Each member of the A320 family has its maintenance programme detailed in a single maintenance planning document (MPD). This document has now begun to include additional A320 new engine option (neo) tasks. A detailed examination, building on the findings of Issue 105, is given.

A320 base check maintenance inputs

The Airbus A320 family has added a new member in the form of the A320 neo (new engine option). The first A320neo entered service in early 2016, so its maintenance programme has only recently been incorporated into the A320 family's maintenance planning document (MPD). The latest revision of the MPD, which was published in June 2016, includes the additional tasks related to the new generation aircraft.

This means that as of April 2017, the MPD now contains all the core maintenance requirements of the A318, A319, A320 and A321ceo (current engine option) and their associated variants, as well as the emerging A320neo tasks. The A319neo and A321neo will be added to the MPD once they enter service. This suggests an increasingly complicated document that can map the requirements of a growing number of different types, variants and series.

The A320's MPD maps these variants by adding parameters to each task entry that define its applicability and effectivity *(see The A320 family's new MPD analysed, Issue 105 Apr/May 2016, page 50)*. The MPD used in issue 105 included 2,967 tasks, but not every task applied to every A320 family type. Some tasks, for example, applied to the A321, but not the A319. Tasks were applicable depending on whether the aircraft has CFM56 or V2500 engines. The main difference between types in the MPD relates to structural tasks, and can be as straightforward as the A321 having greater access requirements and a longer fuselage to inspect than its other family members. On a more complex level, each structural inspection task may only apply to a type's specific modification status.

The aircraft's line number also affects an A320's task requirements, so an early model A320ceo has a different number of tasks to a later model A320ceo. Moreover, the analysis highlighted that weight variations, modification status, and whether the aircraft was deployed for passenger, freighter and VIP usage all influenced the type of tasks required.

It is important to consider, therefore, that there is no one 'size fits all' description of an average A320 maintenance programme. It is subject to a myriad different factors, which will be described throughout this analysis.

The 2016 analysis used revision 41 of the MPD, whereas this feature will use the amended tasks included in revision 42. *Aircraft Commerce* will summarise the task amendments that have occurred between these revisions. The main purpose of this analysis is to detail of the expected size and contents of the light and base maintenance checks commonly seen in the A320's maintenance cycle. Where possible, the man-hour (MH) labour requirements, cost of materials, non-routine ratios (N-Rs), defects and common findings per check will be given, to add depth to the previous analysis.

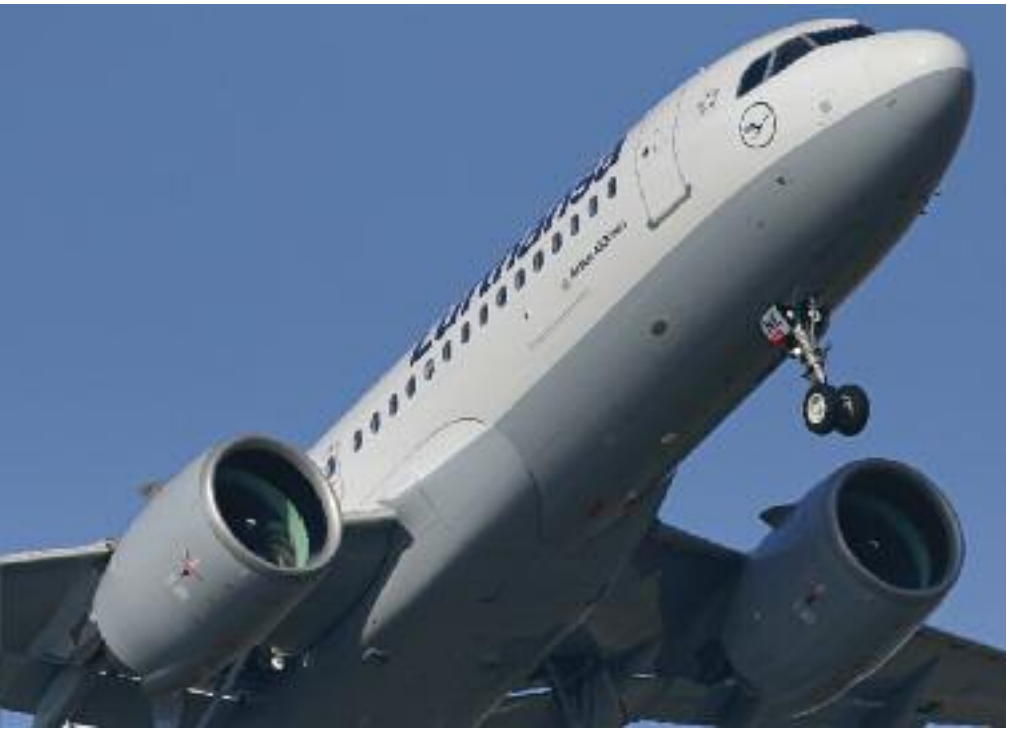
All following check and MH analysis will pertain to A320ceo aircraft, rather than the family's other members, because it is most representative of the A320 family's core structural attributes, and is the most widely used type in the family.

The analysis in issue 105 broke down the tasks included in the A320 MPD, showing which ones applied to each family member and engine option. It also explained how the tasks are commonly grouped in light and base checks. This follow-up study comes soon after the last breakdown because more analysis is needed of this complex MPD, which meets the needs of a diverse family.

Check snapshot

While original equipment manufacturers (OEMs), including Airbus, now rarely refer to A and C checks within the MPDs, these terms are often used by airline engineers and maintenance, repair & overhaul (MRO) providers to refer to light and heavier airframe checks. As was previously established in issue 105, the A320 typically follows light and heavy checks via 750 flight hour (FH) and 7,500FH increments respectively.

