The oldest A380s are now seven years old, and the first aircraft have been through their C3 checks. Analysis of the MPD reveals how base checks could be structured, and the deep access tasks that will drive man-hours. Labour and material inputs for the first base checks are examined.

A380 MPD analysis & base check costs

The A380 entered service in late 2007. It was the first Airbus type to enter service with a standard base check interval of 24 months, and also the first to have a base check cycle of six checks, with heavier checks that include structural inspections at the third and sixth checks. This compares to the historical base check cycle of eight base checks, with structural inspections at the fourth and eighth. All Airbus base maintenance programmes include two heavier structural checks, often referred to as 'intermediate', and 'heavy' or 'D' checks.

The age of the oldest A380s means that a few have been through their first intermediate checks, which have an interval of six years/72 months. These heavier checks, and the two preceding lighter base checks, provide a strong indication of the aircraft's maintenance requirements in terms of man-hour (MH) and material inputs.

A380 in service

There are now more than 140 A380s in active passenger service with 12 operators, including: Emirates, with the largest fleet of 52 aircraft; Air France; Lufthansa; Korean Air; British Airways; Qantas; and Singapore Airlines (SIA) with the largest fleets. There are also other carriers operating small fleets.

Although it has an ultra-long-range capability, the A380 is utilised as a traditional long-haul aircraft by its operators on high-density, established long-haul routes, previously operated with 747s in the 1980s and 1990s. In most cases, the A380 is not operated on ultra-long-haul routes opened over the past 10 years and operated with types such as the 777-200ER and -300ER.

As a result, the A380 achieves moderate average rates of annual utilisation with most of its operators. These are 4,500 flight hours (FH) and 575 flight cycles (FC) per year, equal to an average FC time of 8.3FH.

The average annual rate of utilisation achieved by most aircraft has implications for the FH and FC intervals that airliners can achieve between base checks and across the entire base check cycle of six checks.

A380 MPD

The A380 was the first Airbus type to enter service with a standard base check interval of 24 months and a base check programme using a system of six base checks. The standard base check interval has a second criterion of 12,000FH, because the aircraft's maintenance planning document (MPD) has been based on it achieving an annual utilisation of up to 6,000FH.

Like all other Airbus types preceding the A380, the A320 entered service with a base check programme of a cycle of eight checks. The fourth and eighth base checks included structural and heavy tasks, making them the 'intermediate' and 'D' checks.

The A320's MPD has had a large number of revisions since it entered service in 1988. In 2010 the A320's MPD changed the maintenance programme, through a series of task escalations and mergers, to a base check cycle of six checks. The intermediate and heavy checks were changed from the fourth and eighth checks in the cycle, to the third and sixth checks in the new six-check cycle. The A330 has also undergone a change from a base maintenance programme of a cycle of eight base

The A380's standard base check interval is 24 months. The base check programme is a system of six checks, with heavy maintenance visits at the third and sixth checks. The oldest aircraft have now been through their first heavy checks, the third in the cycle.

The labour and material cost inputs for the A380's first three base checks are about 10% more than for the full base check cycle for a 747-400. The two groups of checks are performed over a similar interval of about eight years.

checks to a cycle of six base checks.

The A380's maintenance programme has been conceived around a similar programme of base checks. These six checks can generically be referred to as the C1, C2, C3, C4, C5 and C6 checks.

The first C1 check comes due at 24 months, which is equal to 9,000-10,500FH and 1,150FC, depending on the aircraft's rate of utilisation *(see table, page 28)*. The C3 and C6 checks are therefore the intermediate and heavy checks. The C3 check comes due at 72 months and 27,000-31,000FH, and about 3,500FC *(see table, page 28)*. The C6 check comes due at 144 months and 54,000-62,000FH, and about 7,000FC *(see table, page 28)*.

A large number of tasks in the A380's MPD have intervals that are multiples of either 10,000-12,000FH or 24 months. These tasks can thus be planned into the pattern of six base checks relatively easily. Given that the average aircraft utilisation is 575FC, tasks with FC intervals close to 1,150FC also fit in well or are in phase with the six base checks in the base check cycle.

