The 787 & A350XWB have been designed with the objective of reducing airframe and component maintenance requirements. The extensive use of composite materials and electrical systems has either eliminated or extended the intervals of maintenance tasks.

The 787's & A350's design & maintenance requirements

The new generation widebodies, the 787 and A350, are due to enter service in late 2010 and 2013 respectively. Like all new aircraft, the 787 and A350 have been launched and ordered on the basis that they will have lower cash operating costs than their predecessors. With advances already made on the flightdeck, the two remaining cost categories where cash operating costs can be reduced are fuel consumption and maintenance requirements. How the 787 and A350 can deliver a reduction in maintenance costs compared to their older counterparts is examined here. The 787-8 and -9 are nominally 240- and 280-seat aircraft, and the three A350 variants are 270-, 310- and 350- seat aircraft, so they are pitched as replacements for the 767-400 and A330-200 at the smaller end of the scale, and the A340-600 and 777-300 at the larger end of the scale.

Maintenance reduction

An aircraft's maintenance costs vary throughout its life cycle. They start low, with only small airframe checks, little component maintenance and no engine shop visits for an initial period lasting several years. They then rise to a mature level, and then continue to climb in the aircraft's latter years of operation. Maintenance costs rise due to more frequent component repairs and engine shop visits, and an increasing amount of non-routine rectifications in airframe checks. The lower maintenance costs of new types like the 787 and A350 compared to older aircraft clearly have to be considered for the same period in an aircraft's maintenance life, or over its whole life, to get a complete idea of the size of the reduction. While this is now becoming clear for most of the types the 787 and A350 are replacing, it is not possible for the 787 and A350. Prior to these types entering service, it is only possible to examine their designs in terms of how a maintenance cost reduction is to be achieved, and how big it might be.

An aircraft's maintenance needs comprise: line maintenance; A checks; base airframe checks; rotable repair and management; engine repair & overhaul; and heavy component maintenance.

787

The 787's two variants broadly have seat capacities that could allow it to replace types from the 767-300 to the A340-200/-300. An objective of the 787's design was for an aircraft that could offer the same unit cost per available seat-mile (CASM) as larger types, and thus make it economically viable to operate a large number of city-pairs that are only likely to generate small volumes of traffic.

The 787 uses several technological features to effect large reductions in fuel burn and maintenance costs compared to similar-sized current generation aircraft. One high-profile feature is the extensive use throughout the 787's structure of carbon fibre, which reduces the cost of maintenance. Benefits include: making the 787 lighter than current aircraft like the 767; eliminating a large number of maintenance tasks related to structural and zonal maintenance; extending the intervals of many remaining tasks; reducing the incidence of corrosion and fatigue; and reducing the ratio of non-routine rectifications compared to routine inspections. As well as an advanced engine design, there are more electric systems and advanced aerodynamics, which help to reduce fuel burn.

The 787 has other design features that are intended to reduce maintenance needs. It has been promoted as a more electric aircraft, which has reduced the number of complex parts and components in the aircraft's various systems, and replaced them with electrical systems. This reduces the number of components that are susceptible to reliability problems, require maintenance and add weight to the aircraft.

"The first example is the landing-gear door and gear-lowering system," says Justin Hale, regional director product marketing at Boeing, and previously the 787's chief mechanic. "These involve a complex sequence and a large number of hydraulic and hydromechanical systems and components in a conventional aircraft. A lot of these are replaced with electrical components in the 787.

"The brake control system on the wheel brakes is also electrical on the 787, reducing the number of complex parts. The anti-ice system for the engine nacelles on conventional aircraft taps hot air from the engines' compressors, which is piped to the front of the engine nacelles. This is replaced by an electrical heating system on the 787," continues Hale. "The bleed system is one of the bigger changes. On a conventional aircraft, hot air is tapped off from the engines' compressors, and then cooled with air cycle machines, before being pumped into the cabin to provide fresh air and pressurisation. On the 787, however, air is taken from inlets in the wing-body fairing, and compressed using electrically powered compressors. This air will be used to pressurise the aircraft. This completely eliminates the need for a bleed air system from the engines.