- The basic interval for light or 'A' checks is currently 750FH, 750 flight cycles (FC), or 4 months (MO); whichever interval is reached first. Several groups of tasks have intervals that are multiples of this basic 'A' check interval. Operators performing normal utilisation of an A320 will typically carry out three to four A checks per year, unless operating an equalised check programme that divides A check packages into smaller checks.
- The basic interval for the 'C' check is currently 7,500FH, 5,000FC or 24MO; whichever is reached first. There are several groups of tasks whose intervals are multiples of this basic 'C' check interval. Assuming normal operator utilisation, there are six C checks in one C check cycle, which therefore has a full interval of 45,000FH of 12 years, but is actually about 11 years at typical rates of utilisation. The C check interval has been extended from an earlier 18MO interval at the last Airbus re-evaluation, thereby increasing the time between checks.
- However, a large number of tasks has an out-of phase (OOP) interval, which falls between main task group intervals. The number of OOP tasks depends on individual aircraft utilisation.



The latest version of the A320 MPD, revision 42, contains A320neo tasks in addition to the other family members. Such tasks mostly relate to ageing wing, spar and skin inspections, in addition to the new engine options.

● Tasks are not typically given a single threshold parameter, so operator utilisation will be the main driver for the pattern and structure of heavy checks. For instance, operators performing a slightly lower rate of utilisation will often see calendar interval limits reached before FH and FC limits. High-utilisation carriers will experience the opposite.

Utilisation & MPD differences

As of April 2017, 41 passenger-configured A318 aircraft are in active service. The FH:FC ratio of the type is 1.38:1, with the average A318 carrying out 2,550FH and 1,850FC per year.

1,304 passenger-configured A319s are also in operation. The average utilisation figures across the fleet are 2,900FH and 1,700FC per year. This equates to an FH:FC ratio of 1,70:1.

Meanwhile, the A320ceo passenger fleet is the largest, with 3,948 in operation. The FH:FC ratio for the A320 is 1.90:1, with the average aircraft carrying out 3,100FH and 1,620FC per year. The average age of the fleet is just under 10 years old.

Dublin Aerospace is a leading MRO provider specialising in A320 and 737 base maintenance, situated in Ireland. From its experience on the A320 MRO, it estimates that the average A320ceo operator reaches 3,000-3,500FH a year.

Last, there are 1,445 A321 passenger aircraft in active service, accomplishing 2,900FH to 1,480FC per year. This is an FH:FC ratio of 1.96:1.

Utilisation figures for the A320 family are provided by Flight Global FleetsAnalyzer.

Jetblue has a large fleet comprising 120 A320ceo and more than 30 A321ceo aircraft. Its fleet growth began rapidly in 2000, and the American operator continues to grow at a rapid pace. In turn, its maintenance programme has also evolved in line with operational changes, as will be explained. Jetblue is a high-utilisation A320 operator. The average utilisation of its fleet is 11.76 FH and 4.2 FC per day; which equates to 4,086FH and 1,459FC per year and an average FH:FC ratio of 2.8:1.

Jetblue also uses certain configurations to optimise efficiencies on its route network. These affect the applicable tasks per check for the operator. "We favour aircraft with high-performing engines or sharklets on our transcontinental routes as well as our A321 fleet," explains Boris Rogoff, director of maintenance planning at Jetblue Airways. He explains that Jetblue's utilisation drives higher FHs and lower FCs that influence its maintenance programme. For example, high-utilisation aircraft are likely to hit FH parameters before calendar intervals, changing the structure and frequency of certain tasks.

Revision 42

Revision 42 was released in June 2016. It now comprises a total of 3,424 tasks, of which about 500 apply to the entire fleet, while the rest are dependent on age, line number (L/N), modification, weight and configuration.

Revision 42 contains about 900 tasks that have been added or amended from Revision 41. Of these 900, 180 are new tasks, 50 have had their intervals changed, 40 relate to system tasks (section 2 of the MPD), while 10 task revisions relate to structural tasks (section 3 of the MPD). Examples of tasks that have been revised within systems include the checking of firing circuit continuity across various zones. These tasks have had their intervals changed from 6,000FH or 72MO, to 72MO or 7,500FH whichever comes first (wcf).

Interval revisions in the structural section include tasks requiring a special detailed inspection of the fuselage structure at the attachment area under the aft cargo door: specifically, inspection of the outer hinge fittings and stringers. Preparation required for these tasks includes removing bolts, ceiling panels, insulation and linings in the area. The interval for these tasks has been revised slightly from 39,000FC or 78,000FH, to 38,600FC or 77,200FH wcf. While this task relates to an ageing aircraft likely to be in its third base check cycle, other revisions relate to younger aircraft and so are more applicable. For example, there has been an interval amendment increasing from 3,000FC or 6,000FH, to 6,000FC or 12,000FH for a special detailed inspection of the outer wing drain holes. MH have also been added to the task, which applies only to A319 and A320 passenger-configured aircraft with dry bay and retrofit wing modifications.

