The A350 has been in service for a little over three years, and the first aircraft have been through their first base checks. Charles Williams analyses the A350-900's MPD, and inspection tasks and their probable grouping into checks is examined.

A350 MPD analysis and maintenance planning

The A350XWB was designed as a replacement for the A330/A340 and 777 families, and as an alternative to the larger models of the 787 family, the -9 and -10. Airbus therefore set targets for the A350 to provide savings in cash operating costs over previous generation aircraft.

The two main targets to achieve this reduction are: fuel burn per seat or seat-mile; and direct maintenance costs and requirements. The A350's maintenance planning document (MPD) and its maintenance programme are examined here to provide some insight into its airframe maintenance requirements.

A350 in service

The A350 entered service in late 2014 with Qatar Airways and Vietnam Airlines. These were serial numbers (S/N) 006 and 0014. There are now more than 136 aircraft in active passenger service. The -900 series is the only one so far to have entered service, and is in operation with 17 airlines. The largest fleets are operated by Qatar Airways (22 aircraft), Cathay Pacific (22), Singapore Airlines (19), Finnair (11), China Airlines (10) and Vietnam Airlines (9). Smaller fleets are also operated by Asiana, Delta Air Lines, Ethiopian Airlines, LATAM Brazil, Lufthansa, French Blue, Air Caraibes, Air Mauritius and Thai International.

Airlines generally operate the A350 on medium-haul sectors with average flight cycle (FC) times of 2.5-4.0 flight hours (FH) during the first few months of service for crew to become familiar with it. Once this initial period is over, most A350 operators, including Ethiopian, Finnair, LATAM Brazil, Lufthansa, Thai International, QATAR Airways and SIA are using it on long-haul missions.

LATAM Brazil has some of the longest missions, with average FC times of 9.4-9.8FH, and annual utilisations of 4,500-5,700FH and 470-700FC. Finnair has FC times of 8.1-8.6FH, and annual utilisations of 4,700-5,400FH and 570-630FC.

Aircraft used for long-haul operations are achieving average annual utilisations of 4,900FH and 650FC, with an FH:FC ratio of 7.5:1. These rates of utilisation are equal to 408FH and 54FC per month, and have implications for the timing of many tasks in the MPD. Some tasks have calendar (CAL) and either FH or FC intervals due on a whichever-comes-first (wcf) basis, while another group has three interval criteria - calendar, FH and FC - on a wcf basis.

A350 MPD

The A350's MPD was released when it entered service. The current MPD is the third revision which came into effect in mid-July 2016, but has been superseded by the fourth revision which came into effect in mid-January 2018.

Airbus's objectives were for the A350 to have 25% fewer tasks in its MPD than the A330, and up to a 40% lower man-hour (MH) requirement for scheduled maintenance tasks than the A330.

The third revision of the MPD has tasks that apply only to the A350-900. It has a total of 813 airframe-related tasks as follows: 484 systems tasks; 204 structural tasks; and 125 zonal tasks *(see table, page 41)*. The MPD also lists nine engine-related tasks that are regarded as being relevant to engine maintenance.

The fourth revision of the MPD has additional tasks for the A350-1000 series, another group for the -900 series, and another group that is common to the -900 and -1000 series; and so overall it has more tasks than the third revision. The A350-1000 is due to enter service with Qatar Airways in early 2018.

"In total, there are more than 944 tasks in the fourth revision. This is 131 more tasks than the third revision. There is a high degree of commonality on a lot of the tasks for the -900 and -1000 series in the MPD," says Jean-Francois Huix, A350 maintenance programme manager at Airbus. "There are 80 new tasks that apply just to the -1000 series. In addition to these 80 tasks, the fourth revision of the MPD also has 25 new tasks for the A350-900 and 34 tasks for both series. These new tasks have been added because some configuration changes for the -900 series have been applied to a batch of aircraft recently built on the production line. The fourth revision has also deleted or revised tasks (253) for the -900 series."

The A350's MPD follows the MPDs of all other modern types: each task is assigned an interval, expressed in the appropriate usage parameter, CAL, FH or FC; and airline engineering departments are free to group and plan tasks into packages that form their airframe maintenance checks in accordance with their own decision of maintenance planning (block checks, equalised, semi-equalised), aircraft utilisations (FH per and year and FC per year), and internal considerations such as cabin aesthetics.