"Another example is the engine start system. On a conventional aircraft compressed air is piped from the auxiliary power unit (APU) in the tailcone all the way to the wings, through the engine pylons and to the pneumatic starter motor mounted on the side of the engine," continues Hale. "The 787 will not use any bleed air from the APU or

The development of the 787's MPD has now been completed. This has 763 tasks, which compares to the 767's MPD of 1,499 tasks and the 777's MPD of 1,389 tasks. The 787's MPD has a small number of tasks, because the extensive use of carbon fibre and composites means many of the aircraft's structures are not prone to fatigue or corrosion.

pneumatic starter motors to start the engines. Instead it will use electric starter motors. The engines will also use electrical generators instead of integrated drive generators (IDGs) or constant speed drives (CSDs)."

Replacing complex mechanical components with electrical ones is shown in the analysis of components by Air Transport Association (ATA) Chapters. "There has been a complete elimination of ATA Chapter 36 (Pneumatics) components," says Hale. "There has also been a reduction in the number of components and parts in ATA Chapters 49 (APU), 30 (Ice and rain protection), 29 (Hydraulic), and 80 (Engine start). This is expected to result in 41% fewer scheduled interruptions compared to the 767, for the ATA chapters influenced by the no-bleed systems design."

All these features will reduce the inspection and test man-hours (MH), and therefore the parts and materials, used in the 787's airframe checks. There are further reductions in the number of maintenance tasks and design features to lower line maintenance requirements and costs. The use of extensive electrical systems should also improve reliability, make it easier to analyse and isolate system faults, and reduce the number of system rotable components.

The design is therefore conceived to make the 787's reserves for airframe- and rotable-related maintenance lower than the 767's and 777's.

When compared to other aircraft of this size in operation today, the 787 is expected to provide a 10% reduction in cash operating costs for airlines. The 787 has won 860 firm orders to date, an unprecedented number for a commercial aircraft prior to entering service.

787 maintenance programme

The 787 has been designed to extend the intervals of maintenance tasks. Its maintenance programme has been under development for several years, and the maintenance planning document (MPD) has been completed. The main feature of the 787's MPD is that, like the 737NG's, it does not pre-define checks. Instead it lists all tasks with their interval criteria, and each operator is free to group tasks into checks in a way that best suits their operations. The three interval criteria are flight hours (FH), flight cycles (FC) and calendar time. There are, however, some guidelines for check intervals. "The guide or target in the MPD for what operators might generically refer to as 'A' checks is 1,000FH, and multiples thereof," says Hale. "The guide for base checks is intervals of 12,000FH and 36 months. The guide for the structural check is intervals of 24,000FC and 144 months."

Given that most 787s will be used for long-haul operations, they are likely to be utilised at a rate of 4,500-5,000FH by most operators. The aircraft will also be used at an FH:FC ratio of 8-10FH per FC in most cases, and so accumulate 450-600FC per year. The aircraft are therefore likely to reach the FH guide intervals for the base checks before they reach the calendar intervals. They are also likely to reach the structural check's calendar interval before they reach the FC interval.

"In addition to these guide or target intervals for most maintenance tasks, there will be other 'drop-out' tasks with different intervals," explains Hale. "Although the MPD does not have pre-defined checks, we are aiming to have a programme of A and base checks based around these parameters. A possible maintenance programme for the base check tasks might divide these by 12 or six into smaller groups of tasks performed every 1,000FH or 2,000FH. This would result in a larger number of smaller and more frequent checks."

The 787's main appeal is the fewer number of tasks in its MPD compared to the 767 and 777. Some tasks in the MPDs of the two older types apply to the left- and right-hand sides of the aircraft, and are grouped into one task card. "Taking Rolls-Royce-powered aircraft for an equal comparison of all three types, the 767's MPD has 1,499 tasks and the 777's has 1,389 tasks. The 787's MPD has 763 tasks, but when some of the left-hand and right-hand side tasks are combined into a single task, the 787's MPD is reduced to 589 tasks."

The 787's design has therefore been effective in reducing the aircraft's maintenance requirements. "The MPD can be divided into systems and engine tasks, structures tasks, and zonal tasks," explains Hale. "The 767's MPD has 708 structures-related tasks, while the 787's has 124. The 767 also has 600 systems tasks in its MPD, while the 787 has 397. The 787, however, has 242 zonal tasks, compared to the 767's 191 tasks.