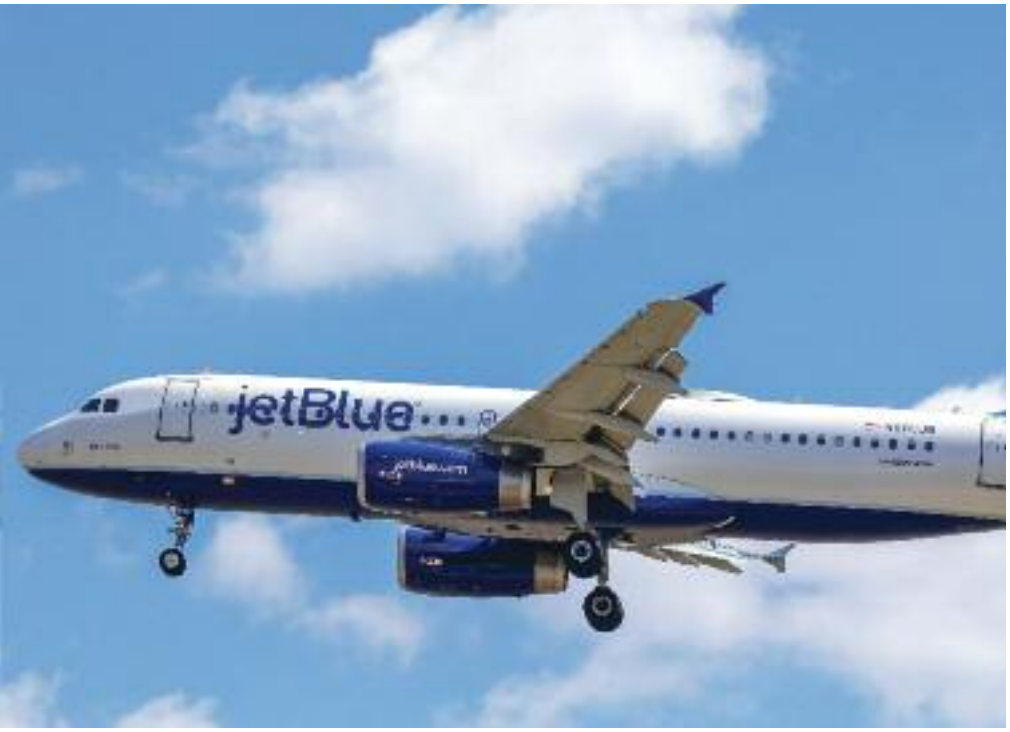
98 tasks have had their applicability definitions redefined, either to define classic, retro or modified wings for wing-related tasks, or to change the term 'classic spar' to standard spar. 135 tasks have had their descriptions revised or amended. 143 tasks have had MH added, although these relate to the time taken to undertake the task, rather than to prepare and access the areas needed to perform it. These form separate considerations when compiling and planning check packages.

50 tasks referenced in Revision 41 have now been deleted from Revision 42. However, these inspection task numbers are still commonly used if they remain active within an operator's aircraft maintenance programme (AMP).

Chapter 53 & 57

Issue 105's analysis focused on the zonal, structural and system MPD tasks in detail. The two main ATA chapters in the MPD (that is, the sections that group relevant tasks together) are chapter 53 for the fuselage, and chapter 57 for the wing.

To demonstrate the diversity of the A320's MPD, it is worth noting that of the 1,758 structural, zonal and system



Jetblue is a high-utilisation A320 operator. It uses certain configurations to optimise efficiencies on its route network. These affect the applicable tasks per check for the operator. For instance aircraft with sharklets are preferred for its transcontinental routes and A321 fleet. Jetblue's utilisation drives higher FHs and lower FCs that influence its maintenance programme.

tasks that comprise these two chapters, only 137 apply to all four A320 family aircraft types. 144 chapter 53 and 57 tasks apply to the A318, 231 are only relevant to the A319, 280 are specific to the A320, and 305 to the A321. Again, these do not necessarily apply across the fleet of each type, however, and depend instead on whether the A320 family member in question: is VIP or passenger-configured; is ceo or neo; has a classic, modified or retrofit wing; or has a standard, modified or reinforced spar.

The remaining 658 tasks apply to more than one type or configuration, or are modification-specific.

Neo tasks

69 tasks in Revision 42's MPD relate to the new engines powering the neo variants: the Pratt & Whitney PW1100G and the CFM International LEAP-1A. 29 tasks in chapter 53 and 57 are structures tasks, which are also A320neo-specific. Most relate to ageing and high FC accumulated neos. Such tasks mostly apply to wing, spar and skin inspections. The earliest neo-specific task arises at 3,000FC, and requires a special detailed inspection of the main landing gear (MLG) door fittings, the actuators and hinge fittings. The MPD provides 5.5MH for inspection of these tasks.

Considerations & modifications

As described, the A320's MPD is a complex document. Its structure has adapted to the variances, diversity and types of a long-running aircraft family. The complexity of this MPD makes it difficult to provide a 'one size fits all' illustration of an 'average' maintenance programme for the A320. Indeed, it is difficult to actually describe an 'average' A320's build and configuration, other than establish basic characteristics such as age and utilisation. It is, however, more complicated than that when determining check items for the A320.

While the basic intervals for tasks in the MPD are determined by FH, FC and calendar terms such as MO and YR, and enable a basic check structure to be worked out in accordance with utilisation, many other factors influence what may actually be included in a check.

It has been established that the applicability of each task in the MPD largely influences the task profile of each A320. A prime example of this is the type of wing the A320 has, and whether it is equipped with Sharklets. The type of wing will largely depend on the aircraft serial number (S/N) *(see The benefits of winglets & performance enhancing kits, issue 109, page 48 Dec 2016/Jan 2017).*

As described by the article, A320 family aircraft with MSN above 5,514 have a sharklet-ready wing, so it is suitably reinforced and ready for Sharklet retrofits. Jetblue was a launch customer of the Sharklet retrofit programme in 2013. It is important to note that wing task requirements and inspections for aircraft with a Sharklet-ready wing will differ from those with the original wing structure seen in older models (before MSN 5,514). A319s and A320s with MSN 1,200 upwards can undergo the reinforcement modification, whereby a kit and topskin are installed on the classic wing structure subject to inspection and service bulletin (SB) work. Meanwhile, A319s and A320s before MSN 1,200 cannot be retrofitted with Sharklets, because the early developments in the A320 family wing structure have been collectively integrated into all wings from MSN 1,200 onwards. Moreover, aircraft post MSN 1,200 have higher take-off weights, so their wings differ structurally from the earliest aircraft. This affects the task requirements for each individual aircraft in an operator's A320 fleet.

To efficiently align maintenance requirements, operators will try to ensure that their fleet is as similar as possible in terms of configuration. This makes sense, because it is this configuration that best matches their operational demands and habits. "Our fleet is fairly homogenous regarding modifications or task effectivity," says Rogoff. "We use the same engine type (V2500), and our delivery schedule has been sequential since we took our first A320 delivery in 1999.