A large number of other tasks have intervals that are similar to multiples of 12,000FH, 575FC and 24 months. These tasks can therefore also be grouped into the six base checks in the base check programme relatively easily.

Tasks that come due every base check could be put into one group by maintenance planners and generically referred to as 1C tasks. Tasks that come due every second check can be grouped and referred to as 2C tasks. Tasks that come due at or close to 72 and 144 months could generically be referred to as 3C and 6C tasks.

The C1 and C5 checks will therefore have just the 1C tasks. The C3 check will have the 1C and 3C tasks, while the heaviest C6 check will have the 1C, 2C, 3C and 6C tasks.

Other tasks, however, have intervals that are not in phase with multiples of 12,000FH, 575FC or 24 months. These may be referred to as out-of-phase (OOP) tasks. Maintenance planners may generally plan these tasks into line and A checks that have intervals shorter than base check intervals, or bring them forward and include them in base checks, so that they can be carried out without utilising a large portion of their interval. OOP tasks should be planned into base checks if they need a lot of deep access or preparation time, or several mechanics to carry them out, or are more efficiently performed with base check tasks.

MPD tasks

The A380's MPD has tasks in three main sections: systems tasks, structural tasks, and zonal tasks. The structures group has the most tasks. The tasks in each of these groups have several interval criteria. Operators are free to group tasks into checks, or arrange an 'equalised' system of smaller and frequent checks, according to the aircraft's rate of FH and FC utilisation and FH:FC ratio. That is, large numbers of tasks are not pre-arranged into particular checks.

There are several hundred tasks in each MPD section that have intervals shorter than the base check intervals, and so will be included in line or A checks.

System tasks

The systems group of tasks totals 730 in the MPD. The main interval criteria are FH, FC, FH & FC, calendar, FH & calendar, and vendor recommended (VR) or 'NOTE' tasks. There are therefore two groups of tasks with dual interval criteria. VR tasks are mainly the replacement or restoration of components, with intervals recommended by the particular vendor.

The two largest groups of tasks are the FH tasks (231) and calendar (365).

FH tasks have intervals of 100FH-80,000FH.

The 74 tasks with intervals of up to 6,000FH are most likely to be planned into line and A checks.

There are 157 tasks with intervals of 10,000-80,000FH. There are 17 different FH intervals in this group. The largest are the 10,000FH (14 tasks), 12,000FH (67), 20,000FH (19), and 24,000FH (17). Most tasks therefore coincide with every base check, or can be referred to as 1C tasks; and every second base check, or be referred to as 2C tasks. The remaining 40 tasks have 13 different intervals.

Many of these FH tasks involve detailed inspections (DET), general visual inspections (GVI), functional checks (FNC), operational checks (OPC), and visual checks (VCK). Few require deep access or a large amount of preparation.

The calendar tasks have intervals from 45 days to 180 months, with base check tasks starting at 24 months. The intervals with the largest number of tasks are 24 months (90 tasks), 36 months (11), 48 months (41), 72 months (122) and 144 months (54). These are clearly tasks that fall into what may be referred to as the 1C, 2C, 3C and 6C task groups.

Many of the tasks with these intervals also require deep access or a large number of MH for preparation.

The 72-month tasks, for example, have 25 that require deep access. Of these, 11 need 100MH or more for preparation.

A large number of these deep access tasks require the removal of interior furnishings such as seats, galleys, lavatories, and ceiling and sidewall panels. Others require the aircraft to be lifted on to jacks, or the flaps and slats and slats to be lowered.

"The A380 is of course a large aircraft, with a large fuselage and a double-deck configuration. The checks and inspections for systems integrity require the removal in the cabin of sidewall panels, hatracks, galleys and

A380 BASE CHECK INTERVALS & TASK GROUP ARRANGEMENTS

Base check	Approximate FH FH interval	Approximate FC interval	Calendar Interval-months	Base check task groups	MPD task numbers
C1	9,000-10,500	1,150	24	1C	285
C2	18,000-21,000	2,300	48	1C + 2C	473
C3	27,000-31,500	3,450	72	1C + 3C	667
C4	36,000-42,000	4,600	96	1C + 2C + 4C	544
C5	45,000-52,500	5,750	120	1C	285
C6	54,000-63,000	6,900	144	1C + 2C + 3C + 4C	1,179

Based on an annual utilisation of 4,500-5,250FH & 1,150FC per year

monuments, and floor panels in some areas," says Francois Jouan, Airbus fleet phase-in and projects, at Air France Industries. "There are also inspections of the wiring routes inside the wings and the outside fuselage, so numerous doors, panels, and fairings need to be opened.