"The reduction in structures and systems tasks is due mainly to the type of materials used in the aircraft's structure," continues Hale. "Three criteria drive the need for a task: fatigue, corrosion and damage. Although accidental damage cannot be eliminated, the 787 is more robust against accidental damage than metal types. Using carbon fibre and other materials has meant that fatigue and corrosion have been largely eliminated on the 787, so some tasks can be removed altogether. We have therefore been able to eliminate 82% of the structures tasks and 34% of systems tasks on the 767."

The largest reductions in base check tasks are in the second and fourth base checks, or C2 and C4 checks, which are targeted to be at six and 12 years. "There will still be a few structures tasks in the six-year, C2 check," says Hale. "These will only be external tasks, not heavy internal tasks. The big check will

787 MPD 'A' CHECK TASK GROUPS

Task interval	Number of tasks	MPD man-hours
1,000FH	11	4.8
1,500FH	8	6.5
4,000FH	12	7.2
6,000FH	38	25.5
8,000FH	12	5.5
1,000FC	12	18.4
6 months	7	2.4
12 months	11	6.9
24 months	10	10.7

787 MPD 'C' & 12-YEAR CHECK TASK GROUPS

Task interval	Number of tasks	MPD man-hours
12,000FH	190	117.7
24,000FH	33	30.6
36,000FH	5	4.5
72 months	133	104.0
84 months	11	22.8
108 months	4	5.0
144-month, 24,000FC & 48,000FH	201	298.3

therefore be the C4 check, at the 24,000FC and 12-year interval."

Most tasks in the 787's MPD can easily be grouped into checks at the target intervals set by Boeing. The expected 'A' and base or 'C' checks can therefore have intervals that are twice those on the 767: every 600FH and 18 months for most operators. The 787's base check intervals are one-and-a-half to two times those of in-service aircraft like the A330 and 777.

The 787 also has fewer tasks. The extensive use of composite materials and carbon fibre means that the incidence of findings and defects is expected to be lower than on current generation aircraft. This will result in a lower non-routine ratio, and also a slower rate of increase the non-routine ratio. The use of longer task and check intervals, few task cards and the expected lower non-routine ratio overall means the 787 is expected to have lower airframe-related maintenance costs.

'A' check tasks

Hale explains that the 787's A check tasks in the MPD can be broken down into nine simple groups. These are summarised *(see table, this page)*. Intervals vary from 1,000FH to 8,000FH; the highest being equal to just less than two years' operation. There are three task groups with calendar intervals; the highest being two years. There is one group of tasks with a 1,000FC interval.

The MPD MH, estimated by Boeing, are also quoted in the table. The largest group of tasks are clearly: the 6,000FH tasks, resulting in 25.5MH; the 1,000FC tasks, resulting in 18.4MH; and the 24-month tasks, resulting in 10.7MH.

It should be noted that MPD MH estimates always assume perfect working conditions. Operators and independent maintenance providers always apply a mark-up factor to MPD estimates to predict actual MH for inspections. This includes allowances for the additional time for aircraft docking, aircraft preparation, accessing the individual areas where the routine inspections will be made, and restoration. Most operators and maintenance providers use a mark-up multiplication factor of about 2.0 for MPD routine MH.

As well as routine inspections, there are non-routine defects and rectifications, additional tasks added by the operator, cleaning and some interior refurbishment, clearing outstanding defects, and incorporating airworthiness directives (ADs) and service bulletins (SBs).

The nine task groups will be arranged into a convenient schedule of A checks. If the 1,000FH multiple is used, the intervals of some task groups must be adjusted, so that the 1,500FH tasks are brought forward to a 1,000FH interval. The 1,000FC tasks will be performed at the equivalent FH interval depending on the FH:FC ratio, which may be 8,000FH for a long-haul operation. The calendar tasks will have to be performed at the most appropriate 1,000FH multiple in relation to utilisation.

A system of block checks for an aircraft operating at 4,800FH and 600FC per year, would have MPD MH for the nine task groups varying from 11.3MH to 53.3MH for the 12 checks up to the 12,000FH interval, which coincides with the base check interval. Using a mark-up factor of 2.0, this equates to routine inspections using 23-107MH for A checks arranged in a block system, which is relatively low for an aircraft of its size.

