1,000MH for ground handling/technical cleaning/final functions/de-fuelling/planning and engineering support. This equates to a guide check figure of 7,300MH. When a 0.3:1 defect ratio is applied to the base

Direct labour inputs for the 6YE check are about 25,000-27,000MH. After initial experience with the first checks, the non-routine ratio for the 6YE check is about 0.4, thereby adding a further 10,000-11,000MH.

inspection and access figure, a further 1,890MH will be required, taking the sub-total for these elements of the check to 9,190MH. Major aircraft modifications or interior work and refurbishment, and component changes will require additional labour.

For a more detailed look at the C3 at 72MO, a routine figure across all trades with the MPD-factored and customer-specific cards included is 17,000MH, access and preparation is 6,000MH, and ground handling/technical cleaning/final functions/de-fuelling/planning and engineering support add another 1,500MH. This equates to a sub-total of 24,500MH. When a 0.4:1 defect ratio is applied to the base inspection and access figure, another 9,200MH will be needed, taking the sub-total to 33,700MH. As with the C2 check, major modifications or interior configuration work, and component changes will all be additional. The same applies to any stripping and painting that might be included in the check, or performed later.

For guide costings, a C2 check with a sub-total of 9,190MH for the main elements at a labour rate of $60 per MH and a further budget of $12 per MH for consumable materials would total about $662,000.

A C3 with a sub-total of 33,700MH at a labour rate of $60 per MH and $12 per MH for consumable materials, a guide C2 check would be $2.43 million.

What impacts the 6YE check MH more is inclusion of a cabin refreshment/overhaul request. This will be the same for the 12YE checks.

Base check downtimes are 17 days for the 24MO, 22 days for the 48MO, and 47-53 days for the 72MO check.

Downtimes are affected by the addition of modification work, including AD and SB releases to the work packs. For example, the wing rib modification could be carried out over different maintenance inputs, but when carried over to the closest C check an extra 22,000-25,000MH is needed to complete the full AD.

"Several fatigue-test-related structural ADs (flap-track fairings, wing tips, passenger doors) have to be performed, but most of the modification on the Lufthansa fleet was already carried out during the 72MO check," says Rieckborn. "The situation might vary among fleet leader aircraft depending on kit availability."

Resourcing

Hangar logistics and manpower resource planning is always an important behind-the-scenes activity before any large maintenance input, especially for heavy checks on newer, larger aircraft.

A380 heavy structural check resource planning can follow the patterns of similar-sized aircraft which have the same engine and landing gear configurations. Where it differs is on the size of the cabin, which stretches across two full decks.

"Handling the A380 cabin requires a well-staged double cabin team," explains Ray Kazmierczak, director at RFK Consulting. "Stripping out the aircraft interior should take no longer than any other aircraft if the staffing is correct. For a 6YE input it is possible to remove all the cabin equipment, including seats, galley and lavatory modules, and floors, in three or four days with a cabin team of 50 personnel. Initially the MH needed to do this can be based on similar-size cabins, but can be scaled up as necessary. The same methodology will be used on the 12YE checks, as well as in-service experience gained on the type."

"At Etihad Airways Engineering (EAE) we start preparing for the check six to seven weeks before the input by evaluating the work scope to create a check plan," adds an EAE spokesperson. "The check plan will include the day-to-day inspection listing and required manpower allocation. With manpower planning, we split the trades, for example, into cabin, avionics, or structures. These are then allocated to the inspection requirement of the check plan. Night coverage will also be used, depending on the inspection type, to spread out the inspection loads in critical or confined space areas. This is not very different from any other check apart from the amount of labour required. It is a labour-intensive aircraft, which in turn needs some resourcing flexibility. If the check progress lags behind, you need a clear link to resource allocation to see how to recover the time.

"Additionally while performing A380 maintenance, what needs to be considered, especially on the heavier checks, is not just the MH required, but securing the essential support needed from the OEM," further explains the EAE spokesperson. "EAE is part of the Airbus Alliance, in which Airbus recommends the MRO facility as an A380 Center of Excellence. Subsequent engineering and materials support from the OEM plays a key role in assisting the delivery of the aircraft on time."

Another consideration when carrying out A380 maintenance is the hangar floor space commanded during the input. Additional planning is needed to include enough workable area for the large quantity of cabin equipment to be inspected, overhauled/repaired, and stored pending re-installation.

"To carry out A380 maintenance efficiently, the infrastructure needs to be correct. A big part of that infrastructure is interior workshop capabilities," says Kazmierczak. "At 6YE check intervals most operators are removing and refurbishing/upgrading the complete cabin. I see this being the same for the 12YE checks. This requires an interior shop of 3,000 square metres per aircraft to support the removed cabin equipment. This shop is ideally located close to the aircraft for efficient access. The aim is to start refitting the cabin after two weeks."