"It is also necessary to prepare the aircraft for some of the inspections," continues Jouan. "This includes putting the aircraft on jacks, putting flight controls in a certain configuration, opening the engine pylon, opening a large number of external doors, removing all panels in the cargo compartment, and opening and ventilating fuel tanks. The landing gear has to be removed for overhaul, and then replaced at the C6 check interval of 144 months.

Tasks with this interval that require a large number of MH for preparation include the inspection of drainage pipes, but mainly overhead passenger cabin inspections and cleaning tasks. These all require a large part of the aircraft's cabin interior to be removed and reinstalled.

The 144-month tasks that need deep access include inspections of the cargo compartment, cabin utility area, cabin overhead area, and fuel tank area, as well as testing of the landing gear while the aircraft is on jacks. More than half of these tasks also consume a large number of MH for preparation, such as removing and reinstalling the cabin interior.

The other system tasks are those with FC, FH and FC, FH and calendar intervals, FC and calendar intervals, VR & NOTE tasks, and APU tasks. These account for 134 tasks in the MPD.

Structures tasks

The structures group of tasks has a total of 807 in the MPD. The main interval criteria are: calendar; FC; FH; FC and FH; FC and calendar; and FH, FC and calendar tasks.

The interval criteria with the largest number of tasks are the calendar (246), and the FC and FH tasks (500).

"The structures tasks include a large number that require a lot of MH for access and aircraft preparation," says Jouan. "These are tasks that involve removal of all seats, flightcrew rest area, inspection of outer skins, and fitting of primary flight controls."

The calendar tasks have intervals of 24 months, 36 months, 72 months, and 144 months. The 72-month and 144-month intervals have the largest number of tasks, with 132 and 112 tasks. A small portion of the 144-month tasks, 23 inspections, has an initial interval of 144 months, but then a repeat interval of 72 months.

These tasks are structural inspections, and account for a large portion of the routine MH required to complete the C3 intermediate and C6 heavy checks.

A large portion of these tasks require deep access, as would be expected with structural inspection tasks.

The 72-month inspections most affected are those relating to the landing gear; passenger doors; forward, centre and rear fuselage structural inspections; the belly fairing; the tail section; the wing box; and the wings, flaps, slats, and spoilers. The tasks relating to the fuselage structure and belly fairing also require a large number of MH for aircraft preparation, since they involve the removal and reinstallation of the interior and belly fairing.

The 144-month inspection tasks include: forward, centre and rear fuselage structure inspections; nose fuselage inspections; landing gear retraction tests; the aircraft tail section; inspections in the centre and outer wing box structures and areas; wing fittings; and flaps, slats and ailerons. Most of these inspections need deep access, with the fuselage structure inspections requiring the removal and reinstallation of the cabin interior. The fuselage structure inspections consume a large number of MH for pre-inspection preparations.

Tasks with dual FC and FH intervals are the largest group, with 500 different inspections and more than 375 different intervals. The ratio of the FH to FC intervals in the case of most of the tasks is 7.3FH per FC. This suggests that most aircraft operating on an average FC time of 8.3FH will reach the FC limit for each task before the FH limit.

The intervals are a combination of FH and FC. Each task has an initial and repeat interval. In the case of some tasks these two are the same. The shortest initial interval is 8,000FH and 950FC, while the highest is 136,000FH and 18,400FC.

These tasks are airworthiness limitation items (ALI), and they relate to various structural parts of the aircraft, such as joints and stringers. Each of these items has a finite life, but the initial and repeat inspection intervals are far shorter than these. In addition to the structural programme, the ALI items are listed in the airworthiness limitation section (ALS). The intervals in the ALS may get revised before the intervals are updated in the MPD, so maintenance planners have to pay attention.