Airbus has removed the traditional letter checks from the MPD. Some tasks are grouped into large numbers with the same interval. There are large numbers of tasks with intervals that are multiples of 1,200FH, that could be regarded as being a replacement for traditional 'A' checks; and other groups that are multiples of 36 months (MO), and could be regarded as a replacement for traditional 'C' checks.

It is practical, however, to group most tasks into relatively small and frequent check packages instead of into checks

that more closely resemble the larger and less frequent traditional block checks.

Since the launch of the A300B2 in 1974, Airbus base maintenance programmes have been based on a system of eight base checks. The fourth has been an intermediate heavy check, so it includes some deep access and heavy structural tasks. The eighth check has been the heaviest check, including the same deep and heavy tasks as in the fourth intermediate check, as well as a larger number of heavier and deep access tasks.

With escalations of checks due to individual task interval escalations, this system has been upgraded to a pattern of six base checks. The third is the intermediate heavy check, and the sixth is the heavy check with most of the structural inspection tasks. This programme is now in place with the A320 family, A330/A340 and was already in place for the A380 at entry into service.

The A350 and its maintenance programme have been designed to allow development of a programme of just four checks in the base check cycle. The standard base check interval is 36MO or three years (3YE), so the full cycle is 12YE. Another change in the A350's design compared to previous Airbus types is that only the last check in the cycle will be a heavy check. The second check in the cycle will have some medium deep access tasks, but overall it will not be a heavy check.

A large number of tasks in the MPD have intervals that are multiples of the basic 36MO interval, at 36MO, 72MO and 144MO. If the sequence of four base checks in the cycle is referred to as C1, C2, C3 and C4 checks, then these will be performed at 36MO, 72MO, 108MO and 144MO intervals.

These three groups of tasks could be referred to as 1C, 2C and 4C tasks. That is, groups of tasks with intervals that are one, two and four times the basic 36MO interval. These could be referred to as the 1C, 2C and 4C tasks. 1C tasks would come due every 36MO and C check; 2C tasks would come due every 72MO and second C check, the C2 and C4 checks; and 4C tasks would come due every 144MO and every fourth check, the C4 check *(see table, this page)*.

The cycle would then repeat over another 12YE interval, so the aircraft would be up to 24 years old when it undergoes its second heavy check. It could theoretically operate for up to 35-36 years before being retired just before its third heavy check comes due.

"We are able to have a base check programme of just four checks and a standard 36MO interval because of the A350's new systems technology, the materials we have selected in the aircraft's

A350 3RD REVISION MPD MAINTENANCE INSPECTION TASKS

CALENDAR TASKS	SYSTEM TASKS	STRUCT TASKS	ZONAL TASKS	TOTAL TASKS	NOTES	DEEP ACCESS
48HR	2			2		
8DY	1			1		
10DY	1			1		
28DY	1			1		
4MO	3		4	7		
6MO	4		8	12		
12MO	4		1	5		
18MO	1			1		
24MO	45		13	58		1+0+2
36MO	17	1	12	30	1C TASKS	0+0+1
42MO	2			2		
48MO	34		18	52		0+0+8
54MO	1			1		
60MO	9			9		
72MO	67	40	20	127	2C TASKS	0+3+3
80MO	2			2		
120MO	6			6		
144MO/72MO		5		5	4C TASKS	
144MO	55	81	49	185	4C TASKS	30+20+33
168MO	3			3		3+0+0
180MO	3			3		
300MO	2			2		
TOTAL	**263**	**127**	**125**	**515**		**104**

FH TASKS	SYSTEM TASKS	STRUCT TASKS	ZONAL TASKS	TOTAL TASKS	NOTES	DEEP ACCESS
120FH	1			1		
250FH	1			1		
500FH	1			1		
750FH	2			2		
1,200FH	10			10	1A TASKS	
1,500FH	3			3		
2,000FH	5			5		
2,400FH	4			4	2 A TASKS	
2,500FH	2			2		
3,250FH	1			1		
3,500FH	1			1		
4,000FH	8			8	3A TASKS	
4,800FH	1			1	4A TASKS	
6,000FH	8			8	5A TASKS	
7,000FH	1			1		
8,000FH	1			1		
8,500FH	1			1		
10,000FH	7			7		
12,000FH	34			34	10A TASKS	
15,000FH	2			2		
16,000FH	1			1		
18,000FH	4			4	15A TASKS	
20,000FH	6			6		
24,000FH	17			17	20A TASKS	
25,000FH	4			4		
27,000FH	1			1		
32,000FH	1			1		
35,000FH	1			1		
36,000FH	11			11	30A TASKS	3+0+0
40,000FH	1			1		
44,000FH	1			1		
48,000FH	3			3	40A TASKS	
60,000FH	1			1	50A TASKS	
65,000FH	2			2		
TOTAL	**148**	**0**	**0**	**148**		