Base check tasks

The base check task groups are also summarised *(see table, this page)*. There are just seven main task groups. Three of these have FH intervals of 12,000FH, 24,000FH and 36,000FH; the target intervals for the first three base checks. The largest of these is first, with 190 tasks and an MPD MH requirement of 117.7. The 36,000FH group has just five tasks and an MPD MH requirement of just 4.5.

There are also three groups of tasks with calendar intervals of 72, 84 and 108 months. The largest is the 72-month group, with 133 tasks and an MPD requirement of 104MH. This group coincides with the target interval for the second base check. The second group's interval of 84 months is out of phase with

The 787's MPD allows airlines to package tasks into checks as suits their operations and rates of utilisation. The aim, however, is for airlines to have light or 'A' checks at 1,000FH intervals, base or 'C' checks at 36-month intervals, and a structural check at a 144-month interval.

target intervals. It has 11 tasks and an MPD MH requirement of 22.8. The third group's 108-month interval coincides with the target interval for the third check.

The last group of tasks, with a triple interval of 48,000FH, 24,000FC and 144 months, is a large group of 201 tasks with an MPD MH requirement of 298.3.

The target is to have a base check every 12,000FH and 36 months, with the heavy structural check being the fourth in the cycle, at 24,000FC and 144 months. The calendar target intervals for the base checks could only be fully utilised, however, for aircraft operating at 4,000FH per year. Most long-haul operations already achieve higher rates of utilisation. On the basis of 4,800FH per year, the calendar tasks would have to be brought forward. The 72- and 84-month tasks would have to be brought forward and grouped together and performed at every second C check, which would be every 60 months. The 108-month tasks would be performed every 36,000FH or every 90 months.

The 24,000FC/144-month tasks could still be performed every 144 months, but the fourth base check would have been performed at 120 months. It may make sense for operators to bring the structural check forward and perform it at 120 months with the fourth base check.

The base checks therefore have to be arranged as a series of four checks at an interval of 12,000FH and about 30 months. The C4 check and structural tasks would be combined at about 48,000FH and 120 months. If the target interval of 36 months for the C check is to be reached, then the FH interval would have to be extended to 14,000-15,000 to suit most operators' probable rates of utilisation.

By arranging these seven groups of tasks into block base checks, the four checks are performed at intervals of 12,000FH and the fourth check (C4) comes due at 48,000FH. With this arrangement, the task groups do not come into phase until the C12 check, the third heavy check. The total MPD MH requirements for routine inspections of the three lighter checks in the first two cycles vary from 118 to 284. The routine MPD MH requirement for the heavy C4 check is about 574. A mark-up factor of 2.0 gives routine MH requirements for the four checks of 240-1,150.

Line maintenance

The 787's line maintenance tasks are all included in the MPD. For current and older types, most tasks in the standard pre-flight, transit, daily and weekly checks are listed in the aircraft's flight operations manual. A few are listed in the MPD, and grouped into the line checks. "All line maintenance tasks are confined to the MPD. These have intervals of less than 1,000FH," says Hale. "The 787 only has six line check tasks in the MPD: a two-day tyre pressure check; a three-day visual inspection of tyre condition; a seven-day visual inspection of the wheels and brakes; a 200FH initiated test of actuators in the flight controls; a two-month task to clean the exposed portion of the landing gear cylinders; and a 100FC brake disc thickness inspection."

Pilots also do a walkaround inspection, as with all types. Hale says the small number of line maintenance tasks means that the pre-flight/transit, daily and weekly checks have effectively been eliminated on the 787, an industry first. Line mechanics will still need to deal with technical faults and clear defects as they arise during the aircraft's operation.

Technical faults

Interpreting, isolating and correcting technical faults during the operation consumes mechanic MH and resources from an airline's maintenance control centre or department. On-board maintenance computers on aircraft have evolved since the early 1980s to make fault identification and isolation easier.