Virtually all ALI tasks have intervals that are at least equal to a C1 check interval. The large number of different intervals and the wide range of intervals means that a lot of tasks will inevitably have to be brought forward and grouped into base checks. A large portion of their interval will therefore not be utilised.

The structural tasks also include 51 FC tasks. There are 37 different intervals, and most have an initial interval that is

A380 BASE CHECK MPD TASK NUMBERS

Check group	FH	FC	FH & FC	Calendar	FH & calendar	FC & calendar	FH, FC & calendar	ALI	TOTAL
1C	86	20	2	153	16			8	**285**
2C	48	2	43	78	3			14	**188**
3C	4	9		293		1	4	71	**382**
4C	11	2	4	5	5	1		43	**71**
5C	6	2		1				41	**50**
6C		1		213	1		1	108	**324**
7C		4		5		2			**11**
8C	2	2			1				**5**
9C	1	7							**8**
10C		2							**2**
11C		3							**3**
12C								22	**22**
TOTAL	**158**	**54**	**49**	**748**	**26**	**4**	**5**	**307**	**1,351**
VR/NOTE	**56**								

longer than the repeat interval. For tasks that would have intervals corresponding to base check intervals, initial intervals vary from 1,200FC to 18,700FC; the latter being more than twice the probable C6 check interval. Most repeat intervals vary from 1,200FC to 9,000FC, so all these tasks are likely to be included in the six base checks.

The large number of different tasks means that it is inevitable that most airlines will have to bring forward many tasks to be in phase with all the other tasks that come due at the main base check intervals. Most of the FC tasks will therefore be unable to utilise a large portion of their available MPD intervals.

Zonal tasks

The zonal programme is the smallest section of the MPD. There are 191 inspection tasks, all with calendar intervals of 45 days to 144 months.

There are 23 tasks with intervals of 45 days to 18 months, and these would be planned into line and A checks.

The remaining 168 tasks have intervals of 24 months to 144 months, so they would be planned into base checks.

There are 42 tasks with a 24-month interval, and another eight with a 36-month interval. These are likely to be grouped as 1C tasks. Of these, 15 have deep access requirements, mainly for the fuselage and interior structure, thrust reversers, and flaps and slats.

There are another 29 48-month tasks, and 12 of these have deep access requirements. These would be grouped as 2C tasks. They relate to inspections of the fuselage and interior structure, thrust reversers, and engine pylons.

There are 38 72-month tasks, and these would be grouped as 3C tasks. 28 of these have deep access requirements, and the inspections relate to the fuselage and interior structure, and flaps and slats. 11 of these tasks also have a high MH requirement for aircraft preparation. These are the inspections that relate to fuselage structural inspections, which require the removal and reinstallation of interior furnishings and equipment, insulation blankets, and panels.

There are four 96-month tasks, which would be grouped as 4C tasks. Three of these have a deep access requirement, and they relate to the fuselage and engine pylons.

The last main group of inspection tasks in the zonal programme is the 47 144-month tasks, of which 33 tasks, relating to inspections of the fuselage and interior structure, main structural items, and fuel tanks, have a deep access requirement. Nine of these tasks also require a large number of MH for preparation, for the same reason as the tasks with a 72-month interval.

MPD summary

A summary of the system, structural and zonal tasks indicates how many of the 1,535 MPD tasks with base check intervals are arranged.

There are 277 tasks that are likely to be grouped as 1C tasks, another 174 tasks that are likely to be grouped into the 2C tasks, and 311 that would be grouped into the 3C tasks.

There are also another 282 tasks that could be grouped into what may be referred to as 4C, 5C, 6C, 7C, 8C, 9C, 10C, 11C and 12C tasks.

In addition to these 1,044 tasks, there are also 56 tasks with a VR interval, and 435 ALI task that have a wide range of combined FH and FC intervals *(see table, this page)*. The initial intervals for these vary between 10,500FH and 1,425FC, and 136,000FH and 18,400FC. These 435 tasks can be split into the different base check task groups. Eight tasks would be grouped with 1C tasks, and 14 with 2C tasks.