A350 3RD REVISION MPD MAINTENANCE INSPECTION TASKS

FC TASKS	SYSTEM TASKS	STRUCT TASKS	ALI TASKS	ZONAL TASKS	TOTAL TASKS
50FC	1				1
750FC	1				1
1,500FC	1				1
2,400FC	2				2
2,500FC	1				1
6,000FC	3				3
4,500FC/7,200FC		1	1		1
TOTAL	**9**	**1**	**1**	**0**	**10**

FH & FC TASKS	SYSTEM TASKS	STRUCT TASKS	ALI TASKS	ZONAL TASKS	TOTAL TASKS	REACHED FIRST
1,000FC/4,500FC	2				2	4,500FH
3,700FC/18,700FH		1			1	18,700FH
3,900FC/38,000FH	1				1	38,000FH
5,200FC/26,100FH		1			1	26,100FH
5,800FC/29,000FH		1			1	29,000FH
6,000FC/26,000FH	1				1	26,000FH
7,200FC/30,000FH		4	4		4	30,000FH
7,200FC/36,000FH		6	2		6	36,000FH
7,300FC/36,800FH		1	1		1	36,800FH
7,400FC/37,000FH		2			2	37,000FH
7,600FC/38,000FH		1	1		1	38,000FH
7,600FC/38,200FH		1	1		1	38,200FH
7,600FC/38,300FH		1	1		1	38,300FH
7,600FC/38,400FH			1			38,400FH
7,800FC/39,000FH		1	1		1	39,000FH
7,900FC/39,800FH		1	1		1	39,800FH
8,100FC/40,900FH		1	1		1	40,900FH
8,300FC/41,500FH		3	1		3	41,500FH
8,400FC/42,100FH		2	2		2	42,100FH
8,500FC/42,500FH		1	1		1	42,500FH
8,600FC/43,200FH		2	2		2	43,200FH
8,900FC/44,900FH		1	1		1	44,900FH
9,200FC/46,200FH		2	2		2	46,200FH
9,400FC/47,300FH		1	1		1	47,300FH
9,500FC/47,500FH		1	1		1	47,500FH
10,100FC/50,700FH		1	1		1	50,700FH
10,600FC/53,200FH		1	1		1	53,200FH
10,900FC/54,500FH		1	1		1	54,500FH
11,100FC/55,500FH		2	2		2	55,500FH
11,200FC/56,100FH		1	1		1	56,100FH
11,400FC/57,000FH		1	1		1	57,000FH
11,500FC/57,700FH		1	1		1	57,700FH
12,300FC/61,800FH		1	1		1	61,800FH
12,600FC/63,400FH		1	1		1	63,400FH
13,500FC/67,600FH		2	2		2	67,600FH
13,700FC/68,500FH		2	2		2	68,500FH
13,800FC/69,300FH		1	1		1	69,300FH
13,900FC/69,500FH		1	1		1	69,500FH
14,200FC/71,400FH		1	1		1	71,400FH
14,400FC/72,000FH		8	8		8	72,000FH
15,000FC/75,000FH		1	1		1	75,000FH
15,100FC/75,500FH		1	1		1	75,500FH
23,400FC/117,000FH		1	1		1	117,000FH
TOTAL	**4**	**62**	**53**	**0**	**66**	

construction, and the design of the airframe structure," says Huix.

There are, however, two large groups of tasks at 24MO (58) and 48MO (52). If the 36MO base check interval is kept, then airlines will need to have additional special checks at 24MO, 48MO, 96MO and 120MO to perform these tasks.

There are other tasks in the MPD with intervals close to, slightly longer than, or about equal to these 36MO, 72MO and 144MO tasks. These tasks are often referred to as out-of-phase (OOP) tasks. Many of these tasks come due at a large number of different intervals, and some are likely to be included and planned into these four base checks. "These tasks have intervals specified in FH, FC, and FH & FC. Depending on the type of tasks and the access required, airline engineering departments can plan them into line, light, 'A' or base checks as they wish. That is, a task with an interval of say 20,000FH or 30MO could be included in a weekly line check or an A check as it comes due, just as much as it could be included in a base check," says Huix.