The 757/767 were the first Boeing aircraft to have some of this technology. This consisted mainly of a display that indicated fault codes when technical problems in aircraft systems arose. Flightcrews had to manually record these fault codes in pilot reports (Pireps) and technical logs, for analysis by mechanics using the fault isolation manual (FIM), troubleshooting manual (TSM) and aircraft maintenance manual (AMM).

"The 747-400 was the first Boeing aircraft with a central maintenance computer (CMC), which had some ability to analyse the fault codes," says Hale. "The problem is that a single fault in an aircraft system can have a cascade effect, triggering several other problems or faults in other systems. This would result in further fault codes, so more extensive on-board analytical capability was required.

"The 777's on-board computers manage about 18,000 different fault codes," continues Hale. "The 787 manages about 45,000 fault codes, with the fault reporting system, the e-Pireps and the electronic technical log (ETL), the FIM, AMM and the TSM all linked and interfaced electronically. When a fault occurs the system automatically records it, analyses it and tells the mechanic which pages of the relevant manuals to use to rectify it.

"The objective is to reduce the time spent analysing and fixing faults so that line maintenance labour is saved," continues Hale. "It is difficult to monitor the bleed and mechanical systems for faults but we have replaced them with electrical systems that are easier to monitor and need fewer tasks to fix them. All these features will reduce the inputs into non-routine line maintenance."

Rotables

The use of electrical systems in the 787 has reduced the overall number of rotable components on the aircraft.

"A reduction in rotables has also been achieved by using integrated modular avionics (AIMS)," says Hale. "This involves a modular architecture for line replaceable unit (LRU) components in the avionics bay. Unlike earlier aircraft, an LRU in the 787 will have several functions and modules, so that if a module fails it will simply be replaced without the whole LRU having to be changed. There are also spare modules in each LRU, which can have software uploaded into them if required. This concept was first used in the 777, which has 85 independent computing systems. The 787's improved architecture, however, has only 15 computing systems, thereby reducing the number of high cost rotables. The 787's integrated design also means that it has 13 main avionic LRUs on the flightdeck, compared to the 777's 23.

"The effect of this design philosophy has been to reduce the number of rotables needed to support an airline's operation," says Hale. "We compared an airline's recommended spare parts list for rotables on the 767 and 787. Its 767 fleet has 314 part numbers in the ESS Code 1 category, or 'no go' parts. The 787 has just 108."

787 summary

The 787's design and maintenance programme clearly have scope for reducing costs associated with line, airframe check and rotable component maintenance. The reduction in MPD tasks and the extended intervals of many others compared to older generation types indicates that the 787 should use a significantly lower amount of MH to complete base checks. It should also have lower costs related to the management and repair of rotable inventories.

In addition to these design features, Boeing has introduced a maintenance programme for 787 customers called GoldCare. This is a lifecycle programme, structured so that 787 operators can have the engineering support, maintenance control, maintenance planning, airframe maintenance and material repair and management elements of the aircraft managed by Boeing for a fixed fee per FH. The programme is thus not dissimilar to the fixed rate per hour engine maintenance programmes that engine manufacturers offer to airlines.