In addition to aircraft preparation, access, routine inspections and defect rectifications; maintenance planners also have to consider interior cleaning and refurbishment, component changes, modifications, and strip and paint at additional elements of heavy checks.

The importance of cabin interior support is also noted by EAE. "On the 6YE and 12YE inputs you need space, labour, and importantly you need back-shop support," adds the EAE spokesperson. "We have these three requirements. In parallel to the MRO, EAE has the essential expertise to process the cabins through the back shops. The cabin has become our speciality."

An additional commercial complexity is the aircraft's large hangar footprint.

"If you are completing A380 maintenance, you have to be doing well over 1,000MH per day to cover the hangar space's potential earnings," says Kazmierczak. "This puts pressure on other departments, such as engineering and logistics, planning and purchasing, and any other support service needed for that particular input. If the same hangar could take four narrowbody aircraft achieving 500MH a day, then it could be generating 2,000MH a day. These are all factors to consider and price for."

12YE/144MO check

The first 12YE checks are now under way. Experience from the 6YE structural checks will be a huge factor in estimating MH required for the 12YE check. Currently end-of-lease aircraft are the first to have the scheduled check. While shop-floor data collection will be of interest to other airlines planning for the checks, any additional requirements, including cabin configuration changes and general cosmetic work, will disturb the potential flow of the scheduled maintenance data for collection purposes.

Airbus is in constant contact with customers leading up to the checks.

"For everything around the preparation of the check, Airbus is in constant communication with the operator for support needs," explains Salles-Parfouby. "This includes the availability of Ground Support Equipment (GSE), carrying out repair and risk assessments, and to support any task optimisation the operator is looking for or would like to proceed with."

"We estimate that the aircraft will require 50,000MH for the technical inspection tasks and defect rectification," explains Stegerer. "This figure excludes any preparation, access, or cabin reconfiguration work, or repainting that may be needed. So more than 50,000MH will be needed in an airline operation where many additional cosmetic tasks are included at the same time."

A 12YE check figure could be well in excess of 75,000MH when including landing gear changes, cabin configuration and decor changes, reliability programme component changes, aircraft re-painting, and end-of-lease or aircraft transfer work packages to a new operator if required.

Beyond 12YE check

As expected, a large number of task thresholds fall beyond the 12YE check cycle within the structural inspection programme. Utilisation of each aircraft will affect when these intervals are reached in terms of calendar time.

For example, there are 37 different thresholds for 39 different tasks from 8,500FC to 8,900FC, and which have a 62,600FH to 66,000FH back stop. The higher FC aircraft utilisation will hit this at 13-14 years, while the higher FH utilisation aircraft will hit this at 12-13 years. For these aircraft the tasks will most likely be cleared on the 12YE check.

For lower FC utilisation aircraft, the same tasks will fall due at 19-20 years, while the lower FH utilisation aircraft will hit this at 14-15 years. For these aircraft the inspection tasks will either be included on a case-by-case basis, or brought forward to the 12YE check.

Another 211 tasks fall due from 9,000FC to 18,700FC, and 66,600FH to 136,000FH. These will come due at 15-30 years of age in accordance with most airlines' rates of utilisation. Most of these are NDT inspections, including X-ray.

Many of the tasks have a reduced repeat interval that in some cases will fall due again within the same base check cycle. Aircraft utilisation will affect the calendar time these tasks fall due.

The highest FC structures task threshold is 18,700FC, with a 9,000FC repeat interval for an NDT inspection of the pin between NLG hinge and NLG bay 1. Task and preparation MH are currently listed as TBD.

The highest FH threshold is 136,000FH with a 29,000FH repeat interval for a detailed inspection of the fuselage internal structure vertical beams of the NLG bay side panel. Task MH are listed as TBD.

For the systems section only three tasks of a high threshold are above the 12YE check cycle, two of which are 72,000FH interval tasks for a visual check of the cabin air distribution mixer unit and a detailed inspection of the stair attachment point. The other is an 80,000FH task for removal of hat rack shutoff valves for in-shop functional checks of the passenger oxygen system. This will come due at 14-18 years.

Within the Zonal section of the MPD all inspection tasks are contained within the 12YE cycle.

Summary

The move towards a 36MO base check cycle is a big development for the A380 maintenance programme and will have a large impact on reducing maintenance costs. Deletion of two checks from a base check cycle in one MPD revision is rare. Given the A380's current push through the 12YE heavy check milestone, its MPD is at an interesting point in the lifecycle. AC