Some A350 operators have started with a base check interval of 24MO. This is partly explained by the large numbers of tasks at multiples of 24MO: 24MO, 48MO, 72MO and 144MO. There will be six base checks in this case at intervals of 24MO, 48MO, 72MO, 96MO, 120MO and 144MO.

Similar to the base check programme, a programme of light checks is based on a check interval of 1,200FH. These checks can be referred to as 'A' checks. Many tasks in the MPD have intervals that are multiples of 1,200FH, and are as high as 60,000FH. These light or 'A' checks are a regular sequence of checks. Tasks with intervals that are multiples of the 1,200FH interval could be referred to as 1A, 2A, 3A in sequence up to 50A tasks (at 60,000FH) in accordance with their interval *(see table, this page)*.

Again, other tasks with similar or close intervals can be referred to as OOP tasks. These can also be planned into these light checks. All tasks in light or 'A' checks, however, will have to be relatively light and not require deep access.

Design philosophy

The main contributor to such an efficient maintenance programme is the appropriate selection of materials to optimise aircraft weight and performance against the requirements of inspections.

"The two main aspects to be considered for the aircraft's structure are corrosion and fatigue. These generate the need for structural inspections as the aircraft accumulates age, FH and FC," says Huix. Corrosion is both a factor of calendar age and utilisation. It is a particular problem around the floor wet areas in the vicinity of galleys and toilets, and any areas of the aircraft's structure where moisture accumulates. Fatigue comes as the accumulates FH and FC, and so is an issue with ageing aircraft.

"Overall, the content of the aircraft's structure is 53% carbon fibre reinforced plastic (CFRP), 20% aluminium and 14% titanium. The remainder is accounted for by materials used for secondary structures such as interior partition walls, panels, ceilings or other parts such as insulation blankets, wiring and avionic components," says Huix.

The fuselage and wing structures are mainly made of CFRP materials resistant to fatigue and corrosion, and corrosion-free titanium material is used in areas where known corrosion issues are likely, such as cabin seat rails in wet areas.

"It has therefore been possible to eliminate many corrosion and fatigue inspection tasks in the A350's MPD that had to be included in the maintenance programmes of previous generation types. It has been possible to eliminate fatigue inspection tasks through modifications

A350 3RD REVISION MPD MAINTENANCE INSPECTION TASKS

CALENDAR & FH TASKS	SYSTEM TASKS	STRUCT TASKS	ALI TASKS	ZONAL TASKS	TOTAL TASKS	REACHED FIRST
3Mo/1,500FH	2				2	3MO
6MO/2,000FH	1				1	6MO
18MO/2,000FH	1				1	2,000FH
18MO/6,000FH	5				5	18MO
24MO/6,400FH	1				1	6,400FH
24MO/9,000FH	1				1	24MO/9,000FH
24MO/12,000FH	1				1	24MO
36MO/20,000FH	1				1	36MO
36MO/45,000FH	1				1	36MO
60MO/24,000FH	1				1	60MO/24,000FH
72MO/14,500FH	1				1	14,500FH
72MO/16,500FH	1				1	16,500FH
72MO/18,000FH	1				1	18,000FH
72MO/20,000FH	1				1	20,000FH
72MO/24,000FH	1				1	24,000FH
120MO/20,500FH	1				1	20,500FH
120MO/22,500FH	2				2	22,500FH
TOTAL	**23**	**0**		**0**	**23**	

CALENDAR & FC TASKS	SYSTEM TASKS	STRUCT TASKS	ALI TASKS	ZONAL TASKS	TOTAL TASKS	REACHED FIRST
5MO/500F	2				2	5MO/500FC
24MO/2,800FC	1				1	24MO
36MO/3,600FC		1	1		1	36MO
60MO/6,000FC	1				1	60MO
72MO/6,600FC	1				1	72MO
72MO/8,000FC	1				1	72MO
144MO/6,000FC	2				2	144MO
144MO/16,800FC	8				8	144MO
TOTAL	**16**	**1**	**1**		**17**	