There are 71 ALI tasks with initial intervals that would include them in the 3C group of tasks. This includes the 41 tasks with an initial interval of 28,000FH and 3,800FC. There are 43 tasks that would be included in the 4C tasks, 41 in the 5C tasks, and 108 in the 6C tasks *(see table, this page)*.

These ALI tasks increase the number

of 1C items to 285, 2C inspections to 188, 3C tasks to 382, 4C tasks to 71, 5C tasks to 50, and 6C tasks to 324 *(see table, page 30)*.

A C1 check would thus have just the 285 1C tasks, a C2 check the 473 1C and 2C tasks, and a C3 check the 667 tasks *(see table, page 28)*. The first C6 check would thus have the 1,179 1C, 2C, 3C and 6C tasks *(see table, page 28)*.

The number of tasks that are likely to be grouped as 7C, 8C, 9C, 10C and 11C tasks is small, at less than 100 inspections, compared to lesser intervals.

The shorter repeat intervals of ALI tasks means that the number of MPD tasks and the workpackages of base checks increase as the aircraft gets older.

In addition to these inspections with intervals that are at least as high as a C1 check, there are a large number of OOP tasks with lesser intervals. These may get planned into maintenance checks, especially if it is easier to combine them with base check tasks or if they require deep access.

Base check inputs

The oldest A380s in operation are seven years old. The oldest aircraft have therefore been through their first C3 checks, and will go through their first C6 checks in about five years.

Some experience of the first three base checks in the A380's base check programme, and experience of the first C3 heavy maintenance checks, has been gained by operators of the oldest aircraft in the fleet.

The first three base checks have included service bulletins (SBs) for the wing rib (WR) modification. The addition of these SBs extended the downtime to complete each check.

C1 checks have been completed in a turnaround time of about 18 days, but the WR mod extended this to 23 days.

The routine portion of the C1 check has consumed up to about 10,000MH for aircraft preparation, docking, gaining access, performing MPD and non-MPD routine task cards, MH for the WR modification, and interior cleaning and refurbishment work *(see table, page 34)*.

The first aircraft going through these checks had an average non-routine or defect ratio of about 50%, which generated a requirement for about another 5,000MH.

In addition to this, 1,000MH were consumed completing modifications, including SBs not related to the WR modification, and the fleet improvement programme (FIP) modifications.

C1 checks are estimated to have used a total labour input of up to 16,000MH *(see table, page 34)*, although totals of about 12,000MH are also reported.

The cost of related materials, parts and consumables for the routine portion of the check was about $20,000, and is low as would be expected for a first base check.

The cost of materials, parts and consumables for the non-routine portion of the check would be $150,000. The total for materials, consumables and parts is therefore $170,000, but can be up to about $200,000. These costs include the materials and consumables used for interior cleaning and refurbishment. They do not include the cost of large rotable items used for galley and in-flight entertainment equipment.

The C2 check is an overall larger workpackage on average than the C1. The C2's routine labour consumption averaged higher at 12,000MH for checks performed so far *(see table, page 34)*. This input includes aircraft preparation, docking and access; performing MPD

A380 BASE CHECK INPUTS C1 TO C3 CHECKS

Base check	Routine MH	Non-routine MH	Modification MH	Total MH	Materials routine-$	Materials non-routine-$	Total materials-$
C1	10,000	5,000	1,000	16,000	20,000	150,000	170,000
C2	12,000	10,000	1,000	23,000	35,000	320,000	355,000
C3	18,500	22,000	1,000	41,000	140,000	1,250,000	1,400,000

and non-MPD; routine tasks cards; labour for the WR modification; and cabin interior work. The corresponding cost of materials, parts and consumables for this portion of the check averaged $35,000.

The non-routine ratio for this check was much higher, and generated a requirement for 10,000MH. The corresponding cost of materials, parts and consumables is $320,000.

The check also used a similar number of MH as the C1 check for modifications.

The total labour for the check was 23,000MH; while the total cost of materials, parts and consumables averaged $355,000 *(see table, this page)*. Again, this includes those used for interior cleaning and refurbishment.