"Weight variants do drive some task differences, however," adds Rogoff. "Jetblue has installed the enhanced reliability programme in its A320 that comprises upgraded systems. Furthermore, our in-flight entertainment (IFE) and in flight WiFi (Fly-Fi) system drive tasks that are unique to our maintenance programme. These additional tasks are aligned with heavy check cycles, and typically involve structural inspections."

Jetblue's maintenance programme has evolved and escalated over time, due to the various pedigrees in its A320 fleet. "The earliest tails in our fleet had C check intervals that were 5,000FH, which were then escalated to 6,000FH," explains Rogoff. "In 2015 we started to transition the fleet to 7,500FH C check intervals."

Rogoff explains that the higher checks with the older aircraft may have tasks that have to be re-aligned to meet the escalated intervals. "For example, we still have some aircraft that follow an eight C check cycle. These C8 checks, when they apply, have a few different versions (some lighter, some heavier, some with landing gear, or some without)," continues Rogoff. "Jetblue takes advantage of the flexibility of the maintenance program to minimise cost and downtime, but it does make for more complicated packaging."

The A320 leasing market is buoyant, due to its longevity and sheer volume of operators. The A320 is also highly

A & BASE CHECK PATTERNS OF A320 FAMILY

Check name	Interval - FH/MO	Task groups
A1	750FH/4	1A
A2	1,500FH/8	1A + 2A
A3	2,250FH/12	1A
A4	3,000FH/16	1A + 2A + 4A
C1	7,500/24	1C
C2	15,000/48	1C + 2C
C3/6YE	22,500/72	1C + 3C + 6YE
C4	30,000/96	1C + 2C + 4C
C5	37,500/120	1C + 5C
C6/12YE	45,000/144	1C + 2C + 3C + 6YE + 6C + 12YE

configurable to different operational types. Whether an A320 is being returned from a lessee to a lessor, or transitioning to a different lessee, will largely influence its lease-return check. For example, assuming normal utilisation, a 10-year-old A320ceo may expect to undergo cosmetic maintenance and a C5 check (which comprises the 1C and 5C groups of tasks per the previous analysis) to be returned to the lessor up to date and 'clear' of maintenance. It is more likely, however, that because of the aircraft's age, and the lease-return conditions stipulating that the 12YR structural items are also cleared, the A320ceo will have a C6 and 12YR check so that it is returned free of heavy maintenance for an extended period of time.

If this happens, it would shape the maintenance programme of this aircraft going forward to the next lessee. This is not uncommon in the A320 market, so consideration needs to be given not just to utilisation, but operational history when planning checks. *Aircraft Commerce* aims to provide as realistic a picture as possible of what can be expected in most heavy A320ceo checks, by using insights from planners, MROs and operators to establish an industry interpretation of the A320's check cycle. This should be treated as a guideline illustration only. It will present A320 check packages based on participants' experiences, which will vary according to background (including lessor activity), utilisation, climate and operational history. These remain significant factors due to the diversity of the document.

Last, utilisation will significantly influence the structure of an A320's base check cycle. "While VIP operators and smaller carriers may operate on a low utilisation maintenance programme (LUMP), which will mean the calendar parameters are likely met first, high-utilisation operators will often see that FH and even FC are met before calendar thresholds," explains Brendan Begley, aircraft heavy maintenance work price estimator at Dublin Aerospace.

Regular checks

Issue 105's initial analysis of the A320 MPD described which system, zonal and structural tasks from the MPD may form the A checks for operators. For the average A320 performing 3,000-3,500FH a year, Begley estimates that the average operator undertakes three to four A or 'light' checks annually. "These light checks typically comprise additional items too, such as deferred defects, non-airworthy logbook items, and heavier cleaning that cannot be done on a day-to-day basis. It is usually performed by line maintenance people overnight," he says. Begley estimates that an average A check will take 150MH to perform.

Due to its high utilisation, Jetblue sees OOP tasks regularly impacting its line maintenance processes. "This particularly relates to tasks driven at 6,000FH," says Rogoff. "Tasks that cause this disruption, due to the frequency with which they have to be carried out in our high-utilisation operation, include inspections of the air conditioning ram outlet ducts, heat exchanger cleanings, anti-icing duct findings, thrust reverser blocker doors, and MLG torque link inspections." Rogoff adds that Jetblue is working on solutions to mitigate these, but the ground time involved (10-12 hours) and the MHs (40MH per task) can drive significant operational stress on the line.

Dublin Aerospace explains that the structure of the C or base checks keep changing. While the C check has been escalated from 18 to 24MO by Airbus for the average operator for a while, regular life extension and interval escalations between revisions mean that previously OOP tasks are gradually becoming aligned with the basic C check interval, thereby slowly mitigating against a large number of OOP tasks. "The previous 18MO cycle was forcing operators to perform heavy base maintenance during their most active season, the summer time," says Begley. "Industry demand caused Airbus to facilitate the move to 24MO, since this interval allows the average operator to perform winter maintenance. This was only possible once the OEM proved the reliability of the items that these tasks related to."

Much like the fluctuating content of C checks in the base check cycle, the A check also experiences varying levels of work. To regulate workscopes for these more frequent A or light checks, some operators have moved into an equalised maintenance programme, which spreads all A check items into more frequent checks with smaller workpacks.

"We recently moved to an equalised, or segmented A check program," says Rogoff. "Our interval increased from 600FH to 750FH, and many of the general visual inspection (GVI) tasks went to 120 days (four months). So we divided the 750FH cards into 32 segmented checks. These are driven by the weekly check and designed so that a handful of similar task MHs are grouped together to optimise the downtime."

"The 120DY check stands alone outside the segment checks," continues Rogoff. "The main driver on this was to give back the long ground time blocks to our network team. The shorter segments, although more frequent, do not require later departures so we take advantage of those for generating revenue.