CALENDAR, FC & FH TASKS	SYSTEM TASKS	STRUCT TASKS	ALI TASKS	ZONAL TASKS	TOTAL TASKS	REACHED FIRST
72MO/2,100FC/10,500FH		1			1	10,500FH
72MO/2,200FC/11,200FH		1	1		1	11,200FH
72MO/4,100FC/20,700FH		1	1		1	20,700FH
72MO/6,100FC/30,700FH		1			1	72MO/30,700FH
72MO/7,200FC/36,000FH		2	1		2	72MO
72MO/8,300FC/41,500FH		1	1		1	72MO
72MO/10,800FC/54,100FH		1			1	72MO
72MO/14,400FC/72,000FH		1	1		1	72MO
144MO/2,200FC/11,200FH		1	1		1	11,200FH
144MO/11,100FC/55,700FH		1	1		1	144MO/55,700FH
144MO/12,800FC/64,000FH		1	1		1	144MO
TOTAL	**0**	**12**	**8**	**0**	**12**	

OTHER TASKS	SYSTEM TASKS	STRUCT TASKS	ALI TASKS	ZONAL TASKS	TOTAL TASKS
	21				21
TOTAL	**21**				**21**

that include the structural reinforcement of the concerned area," continues Huix. "It also allowed us to select higher structure task intervals compared to previous programmes, so the A350 structures maintenance programme mainly consists of a set of 6YE light access tasks and another set of 12YE heavier access tasks."

For aircraft systems, various aspects of design make them maintenance-efficient. "One of the main contributors of these is the integrated modular avionics (IMA) philosophy for the aircraft's avionics, because it reduces the number of computers and allowed us to implement many monitoring or diagnosis functions in line maintenance. It thereby reduces the need for scheduled maintenance tasks," says Huix.

Overall, the resultant A350 maintenance programme has lower overall scheduled maintenance requirements. This results in fewer MPD tasks and inspections, fewer MH for many of the tasks, and longer intervals for most tasks.

Other features of the A350's maintenance programme are a reduced group of Damage Tolerant Airworthiness Limitation Items (ALI) tasks and the absence of additional requirements such as a Structure Sampling Programme or a Supplemental Structural Inspection Document (SSID).

A Structure Sampling Programme is a set of inspections, designed to detect systematic deterioration caused by the environment and/or fatigue, on a group of aircraft selected from those which have the highest age within a considered fleet. "There is no corrosion or fatigue sampling programme on the A350," says Huix. "A corrosion sampling programme has not been deemed necessary by Airbus and operators participating in the Maintenance Review Board Report (MRBR) process. This is because we have managed to achieve long intervals for the corrosion inspection tasks of the MRBR, the main source data for the MPD.

In addition, Airbus does not plan to develop a fatigue sampling programme for the A350 that is similar to that implemented on earlier Airbus types.

"Moreover, we have an objective to remove the fatigue sampling programmes from the MPDs of all Airbus types in the coming years," says Huix.

"There is also no SSID for the A350. The SSID was originally included in the A300B2/B4's MPD to account for fatigue during operation that accrued as a result of accumulated FH and FC," says Huix. "The CS25 certification now requires Airbus to consider fatigue and damage tolerance on the aircraft's structure and publish the subsequent requirements in the Airworthiness Limitation Sections (ALS) Part 1 for safe life structures or Part 2 Airworthiness Limitation Items (ALI) for damage-tolerant structures. It has therefore effectively included the SSID repetitive tasks in the structures section in the MPD. "The ALI tasks are listed in the MPD, and are identified by looking in the column titled 'source'. Each task has a threshold and interval. The threshold is the interval at which the task initially comes due, and the interval is the subsequent interval at which the task has to be repeated.

"There are also 53 ALI tasks for the A350-900 listed in the fourth revision of the MPD. There were 63 ALI tasks in the third revision, and Airbus has developed some structure reinforcement modifications that allow a post-modification configuration to cancel the requirement for the inspection, or extend the initial and repeat intervals," continues Huix. In the third revision of the MPD, there are 53 ALI tasks that are structural inspections which have FH & FC

intervals. These have initial intervals from 36,000FH to 117,000FH. There is also a small number of ALI structural tasks that have intervals specified in calendar time, FH and FC. These have initial intervals from 11,200FH to 64,000FH or 144MO.

"Airbus's aim is to delete the ALI tasks from the MPD by the second quarter of 2019," continues Huix. "There is a larger number of ALI tasks for the initial batch of aircraft that came off the production line. There was then a batch of modifications incorporated on the production line, and these later-produced aircraft only have 53 ALI tasks. We will introduce more modifications that will be incorporated on the production line in 2019, which is why we think we will be able to remove all ALI tasks from the first half of 2019."