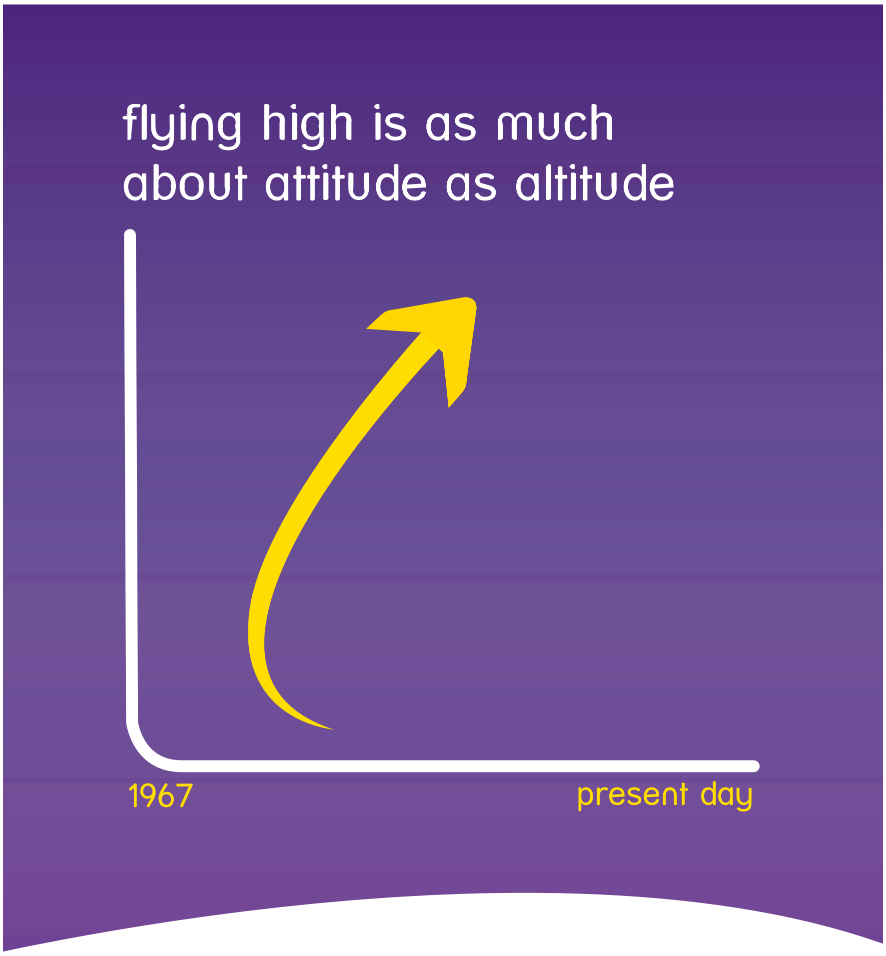
Under Boeing's GoldCare, Boeing will source several maintenance providers to conduct airframe checks for its customers. The first provider in Europe is Monarch Aircraft Engineering, based at Luton, in the UK.

A350

The A350 has three variants with seat capacities ranging from 275 to 350. The aircraft are therefore pitched as replacements for the A330/340 family and 777 family. The A350XWB clearly needs to provide lower cash operating costs per ASM by reducing fuel burn and maintenance requirements, as well as improving comfort standards. Like the 787, the A350 has been designed to reduce all elements of maintenance costs.

Airbus started using carbon fibre reinforced plastic (CFRP) with the A300-600 and A310 in a few structures that included the spoilers and rudder, and gradually increased its use so that it is found in 25% of the A380's structure. "The A350 structure will use 53% CFRP and 14% titanium, with the rest comprising the traditional aluminium and aluminium-lithium alloy," says Marino Modena, maintenance marketing manager at Airbus. "CFRP is corrosion- and fatigue- free, and titanium is corrosion-free, so a lot of structures tasks can be eliminated. The 67% use of CFRP and titanium makes the aircraft less prone to corrosion. These materials will be used in the wings, centre wingbox and keel beam, tailcone, skin panels, frames, stringers, and passenger and cargo doors. This is partly why we are able remove the intermediate structures check."

The A350 will also have new designs in its system architecture to reduce maintenance costs. An example is a reduction in the number of hydraulic systems on the aircraft. On current generation aircraft such as the A330, 767 and 777 there are three hydraulic systems. For example, on the A330 one is powered by two engine pumps and an electrical pump, while the two others are powered by an engine pump 1 or 2 and electric pump. "There are only two 5,000psi hydraulic systems on the A380 and the A350, coupled with two electrical circuits for flight control systems. This architecture combines conventional servo controls with electro-hydrostatic actuators (EHAs) and electrical back-up hydraulic actuators (EBHAs), saving weight and reducing the number of complex parts such as lines, connections



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The A350 will use CFRP and titanium in 14% of its structure. This has the effect of eliminating many of the tasks that are present in the maintenance programmes of current generation aircraft. The A350 will have maintenance programme of four checks in a 12-year period, with just one structural check.

and valves. The heat exchangers and accumulators for this system are maintenance free," explains Modena.

Unlike the 787, the A350 will use an engine bleed air system. This is justified by the fact that the electrical systems on the A350 require much less power (550kVA) than a bleedless aircraft, which needs about three times the electrical power. In addition, the air conditioning system in a bleedless aircraft will need a heavy-duty compressor to compress the air, whereas the A350's air conditioning system does not need one."