"The average A check was 55 days, so a cycle of A1 to A4 checks took about 220 days. The segmented cycle, because it is being driven by the weekly, has a lower yield and the cycle is about 195 days," adds Rogoff. "We have found that the MHs break even (when including the higher yield on the 4MO cards and other tasks we modified), and the demand on the long ground time blocks helps free those times for other work."

OOP tasks & findings

The 2016 analysis established that there were more than 300 FC-led system tasks in the MPD. These are OOP tasks that will fall into A or C checks. Many OOP tasks carry relatively minor inspection requirements, such as GVIs of aft cargo locking doors (10,300FC threshold).

Begley of Dublin Aerospace explains that in its experience, most OOP tasks are performed by the average A320 operator during line maintenance, unless the OOP task requires major access. "If the maintenance planner can establish other base check tasks where the area relevant to substantial OOP tasks is already opened up for C check tasks, then

JETBLUE BASECHECK CYCLE DEMONSTRATION - GUIDELINE EXAMPLE ONLY

1ST BASE CHECK CYCLE

	FH	ROUT MH	N-R RATIO	N-R MH	TOTAL MH	INT CLEAN MH	COMP CHANGE	AD,SB & EO MH	TOTAL MH	MATERIALS $*
C1	7,500	3,000	0.22	660	3,760	400			4,160	37,000
C2	15,000	3,700	0.12	444	4,244	400		160	4,804	50,000
C3 + 6YE	22,500	5,800	0.18	1,044	6,944	400		400	7,744	80,000
C4	30,000	4,200	0.13	546	4,846	400		135	5,381	40,000
C5	37,500	3,400	0.21	714	4,214	400		150	4,764	50,000
C6 + 12YE	45,000	9,000	0.60	5,400	14,500	400	600	2,500	18,000	90,000

2ND BASE CHECK CYCLE

C7	52,500	3,600	0.24	864	4,564	400		330	5,294	48,000
C8	60,000	4,500	0.18	810	5,410	400		340	6,150	55,000
C9 + 6YE	67,500	7,210	0.80	5,769	13,080	400		2,000	15,480	100,000

* CONSUMBALES & EXPENDABLES ONLY

they will bring the OOP task in question forward, even if by 100s of FH ahead of the threshold interval," adds Begley. "It may be that the inspection or task itself is minor, yet the heavy access requirements mean it still makes sense to reduce the OOP interval and perform the task in the hangar. It is possible, therefore, that OOP tasks with significant thresholds might be reduced to 12YR or 6YR intervals to combine them with the structural checks that occur at this event."

The other reason why planners might allocate OOP tasks into the heavier C checks, is if experience has shown that there is a risk of findings from the inspection that may extend downtime.

According to Begley, one of the main findings during structural inspections that cause additional downtime in the maintenance hangar is corrosion along the wing trailing edges and overhang panels. "Wing skin corrosion presents a significant, common finding in the A320 fleet," he says. "It was found to be a recurring problem across much of the fleet, so it is now inspected at every C check via a terminating inspection that was introduced by Airbus into the MPD." The inspection itself takes 700-800MH to carry out, while treating and repairing the affected areas can take 300-400MH. "When planning a C check, operators know that this finding can add 30% to the total downtime," adds Begley. While no real materials costs are involved, the repair process can cost EUR 50,000-60,000.

"Our most problematic findings at heavy check are wing top skin corrosion," confirms Rogoff. "If it is discovered during a light check, the repair can drive many days of delays." Jetblue is therefore working closely with its MRO service providers and Airbus to ensure the repair process is as efficient as possible.

"We have also been addressing reliability issues, such as airframe vibration. Inspection of flight control bearing and proactive replacements drive spans and cost, but have helped reduce the number of out-of-service aircraft. To address floor beam corrosion, which is an ongoing problem, especially from cracked lavatory floor pans, we are installing a customised tape. This is on-going and we will see the benefits in the next cycle of checks," says Rogoff.

Another thing that extends the downtime of checks, other than findings, is modifications to improve aircraft efficiency and performance. Jetblue is performing significant modifications to its fleet, including to the fuel tank interning system (FTIS), which is due to complete this year. "These modification tasks extend time on the checks when combined," adds Rogoff. "As this modification programme ends, we will begin ADS-B and data communication modifications."

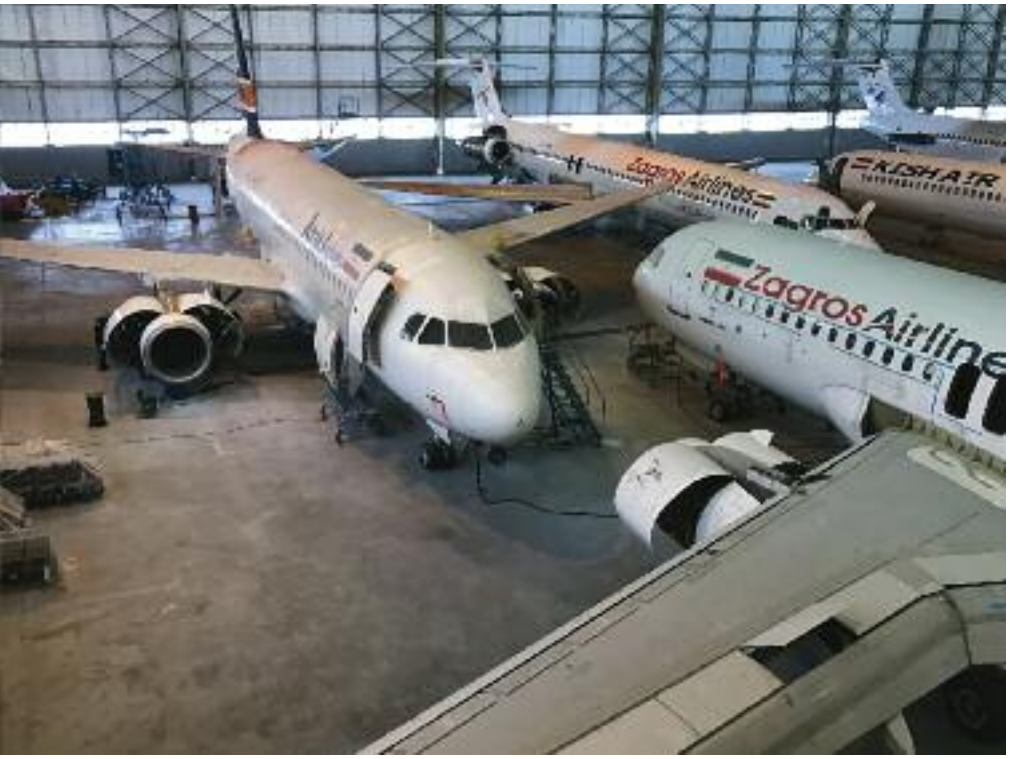
In addition to OOP tasks, modification work, and common findings that arise during routine checks, ageing and sampling tasks arise in the A320 MPD as the aircraft accumulates FC. Once the A320 meets and exceeds 20,000FC, an increase in structural and deep access-focused tasks is gradually introduced. The ageing task programme applies to all aircraft in the fleet, and the relevant tasks again depend on type, modification status, and engine fitted.