The C3 check, which has a maximum interval of 72-months and 36,000FH, has been a far larger input than the C1 and C2 checks. "There are a lot of deep access and large aircraft preparation tasks in the 72-month check," says Jouan. "We expect our aircraft will use 1,300MH for access and 5,700MH for preparation for this check; a sub-total of 7,000MH. The actual routine inspections will be only 800MH. There are other elements such as cabin interior and SBs."

Armin Bayer, project manager maintenance programmes A350/A380 at Lufthansa Technik comments that in the case of the 747-400 D check, about 75% of the routine work was spent on aircraft preparation, access and replacing removed items. The routine inspections only used about 25% of the MH employed. Bayer says that for the first intermediate checks (C3) Lufthansa Technik is packing tasks with similar access requirements in the same check, even if the tasks do not have matching intervals. This is to minimise aircraft downtime. He expects the A380 to have a comparable ratio between preparation and access to inspection tasks as the 747-400, when Lufthansa performs the first C3 checks on its aircraft.

A labour consumption of up to 18,500MH has been used for the routine element for C3 checks performed so far; and a corresponding materials, parts and consumables cost of $140,000. The non-routine portion of the check has also been correspondingly high, at more than 100%. This has generated a labour requirement of up to 22,000MH; and a related materials cost of $1.25 million. An average of another 1,000MH were used for modifications. Total labour input for the check was therefore about 41,000MH, and total cost of materials $1.4 million *(see table, this page)*. This is similar to other reports and estimates of a total labour input of 40,000MH, including a typical average cabin refurbishment, and about $1.25 million for parts and materials.

While these MH inputs do include the refurbishment of the aircraft's interior, they do not include labour for stripping and repainting. An allowance of up to about 4,000MH for labour and an addition of $200,000-250,000 for paint and other materials should be a reasonable budget.

The input for the C3 check compares to 45,000-55,000MH and $1.20 million for all materials and parts for the first D check, including stripping and painting, performed on a 747-400 *(see Assessing the 747-400's ageing maintenance, Aircraft Commerce, August/September 2012, page 43)*.

The input for the first three checks so far in the first half of the A380's base check cycle is 80,000MH and $1.92 million in materials, consumables and parts, over an MPD interval of 72 months. This compares to 73,000MH and $1.7 in materials, consumables and parts for the first base check cycle of four checks on the 747-400 *(see Assessing the 747-400's ageing maintenance, Aircraft Commerce, August/September 2012, page 43)*. This is for an MPD interval of five, six or eight years, depending on when the aircraft entered service.

Rotable support

A380 operators also have to consider technical support for engine maintenance, and the provisioning and management of rotable components.

Engine maintenance is supplied by the engine manufacturers for most operators. Acquiring rotable inventory and establishing repair capability for all part numbers requires an up-front investment that most A380 operators, with small average fleet size, cannot justify. Several specialist suppliers now supply rotable provisioning, management and logistics, and repair services.

Spairliners is a joint venture between Air France Industries and Lufthansa Technik. These two maintenance providers are airline M&E organisations of two airlines that operate the A380: Air France and Lufthansa.

Air France and Lufthansa operate a combined fleet of 26 aircraft, which themselves require a considerable level of rotable component support. The fleet is still not large enough, however, to achieve the best economies of scale.

Spairliners owns all the A380 rotable component stock, and provides airlines with a homebase stock of rotables for its own use, access to a pool of remaining components, and a repair and management service for all removed rotables that have had to be removed from the aircraft. Airline customers pay a fixed rate fee for the three elements of this service.

Spairliners sub-contracts the repair of the components to Air France Industries and Lufthansa Technik, which share the repair work equally, although they may sub-contract the repair of some part numbers and components to other repair shops.

Qantas and Malaysian Airlines also use Spairliners for a full support programme for 800 part numbers.

The combined fleet of these four operators is 41 aircraft, but will climb to 50 as more aircraft are delivered.

An alternative service is provided by Airbus, which supports British Airways, Thai International, Korean Air and Asiana.

Airbus FHS is a joint venture between several manufacturers, including Thales, Liebherr and Zodiac Aerospace, supporting Singapore Airlines.