A350 maintenance programme

The A350's 2013 service entry date means that its MPD is incomplete. "The first draft of the maintenance programme is due in 2012," says Modena. "The development of the aircraft's Maintenance Review Board Report (MRBR) has just started. The A350 has been designed to reduce maintenance costs through a simple design philosophy, starting with the maintenance cost target, achieved through MPD MH reduction and shorter elapsed time of maintenance tasks and airframe checks.

"The maintenance programme utilises a 'usage parameter' concept, whereby task intervals are defined in FH, FC or calendar time. Operators will then be free to group tasks into checks according to their pattern of operation and rate of aircraft utilisation," says Modena. "This flexibility also means that operators can still group tasks into pre-defined checks in the MPD if they wish. This flexible MPD system is already used for the A380 and A320 families, and will also be used by the A330/340 in the future."

The interval criteria for each task depend on the conditions that cause failure. "As systems deteriorate with FH usage, so do FH intervals," says Mario Araujo, vice president of engineering at TAP Maintenance & Engineering. "Corrosion tasks have calendar time intervals. The old system of pre-defined checks is not optimised for all airlines' operations. Those involved in MPD development, including ourselves and other airlines, meet to determine the interval for each task, and propose the number of tasks and the whole MPD, which will eventually be approved. This will be before its first flight. It is not yet clear how many tasks the A350 MPD will have, but our customised maintenance programme for the A330 has about 1,000. The A330's MPD has more tasks than this, but we have fewer because of issues relating to effectivity. The goal is for the A350's MPD to have about 25% fewer tasks, perhaps about 750 in all."

"The concept of usage parameters means operators could opt for a system of more frequent smaller checks with a shorter downtime, which can now easily be performed during an overnight shift," says Modena. "Alternatively they could arrange tasks into block checks. The number of tasks in the MPD has yet to be determined. But our preliminary analysis is showing that we will be able to meet our target of about 40% lower MPD MH than current generation aircraft."

"The latest outcomes of the MSG-3 maintenance programme development confirms that we can meet the target of each task card," says Modena. "Reducing task card numbers and MH for routine inspections depends on the material used in the aircraft's construction."

A & base checks

"We want to reduce the number of light maintenance checks (formerly known as A checks) in a 12-year timeframe by 20. That is, our light check interval target is 1,200FH. This compares to 500-600FH for the 767 and 800FH for the A330," continues Modena. "We also want to reduce the number of base checks (formerly known as C checks) in a 12-year cycle to four, compared to eight for the current generation aircraft."

The current proposal is to have the lowest interval for 'A' check tasks at 1,200FH. "The aim is to have no tasks with an interval shorter than 1,200FH. Tasks with intervals from 1,200FH to 3,000FH will have intervals going up in increments of 100FH," says Araujo. "Task intervals higher than 3,000FH would go up in increments of 500FH."

There will be tasks with multiples of the basic 1,200FH interval for 1A tasks. These will be 2,400FH and 3,600FH. "These tasks will include some variable frequency generator oil filters and some light operational checks that can be done through the on-board maintenance system (OMS)," says Modena.

The A350 target interval for base checks is thus 36 months. The A330's base check interval is 18 months, although it is targeted to be extended to 24 months in 2011. The extension of light and base checks is also due to many of the tasks being systems related. In particular, the A350 will feature integrated modular avionics (IMA) technology which will incorporate standard modules, greatly reducing the number of different components and complexity.

"All the heavy check tasks for the A350 have been pushed out to the 12-year interval; the fourth base check in the cycle," adds Modena. "This compares to some structures tasks being performed in the fourth check, an intermediate structures check at six years in the base check cycle of our older types. In the A350, the second check at six years will now mainly be systems tasks, plus a few easy-to-perform structures tasks, due mainly to the choice of corrosion-free materials such as composite and titanium."

There will thus be a basic multiple of

The initial threshold for structures tasks is likely to be 144 months. The repeat interval for many of these will be 144 months, but some tasks will have shorter repeat intervals of 72 months.