These checks include galley removal at 35,900FC, engine and antenna removal at 60,000FC, and a large number of non-destructive testing (NDT) requirements that will all require varying levels of access. To fully address and assess the affect that operational fatigue can have on the airframe, sampling tasks are a common requirement in an MPD. These are present in the A320 document and also take effect from 20,000FC onwards. Now that 10% of the A320 fleet is over 20 years old, given the average utilisation it can be assumed that a significant number of aircraft are nearing these thresholds. "Ageing aircraft evaluation complicates the heavy checks," explains Rogoff. Jetblue's oldest aircraft is 17 years old, given the approximate annual utilisation of 1,550FC, a portion of its fleet has begun incorporating ageing tasks into its checks. "When addressing the ageing tasks, it is critical to perform the repair evaluations early in the check so that we can get design office feedback with sufficient time to implement any repair," Rogoff adds.

As well as the ageing tasks, the age of Jetblue's fleet means that the older A320s in its fleet will soon begin the third base check cycle. "As our fleet is maturing, we are preparing for service-life-extending SBs. This is likely to affect upcoming check downtimes and cost," says Rogoff.

Base check cycles

As established, the average A320 base check cycle comprises six base (or 'C') checks of varying content and downtime. The previous analysis established that, for instance, the first C check will comprise the 1C set of tasks; the second C check



The average or 'normal' base check cycle for the A320 family currently comprises six C checks. These occur roughly every two years depending on operator utilisation. The third and sixth base checks, at six and twelve years respectively, are the heaviest checks and they contain major structural tasks.

will incorporate the 1C and 2C tasks which have thresholds of 7,500FH and 15,000FH respectively; and the third C check will consist of 1C and 3C tasks in addition to 6YE structural items, thereby making it a more extensive check.

The fourth C check will therefore comprise the 1C, 2C and 4C task groups at their corresponding intervals of multiples of 7,500FH. Meanwhile, the fifth C check includes 1C and 5C items, and the C6 check is made up of 1C, 2C, 3C and 6C tasks in addition to the 12YE structural items *(see table, page 75)*.

The C3 and C6 checks are therefore the heaviest in terms of tasks and deep access requirements. "A C check takes an average of two weeks, but this varies throughout the base check cycle," says Begley. "A C1 check can take as little as three days, however. The duration increases throughout the cycle; and by the C6 check, if coupled with the 12YE structural items, a downtime of three weeks can be needed for the required inspections. This is due to the need to remove the landing gear during the check. Findings can easily add another week's downtime for the aircraft, before even considering the impact of modification work in a check." The wing inspections can also drive significant downtime if corrosion is found, and the terminating inspection alone can take about six days to perform regardless of findings.

To accurately plan and factor for findings during checks, maintenance planners apply an N-R ratio to the anticipated routine inspection MH for the check to budget for findings and defects. "Determining which N-R to apply will depend on both the MRO's experience of A320 base maintenance, and the individual characteristics of the A320 in question," says Begley. For example, if the aircraft is based in a harsh climate, corrosion will be an expected problem. The age of the A320 is also a consideration, as well as the CAP set by the customer and agreed with the MRO. "In our experience a new aircraft will usually need an N-R of 0.3:1 per base check to account for early findings, while the oldest A320s are more accurately covered if N-Rs of 0.9-1.0:1 are used to address potential findings," adds Begley.

Begley estimates that the cost of materials (consumables and expendables) for younger aircraft in lighter C checks equates to $15 per MH, while for older aircraft this ratio may be $25 per MH.

An illustration of MH and cost is provided by Jetblue *(see table, page 75)*, up to the C9 check halfway through the second base check cycle. This should therefore be seen as an example of the fluctuation in MH and cost throughout a typical cycle. Jetblue outsources its heavy maintenance to business partners. Via its agreements with its service providers for base maintenance, a portion of N-R maintenance is already accounted for. The N-R may therefore appear lower at 10-60%, depending on the C check in question. The figures in this table are averages and relevant to Jetblue's fleet configuration and utilisation, so this is not an industry-wide representation.

Lease return checks

Civil Aviation Services Ltd (CAS) is based in Ireland, and specialises in providing technical management and consultancy to operators and lessors throughout commercial aircraft transitions, such as return from lease, and delivery processes. CAS has managed and overseen several A320 checks due to an active lease demand and market.

Lease return checks vary in terms of demand and scope, but their purpose is generally to clear significant maintenance for a period of time for the new owner or incoming lessee. A lease return check may include more than the typical expected check content to meet the conditions set by the lessor or the A320's new lessee.