SUMMARY OF MAINTENANCE TASKS 3RD REVISION A350 MPD

TASK INTERVAL	SYSTEM TASKS	STRUCT TASKS	ZONAL TASKS	TOTAL TASKS	DEEP ACCESS TASKS
Calendar	263	127	125	515	104
FH	148	0	0	148	3
FC	9	1	0	10	
FH & FC	4	63	0	67	18
Calendar & FH	23	0	0	23	
Calendar & FC	16	1	0	17	8
Calendar, FC & FH	0	12	0	12	
Other	21	0	0	21	
Total	**484**	**204**	**125**	**813**	**133**

SUMMARY OF BASE CHECK ARRANGEMENT FOR A350

BASE CHECK	INTERVAL - MONTHS	MAIN TASKS	TOTAL TASKS
C1	36MO	1C/36MO	33
C2	72MO	1C/36MO + 2C/72MO	176
C3	108MO	1C/36MO	33
C4	144MO	1C/36MO + 2C/72MO + 4C/144MO	379

MPD tasks

The MPD uses three main interval criteria: calendar time, FH and FC.

There are seven different interval groups: calendar time; FH; FC; FH and FC; calendar and FH; calendar and FC; and all three criteria of calendar time, FH and FC.

Calendar tasks

There are 515 tasks in the MPD with calendar intervals. These account for most MPD tasks. Only five tasks with calendar intervals have intervals specified in days *(see table, this page)*. The remainder of the tasks have intervals between 4MO and 300MO. There are 18 different MO intervals. Most tasks have intervals at 24MO (58 tasks), 36MO (30), 48MO (52), 72MO (127), and 144MO (190) *(see table, this page)*. This is a total of 457 tasks. The remaining 58 OOP tasks have a large number of different intervals, ranging from one to 12 tasks for each interval. Tasks with shorter or lower intervals could be included in light or base checks, while tasks with higher intervals are more likely to be planned into base checks.

Of the 515 tasks, 263 are system tasks, and many have the shorter intervals of 24MO or less, and include the five tasks with daily intervals. It is only tasks with high intervals of 144MO that have deep access requirements and a small number with a 168MO interval.

There are 127 calendar tasks in the structural programme. Just one task has an interval of 36MO, while there are 40 tasks at 72MO, and 86 tasks at 144MO. Five of these 86 tasks then have a repeat interval of 72MO. Many of the tasks at 144MO have a deep access requirement.

There are 125 calendar tasks in the zonal programme, and this accounts for all zonal tasks in the MPD. Of these, 26 have intervals of 4MO to 24MO, but the remaining 99 of these tasks have intervals of 36MO to 144MO as follows: 13 at 24MO, 12 at 36MO, 18 at 48MO, 20 at 72MO, and 49 at 144MO. All of these interval groups include a few medium access tasks, but 33 of the 49 tasks at 144MO have a deep access requirement.

In total, 104 of the CAL tasks have a deep access requirement, and 83 of these have a 144MO interval *(see table, this page)*.

FH tasks

There are 148 FH tasks, all of which are within the system programme. At typical rates of annual utilisation in most long-haul operations, a 36MO base check interval is equal to 14,700FH. Besides a small number of tasks for rudder and elevator actuation, all FH tasks are light and do not require deep access.

Most FH tasks have intervals that are multiples of the standard 1,200FH light check interval. These multiples are 1,200FH (10 tasks), 2,400FH (4), 4,000FH (8), 6,000FH (8), 12,000FH (34), 18,000FH (4), 24,000FH (17), 36,000FH (11), 48,000FH (3) and 60,000FH (1). These total 100 tasks, and form the bulk of the tasks that form the light or 'A' checks.

There is also a large number of other tasks with different intervals between these multiples of 1,200FH. There are 34 different FH intervals. There are five tasks with intervals of 120FH to 750FH for line check tasks, and 143 tasks of 1,200FH to 65,000FH that can be planned into either light/A checks or into base checks.

FC tasks

There are just 10 FC tasks, of which nine are included in the system programme and one is in the structural programme. There is a small number of intervals. There are just two tasks at 50FC and 750FC, which are likely to be included in light checks; and seven tasks at 1,500FC to 6,000FC which are likely to be planned into base checks at typical rates of utilisation. None of the FC tasks has deep access requirements. The structural programme task is an ALI task, with a threshold interval of 14,500FC and 7,200FC.