1C tasks at 36 months. The higher 2C, 3C and 4C multiples will have intervals of 72, 108 and 144 months. There are also some light tasks with an interval of 15,000FH, which will be included in the 1C tasks. The 12-year check will thus comprise the 1C, 2C and 4C tasks.

The initial threshold interval for all structures tasks will be 144 months; the 12-year interval for the heavy check. This will coincide with the landing gear overhaul. "Some tasks, however, will have initial intervals of 180 and 216 months, because they may have lower thresholds due to corrosion-sensitive areas," says Araujo. "There are repetitive intervals for these structures tasks. Some will have repeat intervals of 144 months, meaning there will be a heavy check after another 12 years. Others, however, will have repeat intervals of 72 months which means that some will have to be included in the C6 check; the second check after the first heavy check. Airbus has set up a sampling programme. Several operators' aircraft will have the structures of their aircraft tested while they are in service so that they can get approval for the 12-year structural tasks interval.

"Two other groups of fatigue-damage-related tasks are included in the lower base checks, with dual intervals of 30,000FH and 3,200FC, and 60,000FH and 14,400FC," adds Araujo. "Since most aircraft will operate at 4,500-5,000FH per year, these two task groups will be due every six and 12 years."

Line maintenance

Flightcrew still perform pre-flight checks, but traditional line checks have not been transferred to flightcrews. "All the pre-flight and transit check tasks come from the operations manual, as do most of the tasks for the weekly and daily checks. Only a minority are quoted in the MPD. Airlines also add their own tasks into these checks," says Araujo. "A few tasks have intervals of 36FH, which would be grouped into the daily check. The target interval for the weekly check is 10 days, or 100FH."

Modena explains that, apart from some visual checks at the transit or daily checks, the A350 is designed to have no scheduled maintenance at intervals of less than 10 days. That is, the weekly check. "The target is to have the lowest interval of 48 hours, a daily check, for visual inspections of wheels, tyres and brakes that can easily be performed," says Modena. "The next group of tasks covers the A350's capability to automatically monitor oil and hydraulic fluid levels, as well as rotable component failures using its on-board maintenance system."

The A350 will also have an advanced system for detecting, reporting and analysing fault codes. "Earlier aircraft produced archaic codes, and there was a high level of no fault found (NFF)," says Araujo. "The A350 will be all-wireless and all-paperless. The technician on an A320/321 has to examine a post-flight report. Maintenance faults generated in flight are sent to maintenance control centres by ACARS. The technicians look at the reports, Pireps and technical logs. They then have to analyse problems using the TSM, and often find NFF.

"The fault reporting, Pireps, technical logs, fault analysis, AMM, FIM and TSM will all be electronically interfaced with each other on the A350," continues Araujo. "The aircraft will also have the same avionic and LRU system architecture as the 787. The overall objective will be to save labour and time dealing with technical faults."

Technical faults occurring on the aircraft can be divided into two categories. The first are ones where action is required by the pilots to continue the flight. "An example is switching between hydraulic systems. The pilots at least need to be aware that there has been an automatic switch between hydraulic systems," says Modena. "The second type of faults is those where pilots do not need to know about the technical fault, and they have no action to do. These are called dispatch advisory messages. An example is where Channel A of a computer is automatically replaced by Channel B. Most faults are in this second category. There will be a direct link between dispatch messages and minimum equipment list (MEL) items, so that the system knows if the failure is related to the MEL and, if so, whether the failure is an MEL category A, B or C. This new feature on the A350 reduces the need for troubleshooting. The system will also have hyperlinks to the pages of the relevant electronic technical manuals that provide instructions on how to fix a problem. The dispatch advisory allows the simplification of messages, and overall the new system will save time, and reduce non-routine tasks."

A350 summary

The A350 has been designed to reduce its maintenance requirements in similar ways to the 787. "By reducing MPD tasks and MH, extending task intervals, eliminating some rotable components, and improving the system for analysing technical faults, we aim to have airframe-related maintenance costs that are 40% lower than those of the 777-200ER," says Modena.

Araujo says that another target is for maintenance costs to be 25% lower than the A330-300's. "The electronic system on the aircraft will save line maintenance MH, and utilising electrical systems in place of hydraulic and other systems will use fewer complex parts. There will also be fewer rotables because of the IAM avionic architecture."

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