It should be noted that because lease return checks vary greatly, each may contain additional items as set by the lessor or incoming lessee. This will affect the workscope for the aircraft in check, regardless of its age or utilisation. It is not uncommon for aircraft coming off lease to undergo checks well before their intervals have been reached, in addition to cosmetic demands such as a full strip and repaint of the entire fuselage.

Peter Cooper, planning manager of CAS, illustrates a basic end-of-lease (EOL) check for a 12YR A320. "Typical clearance for off-lease conditions is 24MO, 7,500FH and 5,000FC," confirms Cooper. "This is basically a C check work package." CAS outlines one check package for a 12YR A320ceo coming off lease. The check outlined is relatively light in comparison to what a 12YE might be considered to be, due to the lack of customer cards including cosmetic work, internal safety layout job cards, and any hard-time component advanced work: essentially internal AMP demands. This is therefore a pure MPD package provided by CAS which further demonstrates the variance of lease-return workscopes.

The total check comprised 535 MPD tasks that coincided with the end-of-lease period; these were the tasks that form the check, rather than all 12YE applicable tasks. The check package included 61 zonal items, 172 structural tasks, and 302 systems and engine tasks.

Check observations

Upon analysing the various checks within the lease-return workpack, some consideration needs to be given when summarising MH:

There are 14 tasks with inspection or preparation MH 'TBD' (to be decided) within the lease-return workpack outlined. The lack of MH for these tasks

BASIC 12YE CHECK MPD TASK LIST BREAKDOWN & COMMERCIAL COSTING EXERCISE - END OF LEASE (EOL) WORKPACKAGE

	MPD Inspections	No.MPD Tasks	Airbus Insp' MH total	Airbus Access MH total*	Airbus Prep MH total*
Systems/Eng	302	239.43	37.09	306.78	
Structures	172	136.08	32.57	263.62	
Zonal	61	20.10	14.18	229.35	
Total - tasks	535				
Total - Airbus MH		395.61	83.84	799.75	1,279.20MH

Check Construction	Airbus Insp MH total	3.3 reality MH factor	Guide access MH for 12YE check**	Guide prep MH for 12YE	Routine total	Defect ratio 0.9:1 applied	Check MH total ***	Labour $50/MH	Material $17/MH	Guideline$ basic check
Systems/ Engines	396	1,306	550	1,750	3,606	3,245	6,851	$342,524	$116,458	$459,000

Task Breakdown	Airframe	Cabin	Engine	Electrical	Avionic	Radio	NDT	TOTAL
Check	3							
Restoration	19	1			2	1		
GVI	90		29	1				
Detailed Inspection	172	2		2		1		
Op' Check	38	1	5	28	8	3		
Service			3		1			
Discard	5	2	4			1		
Functional	27	1	3	2				
Lubrication	19							
Special Det' Inspection	2		5				20	
Visual Check	22	1	3					
Protection to electrical conduits				8				
Total	397	8	52	41	11	6	20	535

* NO DUPLICATION MH FACTORED OR REMOVED

** INCLUDES ENGINE, WING, EMPENNAGE, INTERIOR UPPER DECK AND LOWER DECK REMOVAL/REFIT OF STRUCTURES/COMPONENTS AND FURNISHINGS TO GAIN ACCESS FOR INSPECTION TASKS

***THE ABOVE FIGURES DO NOT INCLUDE ANY CUSTOMER SPECIFIC OR REGULATORY TASKS OUTSIDE OF THE MPD TASKS

makes it difficult to provide exact estimates, although an experienced MRO will be able to apply estimates for the purposes of planning, and is likely to add more MH to cover inspection, access and preparation times.

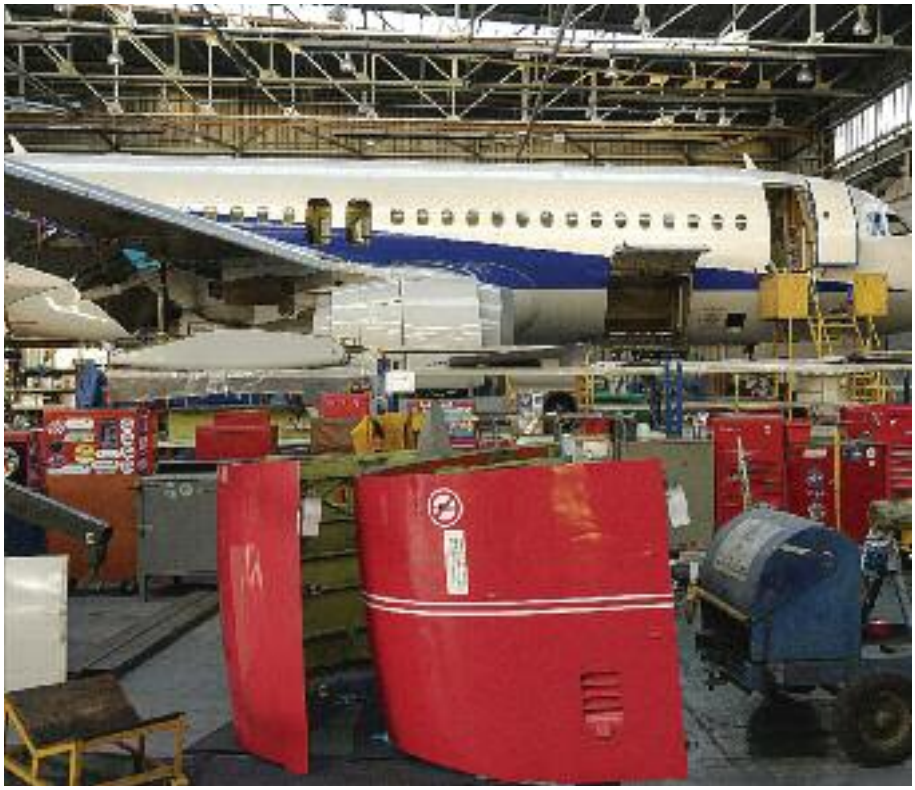
Maintenance planners have to apply realistic factors when providing quotations and downtime estimates to operators and other customers. As well as anticipating N-R findings, they take into account the fact that the MH and access times that are referenced in MPDs often do not reflect the actual time mechanics need to perform tasks.