FH & FC tasks

The FH and FC tasks total 67, the third largest group of tasks. There are just four tasks in the systems programme, none in the zonal programme, and 63 in the structures programme. There are 43 different intervals ranging from 1,000FC/4,500FH to

The oldest A350-900s are more than three years old. There are a large number of tasks in the MPD with intervals at multiples of 36MO. Airbus' target for the base check programme is a system of four checks at 36MO intervals, with a fourth heavy check at 144MO. There are also two large groups of tasks at 24MO and 48MO.

23,400FC/117,000FH. There are no large groups of tasks in one or two particular intervals, and there are no more than three tasks in the case of all but two different intervals. Most intervals have a ratio of about 5:1 in the case of the FH: FC interval used.

The two FC and FH intervals in each case are used on a wcf basis. The ratio of 5:1 means that the FH interval will be reached before the FC interval in most cases. The FH interval is therefore the governing interval. Besides two tasks at 1,000FC/4,500FH, all other 61 tasks have intervals that are appropriate for the tasks to be included in the base checks. Of these, 53 are ALI tasks as described.

Examination of the structures programme shows that a small number of tasks have deep access requirements.

Calendar & FH tasks

The calendar and FH group of tasks is relatively small, totalling 23 tasks. All 23 are from the systems programme.

There are 17 different intervals from 3MO/1,500FH to 120MO/22,500FH. The rate of long-haul utilisation means that the FH interval is reached first in most cases. Half of the 11 tasks with intervals up to 24MO/9,000FH are likely to be planned into line or light/A checks, and the other 11 grouped into base checks. None of the tasks has deep access requirements.

Calendar & FC tasks

There are 17 tasks in the calendar and FC group. Only one task is in the structures programme, and 16 are in the system programme. The rate of aircraft utilisation means the MO calendar interval will be reached first in all cases. Three tasks have intervals relevant to line and light checks, while the other 14 tasks have intervals from 36MO to 144MO, making them relevant to base checks. Many of the 144MO tasks have deep access requirements.

Calendar, FC & FH tasks

The calendar, FC and FH group of tasks is one of the smallest in the MPD, with just 12 tasks. All are included in the structures programme, and eight are ALI tasks. Only two have short intervals for light checks, and the other 10 have intervals ranging from 72MO/4,100FC/20,700FH to 144MO/12,800FC/64,000FH that make it appropriate to include them in base checks. None of the tasks has deep access requirements.

Other intervals

Another 21 tasks, all in the systems programme, have intervals that relate to pieces of equipment and components, and are specified by the manufacturer. Many relate to safety equipment and components of the auxiliary power unit.

Summary

The 813 airframe inspection tasks have eight different interval criteria. There are another nine engine-related tasks in the systems programme. The tasks that account for the calendar multiples of 24MO and 36MO that form the basis of the base checks are in the 515 calendar tasks. This includes 90 deep access tasks with intervals of 144MO *(see table, page 41)*.

The tasks that are several multiples of 1,200FH are included in the 148 tasks with FH intervals *(see table, page 41)*.

There are another 150 tasks in the other six interval groups, and 26 of these are deep access tasks.

Major task groups

As described, 100 FH tasks have a 1,200FH interval or multiples thereof. These are planned and grouped into light or 'A' checks.

In the case of base check tasks, there are 30 calendar tasks, a single 36MO/20,000FH, and a single 72MO/3,600FC task. These 32 tasks form the '1C' tasks, and come due every C check, which has a 36MO interval.

There are 127 72MO, five 72MO/FH tasks, two 72MO/FC tasks, and nine 72MO, FH & FC tasks. These 143 tasks can be regarded as the '2C' tasks, and come due every second base check. They are therefore included in the C2 and C4 checks in the first base check cycle. The C2 check, for example will include the 1C and 2C tasks.

There are 190 144MO, 10 72MO/FC tasks, and three 144MO, FH and FC tasks. These 203 tasks form the '4C' tasks. They come due every fourth base check, and so are performed for the first time at the C4 check.

These three groups of tasks total 379, which is 47% of all tasks in the MPD. The traditional system of grouping these 1C, 2C and 4C tasks would result in just the 32 1C tasks in the C1 and C3 checks *(see table, page 41)*. The total of 174 1C and 2C tasks would be grouped into the C2 check. The C4 check includes all three groups that total 378 tasks. In addition, the OOP tasks in the MPD with similar or close intervals would be included in the base checks.