A 'planning factor' is therefore given to MH referenced in an MPD. This aims to provide customers with as accurate as possible a forecast of how many MH a task will actually use, and what the labour cost will be. It must be noted that this is an 'estimate', and, therefore, in no way guarantees the true cost of any scheduled maintenance event. It is still a useful exercise to help manage customer expectations when aircraft are due substantial maintenance check packages.

Issue 105 established from participants that an average correction factor of 2.5-4.0 tends to be used on the A320, depending on the type of task and check. *Aircraft Commerce* has therefore used a median of 3.3 in its calculations. To be competitive, however, planners and MROs might well reduce inspection MH if experience permits, and gauge occasions whereby inspections are called up in the same area.

With regard to access and preparation MH, *Aircraft Commerce* has calculated that of the 443 panels and doors that require removal/refit/opening in the lease-return check outlined, 21 Airbus MPD MH are attributed for access time, which is very low. An experienced MRO might give an independent figure for MH per panel removal and refit to include a more accurate time and a 'clearance to close' inspection allowance. Since access MH are considered per task, MROs would have to remove duplicated panel entries for an accurate figure as well as for check planning.

Preparation MH are significant for the outlined check, and an MRO will have to consider the configuration and LOPA of an aircraft to build a realistic figure. For instance, IFE installation will have to be factored in, in addition to whether the A320 has a business-class section fitted. Galley and lavatory design will also be considered, as well as the types of seats fitted. According to



There are about 4,000 A320ceo aircraft in operation. These perform on average about 3,000FH and 1,600FC a year. The average age of the A320ceo lies just under 10 years old.

industry sources, a figure of 1,250MH to 1,650MH is a starting point for preparation MH in a 12YE check, depending on the above, and the experience of the engineers.

To establish the appropriate N-R ratio to apply, *Aircraft Commerce* has used 0.9:1 on inspection hours for an aircraft approaching 12YE, and on a low defect ratio agreement with the MRO of CAP 30, which means that in a fixed-price contract, every N-R defect is covered up to 30MH.

In addition to 12YE and due tasks, a typical check such as the workpack outlined by CAS will include FH and FC tasks, which will vary according to A320 utilisation. OOP tasks also comprise a significant part of a check, which will be influenced by operator habit.

12YR lease return check

Airbus provides guideline inspection, preparation and access MH for some (but not all) of the 535 tasks that form the 12YE lease-return check outlined by CAS. Of those that have been provided, *Aircraft Commerce* has totalled the MH for each inspection *(see table, page 78)*. The MPD suggests 800MH should be expected for preparation to carry out these tasks, and a further 85MH to access the required areas for these tasks *(see table, page 78)*. The inspection requirements on their own are given a guideline estimation of 395-400MH. The access and preparation MH do not account for duplication MH, which refers to the mitigated access if an area or zone has already been opened up for another task. MRO providers will typically account for duplications when planning and estimating check MH and costs.

The total MH therefore suggested by the MPD for the 535 tasks illustrated by CAS, is 1,280MH before any efficiency factor is applied, or removal of duplicated access/preparation requirements. *Aircraft Commerce* has produced an independent analysis based on typical industry calculations of costs and defect ratios. This should therefore be considered purely as a guideline example, and not representative of all 12YE or lease-return checks. An important note, however, is that the chart figures are MPD tasks and defects only; no ADs, SBs, customer tasks, component overhauls have been taken into account. This analysis therefore considers only the work carried out on the hangar floor, rather than the component workshop visits.

As detailed further *(see table, page 78)*, the basic inspection MH are put through the reality factor in use, then the access and preparation figures added estimated by the MRO added.

Aircraft Commerce has established a guide starting price $459,000 for the lease-return check analysed, assuming an MH rate of $50D/MH, materials at $17/MH, and CAP 30 agreed with 0.9:1 N-R ratio. This estimate excludes commercial mark-ups, findings, or handling fees, and is an example of the up-front cost given in a workpack estimate on beginning a check or for budgeting purposes. It excludes tasks or material costs that do not go over any CAPs set and agreed between the MRO and operator. For example, major structural floor corrosion will exceed the MH cap set within the initial maintenance agreement. This number has been established by applying industry averages for reality factors, N-R ratios, material coverage and labour *(see table, page 78)*. The preparation MH cover the removal of engines, access to the wings, empennage, and interior upper and lower deck removals of structural furnishings to gain access for inspection.

The check in question comprises several types of inspection and check of varying skill and depth.

Cosmetic maintenance

The initial analysis established that an A320 tends to be repainted every five to six years, at the operator's discretion, and more frequently if aircraft are being returned to the lessor, incur incidental damage (such as a hail strike) or the operator decides to rebrand. "The cost depends on the areas being repainted, such as whether the operator chooses just to sand and repaint the fuselage and tail, or include repainting the wings in the cosmetic workscope," says Begley. "Depending on the option, repainting can cost $60,000-80,000. The colour scheme also influences the cost. If more than two colours have to be repainted, or the paint scheme is complex, the cost will go up."

Cosmetic maintenance is carried out more frequently on the interior. Seat covers, overhead bins, carpets and galleys undergo excessive wear and tear on a daily basis, so their maintenance is a priority to present the best public image. "Operators tend to request a cosmetic run through at every C check, and so about every two years," continues Begley. "Typical workscopes include changing seat covers and carpets, in addition to a general deep clean. Such cosmetic maintenance usually takes 200-250MH during the C check at $65 per MH."

"Jetblue is undertaking a full interior restyle of our A320 fleet in the near future, which will mean removing every seat, and replacing with new seating," adds Rogoff. "We plan on coupling the restyle with heavy checks to take advantage of the down time. This will be a unique chance to refresh the fleet." - *CLD* AC