There are therefore 478 tasks whose intervals are exact multiples of the 1,200FH light or 'A' check, and 36MO base or 'C' check interval. These account for 60% of MPD mandatory tasks, and can be arranged into a series of 'A' checks in a block system with the number of tasks *(see table, page 41)*.

Finnair has initially opted for a base check interval of 24MO, and a base check programme of six checks with a heavy check at 144MO. Its first base or 'C' check was performed on its oldest A350-900 in October 2017. Finnair predicts that the A350 will consume 15-30% fewer man-hours than the A330 on the intermediate and heavy base checks.

Deep access tasks

The degree to which the fourth base check, or 'C4' check, is a heavy check depends on the number of heavy and deep access tasks included in the main task groups.

"There are many corrosion inspections in the 144MO tasks that require the removal of the cabin floor," says Huix. "There is also a large number of zonal and electrical wiring interconnect system (EWIS) inspection tasks in the fuel tanks that have a 144MO interval. This requires the draining and venting of the fuel tanks, so they involve a lot of access MH. A third group of deep access tasks at 144MO is related to the removal and installation of the landing gear, so they need a large number of MH. This includes putting the aircraft up on jacks."

There is also a landing gear freefall test at 72MO, so the aircraft again has to be put up on jacks in the hangar. This also needs specific tooling and a number of MH.

Out of more than 130 deep, access and heavy tasks, about 90 tasks are at the 144MO interval.

Airline experience

Finnair operates a fleet of 11 A350-900s, and the oldest aircraft is more than two years old. While the standard base check interval for the A350 at service entry was 36MO, Finnair opted for an initial 24MO interval for its base check programme. "We chose to start our A350 operation with a 24MO interval for the base check mainly because it is a new type into service, and there were few other operators. These had only up to one year of experience with the type," says Miika Haatio, head of fleet engineering for the A330 and A350 at Finnair. "When we made this decision at service entry in 2015, it was also not known how many modifications would be required during the first years of operation, and what amount of ground time would be required for the base checks.

"Also, selecting a 36MO base check interval would have meant having to stop the aircraft's operation for a 24MO maintenance visit anyway. This is because there are 48MO tasks in addition to 30 36MO tasks in the MPD," continues Haatio. "This would increase the workload for light maintenance visits."

"The pattern of base checks that can be followed for the A350 is mainly determined by the decision to opt for the 24MO or 36MO base check interval. Considering that there are large groups of calendar tasks at 24MO, 48MO, 72MO and 144MO, a pattern of six checks in a 144MO interval would work as an alternative to four checks every 36MO to 144MO.

Finnair's base check cycle is a pattern of six base checks at 24MO, 48MO, 72MO, 96MO, 120MO and 144MO intervals. The 144MO check, the sixth in the cycle, is the only check likely to be a heavy check with deep access structural inspections.

Finnair is keeping the option to increase the base check interval to 36MO. Considering that the 72MO interval is both a multiple of 24MO and 36MO, it may make sense for Finnair to escalate to the 36MO interval for base checks at this stage. If this were to occur then it would hopefully coincide with the 24MO tasks being escalated to a 36MO interval.

In addition to the main groups of tasks with intervals that are multiples of 24MO, there are also large numbers of other tasks with OOP intervals. "We plan these either into light or base checks, depending on the interval, the access required, and the MH requirements," says Haatio. "The higher interval OOP tasks can be planned into the most appropriate 24MO or 36MO multiple check."

Finnair has now operated the oldest A350 for more than two years. It performed the first base or 'C' checks on its A350s in October 2017.

"The number of tasks and overall labour requirement and downtime for the 72MO check makes it much larger than the 36MO check," says Haatio. "The 72MO check is also comparable to the 72MO/C4 check in the A330's base check programme. This is the fourth check in the A330's base check cycle, and the third in our base check cycle for the A350. We have experience of the 72MO/intermediate and 144MO/heavy checks for the A330. We project that the A350 will consume 15-30% fewer MH for the 72MO and 144MO checks than the A330. Overall, we project the A350 will use 15-20% fewer MH compared to the A330, depending on the check in the cycle. This is partly because of the longer tasks intervals and intervals between checks. This also contributes to less overall ground time for maintenance across the light and base check cycles.

Haatio comments that the A350 is more maintenance-efficient than the A330/A340 because of the use of self-monitoring systems, ease of access for deep tasks, and fewer structural tasks. In addition to MPD tasks, Finnair has about 50 of its own tasks that are mainly for cabin maintenance. AC